Economic Growth: Sources, Trends, and Cycles

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The Sources of Economic Growth: An Overview

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The importance of economic growth cannot be overstated. Income growth is essential for achieving economic, social, and even political development. Countries that grow strongly and for sustained periods of time are able to reduce their poverty levels significantly, strengthen their democratic and political stability, improve the quality of their natural environment, and even diminish the incidence of crime and violence.[1] Economic growth is not a panacea; but it greatly facilitates the implementation of public programs that complement its effects and correct its deficiencies, even if its direct beneficial impacts are modest.

It comes as no surprise, then, that an enormous amount of talent and effort has been invested in understanding the process of economic growth. The recent surge in academic research on endogenous growth and the policy preoccupation with poverty-alleviating growth are just two examples indicating that economic growth is a focal point in research and policy circles.

The present collection of studies contributes to this literature on two dimensions. First, it provides a systematic account of the stylized facts that characterize economic growth and, in particular, of the role that policies play in fostering periods of sustained growth. Some of the papers revisit the question of what drives long-run economic growth, drawing on new and improved data, while others

1. See Barro (1996); Easterly (1999); Dollar and Kraay (2002a); Fajnzylber, Lederman, and Loayza (2002).

analyze the consequences that growth has on various aspects of development and welfare. These studies share a concern for identifying the most efficient policies to promote or facilitate growth. They thus critically analyze a broad spectrum of policies, such as financial development, public infrastructure, regulatory framework, and direct government intervention in industrial policies. Second, the papers in this volume focus on new and potentially crucial questions regarding the intricate relationship between economic growth and cyclical fluctuations, particularly whether business cycles have prolonged effects on long-run growth.

The studies included in the volume apply to most countries, particularly in the developing world. Some studies, however, provide specific applications to Chile or use this country for illustration of general issues. Moreover, Chile's experience may be of independent interest to scholars and policymakers, in that it provides an example of a developing country that suffered protracted stagnation (in the 1970s) and then conducted successful economic reforms (in the 1980s and 1990s).

1. Recent Trends

Growth performance has varied notably across regions and countries in the last four decades; in some economies, it has also experienced major shifts over time. For the world as a whole, the rate of growth of per capita output has followed a declining path since the 1960s (see figures 1 and 2 and table 1).[2] To some extent, this reflects the trend in industrialized countries and its influence on developing economies. There are, however, some notable differences across geographic regions. The economic growth rates in East Asia and the Pacific were not only among the highest but also the most stable of all developing economies, showing a steady increase in the 1970s and 1980s and only a mild decline in the 1990s. South Asia also had a relatively successful growth experience in the last two decades, achieving rates of per capita output growth beyond 3 percent per year with remarkable stability.

Other regions have had rather unsatisfactory growth performances. The economic growth rates of Eastern Europe and Central Asia exhibit the fastest decline from the 1960s onward; the negative rates in

2. When comparing per capita growth rates over long periods of time, changes in demographic factors can distort the conclusions. We nevertheless use per capita GDP figures—as opposed to per worker GDP or per family income—to maintain comparability with the rest of the literature.

Figure 1. Growth Rates of GDP per Capita, GDP-Weighted Average by Region, 1961-1999 (constant sample)

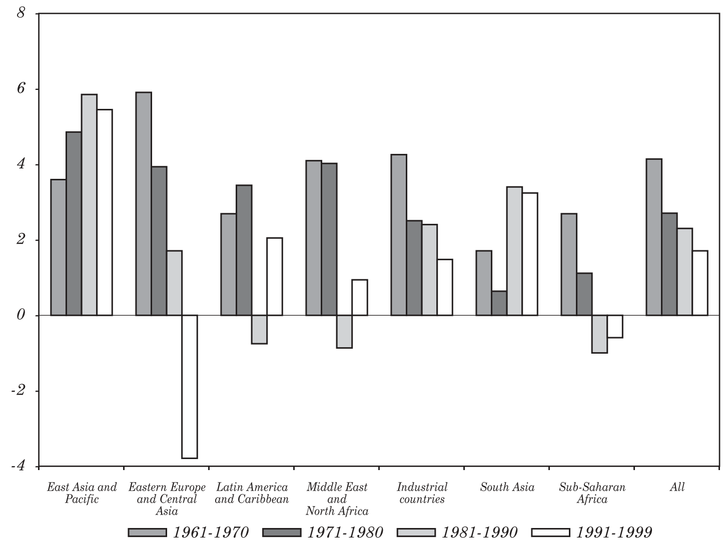

Figure 2. Coefficient of Variation of GDP per Capita, GDP-Weighted Average by Region, 1961-1999 (constant sample)

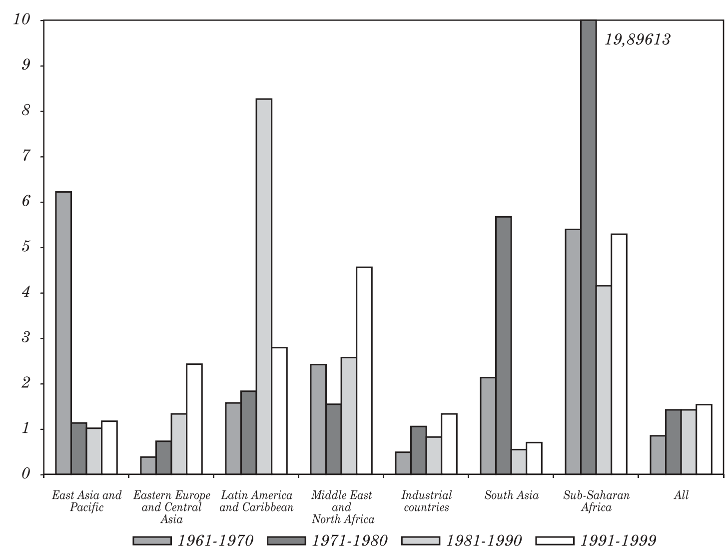

Table 1. Growth Rates of per Capita GDP by Region, 1961–1999[a]
Percent

Region	*Observations*	*Period* 1961–1970	1971–1980	1981–1990	1991–1999
All countries	109	4.15	2.68	2.29	1.72
Industrial countries	21	4.28	2.50	2.42	1.48
Developing countries					
East Asia and the Pacific	14	3.58	4.90	5.88	5.44
Eastern Europe and Central Asia	4	5.92	3.94	1.73	–3.80
Latin America and the Caribbean	26	2.71	3.44	–0.74	2.05
Middle East and North Africa	9	4.11	4.00	–0.86	0.94
South Asia	5	1.72	0.64	3.40	3.23
Sub-Saharan Africa	30	2.68	1.08	–1.00	–0.58

Source: *World Development Indicators* and authors' calculations.
a. GDP-weighted average growth rate by region. Sample is constant over time.

the 1990s reveal the high costs of adjustment from planned to market economies. Sub-Saharan Africa shares some interesting features with the Middle East and North Africa: both regions had similar growth rates in the 1960s, and both experienced a large decline in growth rates in the 1970s and 1980s. The Middle East and North Africa recovered to positive growth rates in the 1990s, but sub-Saharan Africa continued its downward spiral. Not only did sub-Saharan Africa suffer from negative average growth in the last two decades, but its growth performance was also the most volatile in the world. Meager growth and high volatility in Africa appear to be the result of an unfortunate combination of poor policies and negative external shocks on these resource-dependent economies. For Latin America and the Caribbean, the 1960s and 1970s were decades of moderate but stable growth rates. This situation changed in the 1980s, when the growth rate of per capita output fell to negative values and its volatility increased notably. In the 1990s, economic growth became positive again but did not recover its pre-1980s level.

The countries within each region display some interesting disparities as well as common features. Consider, for instance, the case of Latin America in the last decades (see table 2). The large majority of Latin American countries experienced negative growth rates in the 1980s. The only exceptions were Chile and Colombia, and for good reasons. Up to the 1980s, Colombia was the country with the best record of

Table 2. Growth Rates of per Capita GDP in Selected Latin American Countries, 1961–1999
Percent

Region and country	Period 1961–1970	1971–1980	1981–1990	1991–1999
Southern Cone				
Argentina	2.31	1.32	–2.99	3.72
Brazil	3.18	5.75	–0.42	1.07
Chile	1.82	1.22	2.08	5.00
Paraguay	1.79	5.69	–0.30	–0.60
Uruguay	0.36	2.60	–0.66	2.70
Andean Community				
Bolivia	0.35	1.67	–1.95	1.53
Colombia	2.21	3.05	1.26	0.72
Ecuador	1.24	5.65	–0.47	–0.43
Peru	2.31	0.84	–2.99	2.32
Venezuela	1.46	–0.76	–1.75	–0.30
Central America				
Costa Rica	1.93	2.75	–0.32	3.48
El Salvador	2.15	–0.18	–1.47	2.67
Guatemala	2.56	2.87	–1.62	1.43
Honduras	1.52	2.06	–0.73	0.12
Mexico	3.37	3.58	–0.29	1.42
Nicaragua	3.36	–2.84	–4.07	0.33
Panama	4.70	1.47	–0.71	2.80

Source: *World Development Indicators* and authors' calculations.

macroeconomic stability and external credit worthiness in the region, and this played to the country's advantage in the turmoil of the debt crisis that characterized the decade. Chile, on the contrary, did not enjoy such status, and it suffered a deep banking crisis and, consequently, a large fall in output in the first part of the 1980s. This country, however, found its way back to growth starting in the second half of the decade, after substantial reforms in the financial sector allowed the economy to reap the benefits of the market-oriented reforms started in the 1970s. Mexico was hit by similar shocks and had a similar crisis but chose to delay paying the costs of reform, inevitably postponing its recovery.[3]

For most of Latin America, the 1990s was a decade of reform and recovery. Except for Paraguay and (surprisingly) Colombia, all countries

3. For a comparative analysis of the debt crisis and its aftermath, see Bergoeing and others (2002).

in Latin America underwent an increase in growth rates in the 1990s relative to the previous decade. The improvement was quite notable in Argentina, Chile, Bolivia, Peru, Costa Rica, El Salvador, Uruguay, and Mexico. These countries have in common that they conducted strong market-oriented reforms and accomplished processes of economic and political stabilization. Only in a few instances, however—Argentina, Chile, Costa Rica, and El Salvador—did the recovery of the 1990s result in economic growth rates that surpassed those of the 1960s and 1970s.

The 1980s was thus a lost decade for growth and socioeconomic development in many countries and almost entire regions. The 1990s started with high expectations as it witnessed economic reforms in many places around the world, particularly in Latin America. It was a decade full of promise, and, all in all, the performance of reforming countries was not disappointing. Toward the end of the decade, however, some worrisome signs threatened to spoil the growth excitement. Repeated international crises, cases of interrupted reforms, and instances of macroeconomic mismanagement led to severe economic downturns in a number of countries around the world at the start of the new century. For policymakers, particularly in developing economies, one of the most pressing questions is how their countries can find or recover the path of high and sustained growth.

Fortunately, the task of identifying the keys to economic growth does not necessitate the launching of a new research venture. The economics profession has inherited a vast and rich literature. The objective of this volume is to contribute to that literature by exploring some of the issues that are most relevant to developing countries in the present context.

2. The Origins of the New Growth Literature

In the 1950s, Robert Solow and Trevor Swan revitalized the study of economic growth by modeling it as the result of factor accumulation in the medium term and as the outcome of technological progress in the long run. Despite its parsimony, the Solow-Swan model was rich in conclusions and practical implications. Some of these were examined empirically, particularly in the United States, as exemplified by the work of Dale Jorgenson and research associates. However, academic interest in economic growth dwindled and gradually turned to the study of business cycles and stabilization policies.

After about twenty-five years, interest in economic growth studies was rekindled for a number of reasons, of which we highlight two.

First, the use of new theoretical tools allowed researchers to model growth paths as a result of dynamic, intertemporal optimization. Second, the development of new and more reliable databases facilitated cross-country comparisons of per capita income levels and growth rates. The databases generated by Summers and Heston and by the World Bank helped researchers check the sometimes ethereal economic theories against reality.

The new literature on economic growth starts precisely as a reaction to the apparent shortcomings of the neoclassical model in explaining some actual facts. At least in its simplest forms, the neoclassical model implies that owing to diminishing returns, poorer economies should grow faster than richer ones. It further predicts that the return differentials generated by large gaps in capital stocks would produce massive capital flows from richer to poorer countries. Both implications are strongly rejected by the evidence.

The weakness of the neoclassical growth model led several researchers to propose alternatives. Paul Romer (1986) presents a model in which economic growth in the long run occurs not because of exogenous technological progress, but because the accumulation of capital generates externalities that compensate for diminishing returns. Robert Lucas (1988), another pioneer of the new growth literature, introduces a model in which human capital plays a fundamental role in perpetuating economic growth and preventing diminishing returns to physical capital accumulation. Lucas opens his 1988 article with the now famous words, “Once one starts to think about [the human welfare consequences of economic growth], it is hard to think about anything else.” These were premonitory words judging by the large number of talented people who, in the years to follow, devoted their energies to describing the stylized facts of economic growth, deciphering its theoretical puzzles, and proposing public policies to promote and support it.

The paper by Xavier Sala-i-Martin in this volume is devoted to reviewing the main contributions of the new growth literature. Sala-i-Martin identifies three defining characteristics of this literature. They are, first, the empirical touch, that is, the close connection between the new theories and the empirical data and methods used to test them; second, the emphasis on endogenous technological progress, in particular on the type that generates increasing returns and is provided by the market through monopolistic competition; and third, the merging of different strands of economics, which is both a feature of the new growth literature and a consequence of it. One particular example is the fruitful interaction, induced by economic growth, between macroeconomics—previously dominated by business cycle theories—and economic development—formerly centered on institutional analysis and economic planning. Sala-i-Martin's article derives its authoritative perspective partly from his work on the already classic textbook on economic growth that he coauthored with Robert Barro (Barro and Sala-i-Martin, 1995).

3. Determinants of Economic Growth[4]

As an introduction to the study of growth determinants, which is the common thread of the papers in this volume, we now estimate an encompassing model of economic growth. We follow the largest strand of the empirical endogenous-growth literature, which seeks to link a country's economic growth rate to economic, political, and social variables using a large sample of countries and time periods.[5] Although our interpretation of the results accords with the mainstream of the literature, we acknowledge the caveats on this type of exercise pointed out by Steven Durlauf, whose study is included in the volume and discussed below.

3.1 Setup

We estimate the following variation of a growth regression:

$$y_{it} - y_{it-1} = \alpha y_{it-1} + \alpha_C (y_{it-1} - y_{it-1}^T) + \beta' X_{it} + \mu_t + \eta_i + \varepsilon_{it}$$

where y is the log of per capita output, y^T represents the trend component of per capita output, $(y_{it-1} - y^T_{it-1})$ is the output gap at the start of the period, X is a set variables postulated as growth determinants, μ_t is a period-specific effect, η_i represents unobserved country-specific factors, and ε is the regression residual. The subscripts i and t refer to country and time period, respectively (for simplicity, the length of the time period is normalized to 1). The expression on the left-hand side of the equation is the growth rate of per capita output in a given period. On the right-hand side, the regression equation includes the level of per capita output at the start of the period (to account for transitional convergence) and a set of explanatory variables measured during the same period. The inclusion of the output gap as an explanatory variable allows us to control for cyclical output movements and thus to

4. This section is based on Loayza, Fajnzylber, and Calderón (2002).
5. See, for example, Barro (1991, 1999); King and Levine (1993).

differentiate between transitional convergence and cyclical reversion. The time-specific effect, μ_t, allows us to control for international conditions that change over time and affect the growth performance of all countries in the sample. The term η_i accounts for unobserved country-specific factors that both drive growth and are potentially correlated with the explanatory variables.

3.2 Growth Determinants

A large variety of economic and social variables can be proposed as determinants of economic growth. We focus on the variables that have received the most attention in the academic literature and in policy circles. These variables can be divided into five groups: transitional convergence, cyclical reversion, structural policies and institutions, stabilization policies, and external conditions (see appendix A for details on definitions and sources).

Transitional convergence

One of the main implications of the neoclassical growth model, and indeed of all models that exhibit transitional dynamics, is that the growth rate depends on the initial position of the economy.[6] The "conditional convergence" hypothesis maintains that, ceteris paribus, poor countries should grow faster than rich ones because of decreasing returns to scale in production . We control for the initial position of the economy by including the *initial level of real per capita GDP* in the set of explanatory variables.

Cyclical reversion

Although our main objective is to account for long-run trends in economic growth, in practice, we work with relatively short time periods (five- or ten-year averages) for both econometric estimation and forecasts. At these frequencies, cyclical effects are bound to play a role. We include some explanatory variables that are not standard in the long-run growth literature but capture important elements of the business cycle. One of them deals with cyclical reversion to the long-run trend. Other cyclical factors are included under the category of stabilization

6. See Barro and Sala-i-Martin (1995) and Turnovsky (2002) for a review.

policies, which is introduced below. We account for cyclical reversion by including the output gap at the start of each period as a growth determinant. Apart from improving the regression fit, controlling for the initial output gap allows us to avoid overestimating the speed of transitional convergence, which is inferred from the coefficient on initial per capita output. The output gap used in the regression is obtained as the difference between potential and actual GDP around the start of the period. We use the Baxter-King filter to decompose GDP and estimate annual series of potential (trend) and cyclical output for each country in the sample.

Structural policies and institutions

The underlying theme of the endogenous growth literature is that the rate of economic growth can be affected by public policies and institutions. Although there may be disagreement on which policies are most conducive to growth or on the sequence in which policy changes must be undertaken, there is no doubt that governments can and do influence long-run growth in their countries. Theoretical work usually concentrates on one policy in particular or the combination of a few policies, whereas empirical work tends to be comprehensive in the sense of considering a wide array of policy and institutional determinants of growth.[7] Given our objective, we also take a comprehensive approach to explaining economic growth performance. Thus, we consider explanatory variables representing all major categories of public policies. This subsection focuses on structural policies and institutions; the next considers stabilization policies. We recognize that to some extent the separation between structural and stabilization policies is arbitrary. However, the division helps us examine the trends and roles of policies directed at growth in the long run from those related also to cyclical fluctuations.

The first area of structural policies is *education*, and human capital formation in general. Human capital can counteract the forces of diminishing returns in other accumulable factors of production—such as physical capital—to render long-run growth. Apart from its direct role as a factor of production, education and human capital can serve as a complement to other factors such as physical capital and natural resources, determine the rate of technological innovations in countries that produce

7. See Barro (1991); De Gregorio (1992); Easterly and Rebelo (1993); King and Levine(1993); Levine, Loayza, and Beck (2000).

technology, and facilitate technological absorption in countries that imitate it. We measure the policies directed toward increasing education and human capital with the rate of gross secondary school enrollment.[8]

The second policy area is related to *financial depth*. Well-functioning financial systems promote long-run growth. They influence economic efficiency and economic growth through different channels. Financial markets facilitate risk diversification by trading, pooling, and hedging financial instruments. They can help identify profitable investment projects and mobilize savings to them. Moreover, financial systems can help monitor firm managers and exert corporate controls, thereby reducing the principal-agent problems that lead to inefficient investment. Firm-level, industry-level, and cross-country studies provide ample evidence that financial development leads to higher growth.[9] Our measure of financial depth is the ratio of private domestic credit supplied by private financial institutions to GDP.

The third area of economic policy is *international trade openness*. The literature points out five channels through which trade affects economic growth.[10] First, trade leads to higher specialization and, thus to gains in total factor productivity (TFP), by allowing countries to exploit their areas of comparative advantage. Second, it expands potential markets, which allows domestic firms to take advantage of economies of scale, thus increasing their TFP. Third, trade diffuses both technological innovations and improved managerial practices through stronger interactions with foreign firms and markets. Fourth, freer trade tends to lessen anticompetitive practices of domestic firms. Finally, trade liberalization reduces the incentives for firms to conduct rent-seeking activities that are mostly unproductive. The bulk of the empirical evidence indicates that the relationship between economic growth and international openness is indeed positive, and that it reflects a virtuous cycle by which higher openness leads to growth improvement, which, in turn, generates larger trade. Our measure of openness is the volume of trade (real exports plus imports) over GDP, adjusted for the size (area and population) of the country, for whether it is landlocked, and for whether it is an oil exporter.[11]

8. This is the variable used as a proxy for human capital in Barro (1991), Mankiw, Romer, and Weil (1992), and Easterly (2001).

9. See Levine (1997) for a review of the theoretical foundations of the role of financial development and a summary of the available macro- and microeconomic empirical evidence.

10. See Lederman (1996).

11. See Pritchett (1996) for a similar adjustment.

The fourth area is related to the *government burden*; it focuses on the drain that government may represent for private activity. Although government can play a beneficial role for the economy (as discussed below), it can be a heavy burden if it imposes high taxes, uses this revenue to maintain ineffective public programs and a bloated bureaucracy, distorts markets incentives, and interferes negatively in the economy by assuming roles most appropriate for the private sector.[12] We account for the burden of government through a proxy, namely, the ratio of government consumption to GDP.

The fifth important area of policy involves the availability of *public services and infrastructure*. The importance of productive public services in generating long-run growth has been highlighted in the analytical work of Barro (1990) and Barro and Sala-i-Martin (1992), among others. These papers underscore the channels through which public services and infrastructure affect economic growth. Whether they are treated as classic public goods or as subject to congestion, public services and infrastructure can affect growth by entering directly as inputs of the production function, by serving to improve total factor productivity, and by encouraging private investment as they help protect property rights. In any case, their theoretical importance is well established, and recent empirical studies confirm this conclusion.[13] There are a few alternative measures of public services and infrastructure. Among these, the variables with the largest cross-country and time-series coverage focus on the provision of infrastructure. Because of data considerations, we work with telecommunications capacity, measured by the number of main telephone lines per capita.

The last area is related to *governance*. This large area comprises several aspects of the institutional quality of government, including the respect for civil and political rights, bureaucratic efficiency, absence of corruption, enforcement of contractual agreements, and prevalence of law and order. After the seminal work by Mauro (1995) and Knack and Keefer (1995), governance has received increasing attention as a determinant of economic growth.[14] In our regression analysis, we use the first principal component of four indicators reported by Political Risk Services in their publication *International Country Risk Guide* (ICRG). They are the indicators on the prevalence of law and order, quality of the bureaucracy, absence of corruption, and accountability of public officials.

12. See Corden (1991); Fischer (1993).

13. See Loayza (1996); Calderón, Easterly, and Servén (2001).

14. See, for instance, Barro (1996); Kaufman, Kraay, and Zoido-Lobatón (1999b); and the survey in Przeworski and Limongi (1993).

Stabilization policies

Including stabilization policies as determinants of economic growth is important because the regression's fit and forecasting power increases significantly over horizons that are relevant to economic policy (say, five to ten years). An even more important reason is that stabilization policies affect not only cyclical fluctuations, but also long-run growth. In fact an argument can be made that cyclical and trend growth are interrelated processes (see Fatás, in this volume), which implies that macroeconomic stabilization and crisis-related variables have an impact both over short horizons and on the long-run performance of the economy (see Fischer, 1993). Fiscal, monetary, and financial policies that contribute to a stable macroeconomic environment and avoid financial and balance-of-payments crises are thus important for long-run growth. By reducing uncertainty, they encourage firm investment, reduce societal disputes for the distribution of ex post rents (for instance between owners and employees in the face of unexpected high inflation), and allow economic agents to concentrate on productive activities (rather than trying to manage high risk).

The first area in this category is related to macroeconomic stabilization policies. This is a vast subject, and we consider two interrelated effects of fiscal and monetary policies. The first is the *lack of price stability*, which we measure by the average inflation rate for the corresponding country and time period. This is a good summary measure of the quality of fiscal and monetary policies, and it is positively correlated with other indicators of poor macroeconomic policies such as fiscal deficits and the black market premium on foreign exchange.[15] The second aspect is the *cyclical volatility of GDP*, which reflects the lack of output stability. It is measured by the standard deviation of the output gap for the corresponding country and period.

The second area is related to *external imbalances and the risk of balance-of-payments crises*. This factor is measured by an index of real exchange rate overvaluation, which is constructed following the methodology in Dollar (1992). Real exchange rate overvaluation captures the impact of monetary and exchange rate policies that distort the allocation of resources between the exporting and domestic sectors. This

15. The correlation coefficient between the inflation rate and the ratio of fiscal deficit to GDP and the black-market premium is, respectively, 0.24 and 0.26. The inflation rate is the indicator of macroeconomic stability in many cross-country growth studies, including Fischer (1993); Easterly, Loayza, and Montiel (1997); Barro (2001).

misallocation leads to large external imbalances, whose correction is frequently accompanied by balance-of-payments crises and followed by sharp recessions.

The third area concerns the occurrence of *systemic banking crises* and serves to account for the deleterious effect of financial turmoil on economic activity, particularly over short and medium horizons. Banking crises may be the product of an inadequate regulatory framework for financial transactions, which leads to overlending and unsustainable consumption booms. They can also result from monetary and fiscal policies that put undue burden on creditors and financial institutions. This is the case, for instance, of monetary policies that are overly contractionary or fiscal policies that tap scarce domestic financial resources excessively, only to default on debt repayment later on. The occurrence of banking crises is measured by the fraction of years that a country undergoes a systemic banking crisis in the corresponding period, as identified in Caprio and Klingebiel (1999).

External conditions

A country's economic activity and growth are shaped not only by internal factors, but also by external conditions. These have an influence on the domestic economy in both the short and long runs. There is ample evidence of transmission of cycles across countries via international trade, external financial flows, and investors' perceptions of the expected profitability of the global economy.[16] Changes in long-run trends can also be spread across countries. This is achieved through, for example, the demonstration effect of economic reforms and the diffusion of technological progress.[17]

We take external conditions into account by including two additional variables in the growth regression: the *terms-of-trade shocks* affecting each country individually and a *period-specific shift* affecting all countries in the sample. Terms-of-trade shocks capture changes in both the international demand for a country's exports and the cost of production and consumption inputs.[18] The period-specific shifts (or time dummy variables) summarize the prevalent global conditions at a given period of time and reflect worldwide recessions and booms,

16. See Boileau (1996).
17. See Keller (2002).
18. The terms-of-trade shocks variable is important in several empirical studies on growth, including Easterly and others (1993); Fischer (1993); Easterly, Loayza and Montiel (1997).

changes in the allocation and cost of international capital flows, and technological innovations.

3.3 Sample and Estimation Methodology

As mentioned above, we estimate a dynamic model of per capita GDP growth rates using cross-country, time-series panel data. Our sample is dictated by data availability; it contains seventy-eight countries representing all major world regions (see appendix B for a complete list). The regression analysis is conducted using averages of five-year periods. Each country has a minimum of three and a maximum of eight nonoverlapping five-year observations spanning the years 1960–1999 (evidently, the panel is unbalanced). A minimum of three observations per country is required to run the instrumental variable methodology outlined below. Since one observation must be reserved for instrumentation, the first period in the regression corresponds to the years 1966–1970. The total number of observations is 350.

Our main econometric methodology is the generalized method-of moments (GMM) estimator developed for dynamic models of panel data, which was introduced by Holtz-Eakin, Newey, and Rosen (1988), Arellano and Bond (1991), and Arellano and Bover (1995).[19] The growth regression to be estimated poses three challenges. First, the regression equation is dynamic in the sense that it represents a lagged-dependent-variable model. Second, the regression equation includes an unobserved country-specific effect, which cannot be accounted for by regular methods (such as the within estimator) given the dynamic nature of the model. Third, the set of explanatory variables includes some that are likely to be jointly endogenously determined with the growth rate. The GMM methodology that we use allows us to control for country-specific effects and joint endogeneity in a dynamic model of panel data. For comparison purposes, we also report the results obtained with a simple pooled ordinary least squares (OLS) estimator.

3.4 Estimation Results

Table 3 presents the results obtained by estimating the empirical model. The results obtained with the pooled OLS estimator are quite

19. This methodology has been applied to empirical growth models in, for instance, Caselli, Esquivel, and Lefort (1996); Levine, Loayza, and Beck (2000); Gallego and Loayza (in this volume).

Table 3. Determinants of Economic Growth: Panel Regression Analysis[a]

Explanatory variable	(1)	(2)
Transitional convergence		
Initial per capita GDP	–0.0139**	–0.0176**
(in logs)	(–3.49)	(–3.80)
Cyclical reversion		
Initial output gap	–0.2834**	–0.2371**
(log[actual GDP/potential GDP])	(–6.13)	(–8.52)
Structural policies and institutions		
Education	0.0085**	0.0172**
(secondary enrollment, in logs)	(2.52)	(6.70)
Financial depth	0.0031	0.0066**
(private domestic credit/GDP, in logs)	(1.57)	(4.28)
Trade openness	0.0083**	0.0096**
(structure-adjusted trade volume/GDP, in logs)	(2.67)	(3.14)
Government burden	–0.0125**	–0.0154**
(government consumption/GDP, in logs)	(–3.16)	(–3.18)
Public infrastructure	0.0073**	0.0071**
(main telephone lines per capita, in logs)	(3.08)	(2.71)
Governance	0.0012	–0.0012
(first principal component of ICRG indicators)	(1.02)	(–0.68)
Stabilization policies:		
Lack of price stability	–0.0085**	–0.0048*
(inflation rate, in log [100+inf. rate])	(–2.61)	(–1.89)
Cyclical volatility	–0.3069**	–0.2771**
(standard deviation of output gap)	(–3.58)	(–3.76)
Real exchange rate overvaluation	–0.0080**	–0.0061**
(in logs; overvaluation if greater than 100)	(–2.71)	(–3.90)
Systemic banking crises	–0.0171**	–0.0289**
(frequency of years under crisis: 0-1)	(–3.96)	(–7.42)
External conditions:		
Terms-of-trade shocks	0.0619**	0.0720**
(growth rate of terms of trade)	(2.34)	(4.98)
Period shifts[b]		
1971–1975	—	–0.0090**
1976–1980	0.0017	–0.0092**
1981–1985	–0.0147**	–0.0238**
1986–1990	–0.0110**	–0.0194**
1991–1995	–0.0158**	–0.0258**
1996–1999	–0.0168**	–0.0270**
Intercept	0.1418**	0.1216**
	(4.12)	(2.79)

Table 3. (continued)

Explanatory variable	*(1)*	*(2)*
Summary statistics		
No. countries	78	78
No. observations	350	350
Specification tests (*P* values)		
Sargan test		0.996
Serial-correlation test, first-order	0.000	0.000
Serial-correlation test, second-order	0.021	0.461

Source: Authors' calculations.
* Significant at the 10 percent level.
** Significant at the 5 percent level.
a. The dependent variable is the growth rate of per capita GDP. The estimation method in column 1 is pooled OLS, while column 4 uses a system GMM estimator. Observations correspond to nonoverlapping five-year periods spanning the years 1966–1999. *T* statistics are in parentheses.
b. The benchmark for column 1 is 1971–1975; the benchmark for column 2 is 1966–1970.

similar to those found with the GMM estimator. In what follows, we concentrate on the latter given its superior properties. The specification tests (namely, Sargan and serial-correlation tests) support the GMM system estimator of our model.

Transitional convergence. The coefficient on the initial level of per capita GDP is negative and statistically significant. It is consistent with conditional convergence—that is, holding constant other growth determinants, poorer countries grow faster than richer ones. Given the estimated coefficient, the implied speed of convergence is 1.84 percent per year, with a corresponding half-life of about thirty-eight years (this is the time it takes for half the income difference between two growing countries to disappear solely due to convergence).[20]

20. Linearizing the neoclassical growth model around the steady state, the annual speed of convergence is given by the formula $(-1/T)*\ln(1 + Ta)$, where T represents the length of each time period (that is, five in the main sample) and a is the estimated coefficient on initial per capita GDP. The half-life in years is given by ln*(2)/annual speed of convergence*. See Knight, Loayza, and Villanueva (1993). This estimate for the speed of convergence is almost identical to estimates reported in the early cross-country growth regressions (such as Barro, 1991). Previous panel regressions estimate faster speeds of convergence, claiming that this is due to their correction of the downward bias produced by unobserved country-specific effects (see Knight, Loayza, and Villanueva, 1993; Caselli, Esquivel, and Lefort, 1996). By working with shorter time periods, however, these panel studies introduced an upward bias owing to cyclical reversion to the trend; for instance, a post-recession recovery was confused with faster convergence. In this paper we control for both country-specific effects and cyclical factors, and we find that their corresponding biases on the speed of convergence nearly cancel each other.

Cyclical reversion. The estimated coefficient on the initial output gap is negative and significant. This indicates that the economies in the sample follow a trend-reverting process. In other words, if an economy is undergoing a recession at the start of the period, it is expected that its growth rate be higher than otherwise in the following years, so as to close the output gap. This result is symmetric, such that a cyclical boom is expected to be followed by lower growth rates. The cyclical reversion effect is sizable: according to the point estimate, if initial output is, say, 5 percent below potential output, the economy is expected to grow about 1.2 percentage points higher in the following years.

Structural policies and institutions. All variables related to structural policies present coefficients with expected signs and statistical significance. Economic growth increases with improvements in education, financial depth, trade openness, and public infrastructure. It decreases when governments apply an excessive burden on the private sector. These results are broadly consistent with a vast empirical literature on endogenous growth, including Barro (1991) on the role of education, trade, and government burden; Dollar (1992) on trade openness; Canning, Fay, and Perotti (1994) on public infrastructure; and Levine, Loayza, and Beck (2000) on financial depth.

Perhaps surprisingly, we find that governance does not have a statistically significant impact on economic growth, and the corresponding coefficient even presents a negative sign. This is so despite the fact that among the proposed explanatory variables, the governance index has the second largest positive correlation with the growth rate of per capita GDP.[21] Dollar and Kraay (2002b) obtain a similar result: various measures of governance become insignificant in their growth regressions when they control for trade openness. We interpret these results as saying that the effect of governance on economic growth most likely works through the actual economic policies that governments implement and maintain.

Stabilization policies. For the variables in these categories, all estimated coefficients carry the expected signs and statistical significance. Economic growth generally decreases when governments do not carry out policies conducive to macroeconomic stability, including the ab-

21. To check the robustness of this result, we replaced the ICRG index with each of its components in turn, namely, the indicators on bureaucratic efficiency, corruption, law and order, and accountability. We also replaced it with Gastil's index on civil rights. The estimated coefficients were never statistically significant, although the coefficient sign became positive for some governance proxies (law and order and bureaucratic efficiency).

sence of financial and external crises. Like Fischer (1993), we find that an increase in the inflation rate leads to a reduction in economic growth. The volatility of the cyclical component of GDP also has a negative impact on the growth rate of per capita GDP. This reveals an important connection between business cycle factors and economic growth, a subject seldom explored in the endogenous growth literature. Our results in this regard are consistent with the theoretical and empirical work by Fatás (in this volume).

The overvaluation of the real exchange rate is also negatively related to economic growth. This is explained by the misallocation of resources away from export-oriented sectors and the risk of balance-of-payments crises that real exchange rate overvaluation entails. Finally, the frequency of systemic banking crises has a negative effect on economic growth. This effect is particularly large, as it indicates that countries that experience a continuous banking crisis over, say, a five-year period suffer a slowdown in their annual growth rate of almost 3 percentage points.

External conditions. Negative terms-of-trade shocks have the effect of slowing down the economy's growth rate. This result is consistent with previous studies. Easterly and others (1993), for instance, find that good luck (in the form of favorable terms-of-trade shocks) is as important as good policies in explaining growth performance over medium-term horizons (such as decades).

Regarding the period shifts (or time dummies), we find that world growth conditions experienced a gradual change for the worse after the 1960s, with the biggest downward break occurring at the beginning of the 1980s. Broadly speaking, the deterioration of world growth conditions between the 1970s and 1980s leads to a decrease in a country's growth rate of about 1.5 percentage points. Considering only world growth conditions, our results indicate that any country in the sample is expected to grow almost 3 percentage points more slowly in the 1990s than in the 1960s. This is a considerable effect. After noting the world growth slowdown after 1980, Easterly (2001) concludes that worldwide factors are partly responsible for the stagnation of developing countries in the last two decades despite policy reforms.

4. The Contributions of This Volume

As mentioned, the article by Sala-i-Martin reviews the economic growth literature of the last fifteen years and thus provides the academic context for the volume. Most of the studies included therein apply to all countries, particularly in the developing world. Some studies, however, provide specific applications to Chile or use this country for illustration of general issues. For didactical purposes, we divide the studies included in the volume into five groups. The first addresses the characteristics and causes of economic growth from an international perspective. The second undertakes the analysis of the relationship between business cycles and long-run growth. The third group analyzes the role that specific public policies may play in promoting economic growth. The fourth considers the relevance of the financial sector for economic growth and development more generally. Finally, the fifth group of papers derives a number of lessons from the Chilean experience, which can be useful for understanding the path of other developing economies.

4.1 Causes and Characteristics of Economic Growth

William Easterly and Ross Levine's paper describes what the authors believe are the most salient characteristics of economic growth as it happens around the world. The first is that the differences in economic growth across countries are explained not by the rate of capital accumulation, but by the growth of productivity. The second is that the levels of per capita income in different countries do not tend to converge—that is, the gap between rich and poor countries has widened in the last decades.[22] While Easterly and Levine's finding of absolute divergence across countries is not optimistic, their conclusion that growth does not occur randomly, but responds to the quality of public policies is more encouraging. In this paper, the authors also seek to identify the theoretical models that best match the stylized facts. They favor the models that emphasize the growth in productivity, such as those of increasing returns, technological innovations, and externalities. Easterly and Levine recognize, however, that empirical studies have not yet advanced sufficiently to be able to discern among different concepts of productivity growth.[23] They pose this as a challenge for future theoretical and empirical work.

Rómulo Chumacero offers an alternative view on the issue of absolute convergence, and he questions the interpretation of the statistical

22. This finding of absolute divergence is not inconsistent with conditional convergence, which requires that the analyst control for policies and other growth determinants before assessing whether growth diminishes with the level of output.

23. Parente and Prescott (2000) provide an alternative mechanism through which policies can explain the observed differences in productivity levels and growth. Their evidence suggest that policies in low productivity economies usually inhibit technical progress in order to serve interest groups that extract rents from privileged positions.

evidence on the subject. His paper starts by reviewing the empirical tests that have been used to demonstrate or reject the finding of income convergence across countries. Chumacero then asks how effective these tests are in detecting convergence in data generated by models in which *by construction* there is convergence. He designs his experiment by formulating stochastic growth models (that is, with random productivity shocks), generating artificial data from them, and applying the usual convergence tests to these data. Revealingly, Chumacero finds that very often, statistical tests incorrectly reject convergence across countries, particularly when productivity shocks are persistent and somewhat volatile. Apart from its cautionary message regarding convergence, this result should alert researchers to the limitations of empirical tests designed from nonstochastic models and encourage the inclusion of stochastic elements in growth models. In this regard, Chumacero's contribution is an interesting empirical complement to the reservations expressed by Steven Durlauf (in this volume) with regard to the policy interpretations derived from cross-country regression results.

Robert Barro's study links economic growth to the general process of development. Using the cross-country framework for which he is renowned, Barro examines the economic, social, and political elements that accompany economic growth, whether as its causes or consequences. These aspects of human development determine the quality of people's lives and are, consequently, the ultimate objectives of public policy and private actions. Economic growth that promotes human development can thus be considered high quality growth. Barro's study attempts to measure the quality of economic growth by examining its relationship with socioeconomic variables (such as life expectancy, fertility, income inequality, and environmental degradation), political variables (such as democracy, rule of law, and corruption in the public administration), and cultural and social variables (such as criminality and religiosity). The importance of Barro's study is that it gives a human and social face to mere economic progress.

The paper by Steven Durlauf provides an interesting critique of the use of growth regressions to derive policy implications. The author challenges the conventional interpretation of empirical results, arguing that current econometric practice has yielded a body of evidence that is not policy relevant. Extending his own previous work, Durlauf raises two issues of critical importance for policy purposes.[24] First, policy recommendations arising from growth regressions are usually based on the

24. See, for example, Brock and Durlauf (2001).

statistical significance of some regression coefficients, which does not necessarily constitute a valid evaluation of alternative policy trajectories. Moreover, the statistical significance of a parameter does not provide information on the relative merit of the parameter for the objectives of policymakers. Second, growth regressions as conventionally constructed do not provide credible evidence of economic structure. Consequently, policymakers are unable to make better decisions based only on regression results. Durlauf proposes an alternative approach to the interpretation of growth regression based on Bayesian averaging techniques, which allow the weighting of different growth determinants relative to the payoff function of the policymaker and in the context of model uncertainty (because the modeler does not know what growth determinants must be included in a model or what forms of country-level heterogeneity need to be accounted for in the model).

4.2 Business Cycles and Long-Run Growth

As explained in our brief review of growth determinants (section 3), the processes of business cycles and trend growth are not independent. The connection between the two processes opens up a number of interesting questions for academic and policy analyses. Two studies in this volume address some of these questions.

The paper by Antonio Fatás presents evidence from cross-country empirical analysis that reveals an interesting and significant connection between cycles and growth. Fatás examines two main aspects of this relationship. The first consists of a strong positive correlation between the persistence of short-term fluctuations and long-run growth, which implies that business cycles cannot be regarded as temporary deviations from a trend. One way to understand this correlation is that business cycles affect long-run growth, and it is this explanation that Fatás presents in a stochastic endogenous growth model. The second aspect is the connection between business cycle volatility and growth. The author presents robust empirical evidence that countries that suffer from more volatile cycle fluctuations exhibit lower rates of economic growth. Consistent with the evidence in Carkovic and Levine's and Caballero's work (discussed below), Fatás finds that the negative effect of business cycle volatility on growth is much larger for poor countries or countries with weak financial development. Fatás also provides preliminary evidence on the growth effect of different sources of volatility related to monetary and fiscal policies, thus augmenting the paper's practical value for policymakers.

While the linkages between cyclical fluctuations and long-run growth pose a theoretical puzzle to scholars, they pose a much more pressing challenge to policymakers, namely, to determine whether observed high or low growth rates in GDP correspond to turning points in the business cycle or long-term changes in the growth path of an economy. Andrew Harvey's article explores this issue and proposes a novel methodology for separating out trends and cycles, which overcomes the well-known limitations of standard filters such as those of Hodrick and Prescott (1997) and Baxter and King (1999). Harvey's method combines unobserved components with an error correction mechanism and allows the decomposition of a series into trend, cycle, and convergence components. This provides insight into what happened in the past, enables the current state of an economy to be more accurately assessed, and gives a procedure for the prediction of future observations. The methods are applied to data on the United States, Japan, and Chile.

4.3 Public Policies That Promote or Inhibit Growth

The problem of disentangling economic growth from cyclical fluctuations is at the root of several dilemmas that authorities face when choosing among different sets of policies. On the one hand, whenever growth weakens and a country faces external shocks, it is common to hear voices calling for a revision of the policies in place and recommending new mechanisms to help the country cope with the hardships of recessionary periods. A typical suggestion is that of enacting so-called industrial policies that favor specific sectors. On the other hand, whenever growth resumes and a country enjoys a bonanza, the reforms that should be implemented to guarantee future growth are easily postponed or dismissed, under the wrong impression that the country has already achieved its optimal economic structure. Industrial policies and the need for second-generation (governance-related) reforms are the respective subjects of the papers by Marcus Noland and Howard Pack and by Harald Beyer and Rodrigo Vergara.

When countries undergo a stage of stagnation, government authorities are increasingly pressured to embark on policies that promote specific industries and economic sectors. The experience of East Asian countries is often cited as an example of the success of industrial policies. Marcus Noland and Howard Pack exhaustively review the experience of industrial policies in three successful East Asian economies: Japan, South Korea, and Taiwan. The authors focus on two questions. First, were industrial policies indeed the engine of growth in these countries? Second, are their current economic stagnation problems a legacy of the same industrial policies? Noland and Pack provide original and systematic evidence that, notwithstanding industrial policies' positive effects on industrial development and international trade in certain sectors, they had at best a minor contribution to the overall growth of East Asia. Moreover, the implementation of industrial policies distorted the economic incentives faced by the corporate sector. Industrial policies encouraged firms to take undue risks and allocate their resources inefficiently, given the policies' implicit guarantees and explicit relative-price distortions. Industrial policies also pushed firms to devote an important share of their human and financial resources to rent-seeking activities. It is not surprising, then, to see the grave cases of corruption of public officials that occurred particularly in Japan and Korea. Noland and Pack end their paper by admonishing governments to refrain from picking winners, an activity for which they are ill-prepared, and to focus on growth-enhancing measures that do not differentiate among sectors, such as improving primary and secondary schooling, building a large and efficient social infrastructure, and promoting international technology transfer.

Industrial policies are only one component of the incentive scheme faced by entrepreneurs when making investment and production decisions. Surely a larger component for the majority of firms comprises the facilities and restrictions inherent in public laws and institutions. Harald Beyer and Rodrigo Vergara's paper studies how economic growth and, specifically, factor productivity are affected by the structure of incentives in the areas of property rights, market regulation, legal and economic institutions, and political stability. The authors conduct their examination on two levels. First, they use cross-country data to evaluate the effects of broadly defined governance-related rules and institutions. Second, they discuss specific incentives, regulations, and restrictions that affect firm investment and productivity growth, using Chile as an example. Beyer and Vergara's objective for the latter part is to identify specific issues and policies that can be improved in Chile at the macro- and microeconomic levels. Even in a country as advanced as Chile in terms of market-oriented reforms, Beyer and Vergara conclude that further reduction in bureaucracy's red tape, removal of certain excessive regulations, and improved opportunities to compete in external markets can contribute to larger growth in the country.

4.4 The Role of the Financial Sector

The financial system has two major roles in the economy. The first is to promote sustained growth by channeling savings to profitable investment opportunities and monitoring firms to ensure the proper use of such financial resources. The second is to protect consumers and investors from the risks inherent in economic activity. The two papers on the financial sector included in this volume deal, respectively, with each of the major roles of the financial system.

Ross Levine and Maria Carkovic's paper presents confirmatory evidence on the growth-promoting impact of private banking and stock market development. With the clear objective of identifying proper financial policies, the paper also examines the commercial bank regulations and supervisory practices that lead to banking sector development. The authors thus use cross-country regression analysis to find that the depth and activity of banking and stock market operations have a large and significant effect on the growth rate of per capita output. They also expand on previous work by Barth, Caprio, and Levine (2001) to show that bank regulatory and supervisory policies that support private sector monitoring of banks, impose few restrictions on bank entry and activities, and curb the generosity of their deposit insurance schemes achieve stronger banking development than do other policy regimes. Taking Chile as an illustrative example, Levine and Carkovic note that this country is an outlier in the regression analysis on the connection between financial development and economic growth—Chile has less liquid stock markets and lower levels of banking development than other fast growing countries. This implies, first, that there must be some impediments to the development of the financial sector in Chile despite its relatively high level of income and growth and, second, that the removal of such impediments should confer potentially large gains. The analysis of regulatory and supervisory practices that lead to banking development serves as the basis for identifying potential problems in Chile in this regard. The authors conclude that at least part of the problem resides in the fact that Chile has comparatively few regulations to encourage private sector monitoring, while at the same time it imposes tight restrictions on bank entry and activities and provides an overly generous deposit insurance.

Ricardo Caballero's paper addresses the importance of financial development from a different perspective. Caballero's main concern is reducing a country's vulnerability to external shocks. Although the paper focuses on Chile, it can readily be applied to small developing countries that face imperfect financial markets. The large domestic macroeconomic imbalances that characterized the 1980s are no longer a problem in most countries, yet the external sector remains a source of instability. As Caballero argues in the case of Chile, the business cycle in most small countries is driven by external shocks, such as a decline in the terms of trade. In practice, these shocks have an effect many times larger than predicted in the presence of perfect financial markets. The financial system's inability to limit the effects of external shocks has large consequences over employment, income, and productivity growth not only during the crisis itself, but also over the long run. Caballero argues that the excess sensitivity to external shocks is primarily a financial problem, in that, first, access to international financial markets contracts sharply precisely when the country needs it the most and, second, this access is distributed inefficiently among competing domestic borrowers. Caballero's diagnosis of the problem leads him to recommend a structural solution based on two pillars. The first is the formation of institutions that are conducive to the development of the domestic financial system and its integration with international markets. This is a long-run solution that may take many years to implement, such that it requires a complementary solution to be applied right away. The second pillar, to which Caballero devotes the most effort in the paper, is the design of an appropriate international liquidity management strategy—specifically, to encourage the private sector's development of financial instruments that are contingent on the country's main external shocks. The Central Bank could aide in the process by issuing a benchmark instrument contingent on these shocks. In addition, the Central Bank could design a countercyclical monetary policy with the main goal of persuading banks and investors to hold larger and more liquid foreign asset positions in anticipation of crises.

4.5 Lessons from an Emerging Economy

As mentioned above, in the past twenty-five years, Chile has successfully implemented substantial reforms to its economy. Nevertheless, growth faltered in recent years, raising a number of questions that are addressed in the last set of papers. These questions relate to three aspects that are of obvious interest to every emerging economy. First, what is the engine of growth, and will it ran out of fuel in the near future? Second, when facing adverse shocks, can monetary and fiscal policies ameliorate the effects without jeopardizing the sustainability of growth? And third, is it possible and useful to base policies on the notion of potential long-run output growth?

As argued in the introduction, the welfare impact of economic growth can be profound. Even small changes in growth rates can have substantial welfare effects if they last over sustained periods of time. An interesting example of these effects is Chile. Between 1960 and 1980, GDP grew at a moderate average rate of 3 percent per year. Nevertheless, per capita consumption levels—and, to a large extent, welfare—remained basically constant. The Chilean economy responded vigorously to the promarket reforms of the late 1970s. Between 1980 and 2001, GDP grew at around 5.5 percent a year, while per capita consumption levels nearly doubled and poverty levels halved. Since a number of countries have applied or are implementing reforms similar to the Chilean initiatives, it is natural to ask why these reforms were so successful. The paper by Francisco Gallego and Norman Loayza provides a simple, but powerful message: the most important factor behind Chile's success is that market-oriented reforms were implemented strongly and jointly.

Gallego and Loayza's paper applies the concepts and methodologies of cross-country empirical analysis to an examination of the process of economic growth in Chile. First, using a variety of methods ranging from Solow growth decompositions to vector regression analysis, the paper describes the main stylized facts of growth in Chile over the last three decades. The authors highlight, in particular, the change that occurred after 1985: growth in Chile jumped to a higher level, became less volatile and more balanced across sectors, and featured a greater role for productivity improvements. Second, Gallego and Loayza use international evidence from regression analysis to explain what they call the golden age of growth in Chile. Their model is able to explain about 70 percent of the change in the growth rate from the period before 1985 to the period after 1985. According to the authors, the expansion of growth in the golden age stems from improvements in human capital, financial depth, government efficiency, public infrastructure, and, most importantly, the joint implementation of public policies. For the future, the paper identifies the importance of improving the quality of education, expanding the provision of public infrastructure, and eliminating excessive regulatory restrictions as the engines for renewed and sustained economic growth.

Vittorio Corbo and José Tessada's study provides a thorough revision of the post-1998 slowdown in economic growth in Chile. This was a rather turbulent period in economic history, and as such, it provides ample space for speculation on the causes of the slowdown and its likely solutions. The authors use an econometric model to test three competing hypotheses and derive general implications from the analysis. The first hypothesis puts the blame on bad luck resulting from external shocks: namely, terms-of-trade losses and a slowdown in capital inflows following the Asian crisis. A second hypothesis blames the slowdown on policies implemented as a response to the deteriorating external conditions, in particular the inability to achieve a balanced mix of monetary and fiscal policy during the 1997–1998 period. Fiscal imbalances and restrictive monetary policy, it is argued, led to very high capital costs, thus reducing profitability and the incentives to invest. Finally, a third explanation is that the slowdown resulted from the completion of a high growth cycle associated with the structural reforms introduced in the 1985–1995 period. After a careful evaluation of the econometric results, Corbo and Tessada conclude that the slowdown in the Chilean economy was a mix of severe external shocks and lack of cooperation between fiscal and monetary policies.

Gabriela Contreras and Pablo García examine different methodologies for the estimation of potential output levels and, consequently, long-run growth rates. Beyond the technical aspects of these methodologies—which are thoughtfully discussed by the authors—the motivation for the paper lies with the importance of long-run growth estimates for monetary and fiscal policies. This is of particular relevance in an emerging economy (such as Chile) where the Central Bank pursues an inflation target and the fiscal sector usually has to accommodate activity shocks. Under inflation targeting, the forecast path of aggregate demand largely determines monetary policy; errors in estimating the output gap or trend growth can misguide monetary policy and jeopardize the achievement of the inflation target. Information on the duration and nature of the shock is also vital for fiscal policy. For instance, real shocks usually have significant effects on tax revenues and, consequently, on fiscal deficits, and they should be accommodated or not depending on whether they are transitory. Moreover, in countries that have adopted stabilization mechanisms (such as commodity funds) to smooth out cyclical fluctuations, their efficacy largely depends on the ability to determine the magnitude and frequency of transitory shocks, that is, to separate trends from cycles. Contreras and García's study provides key elements for correctly characterizing the shocks hitting the economy and their effects on cyclical fluctuations and potential output, which is essential for conducting proper stabilization and growth-promoting policies.

5. Concluding Remarks

Economic growth is, and most likely will continue to be, one of the most dynamic fields in economic analysis. The question of why most economies in the world are not decisively moving toward a state of development challenges both scholars and policymakers. Economic theory has progressed enormously in the last fifteen years in explaining the mechanics of growth. Its empirical counterpart has provided substantial evidence on the relative importance of the different determinants of growth across countries and on the role of policies in promoting sustained progress. Nevertheless, our knowledge on important aspects of the problem is still rather limited, and creative research is badly needed in these areas.

This volume contributes to the field on two dimensions. First, it extends the frontiers of our understanding about the determinants of sustained growth, going beyond the realms of macroeconomic policies—such as stabilization and basic structural reforms—and into areas dealing with microeconomic and regulatory policies, technological adoption, market formation, and governance institutions. Second, most of the papers in the volume focus on the intricate relationship between long-run growth and cyclical fluctuations, and some provide analytical models or statistical techniques that allow for a rigorous analysis of how and when short-term fluctuations affect long-run growth trends. In this volume, the recent experiences of several developed and developing countries—in particular, Chile—are dissected and studied to provide further insights on and quantification of the determinants of long-run growth and its relationship with business-cycle fluctuations.

Appendix A

Definitions and Sources of Variables Used in Regression Analysis

Variable	*Definition and construction*	*Source*
Output		
Real per capita GDP (in 1985 US$ PPP)	Ratio of total GDP to total population. GDP is in 1985 PPP-adjusted US$. Growth rates are obtained from constant 1995 US$ per capita GDP series.	Authors' construction, based on Summers and Heston (1991) and World Bank (2002).
Cyclical reversion		
Initial output gap	Difference between the log of actual GDP and (the log of) potential (trend) GDP around the start of the period. The Baxter-King filter is used to decompose the log of GDP.	Authors' calculations.
Structural policies and institutions		
Gross secondary-school enrollment	Ratio of total secondary enrollment, regardless of age, to the population of the age group that officially corresponds to that level of education.	World Bank (2002).
Domestic credit to the private sector (% of GDP)	Ratio to GDP of the stock of claims on the private sector by deposit money banks and other financial institutions.	Beck, Demirgüç-Kunt, and Levine (2000).
Openness (% of GDP)	Residual of a regression of the log of the ratio of exports and imports (in 1995 US$) to GDP (in 1995 US$), on the logs of area and population, as well as dummies for oil-exporting and landlocked countries.	Authors' calculations, based on data from World Bank (2002).
Government consumption (% GDP)	Ratio of government consumption to GDP	World Bank (2002).
Main telephone lines per 1,000 workers	Telephone mainlines are telephone lines connecting a customer's equipment to the public switched telephone network. Data are presented per 1,000 population for the entire country.	Canning (1998); International Telecommunications Union.
Governance (index)	First principal component of four indicators: prevalence of law and order, quality of bureaucracy, absence of corruption, and accountability of public officials.	*International Country Risk Guide* (ICRG)

APPENDIX A (continued)

Variable	Definition and construction	Source
Stabilization policies		
Inflation	Measured by the consumer price index: annual percentage change in the cost to the average consumer of acquiring a fixed basket of goods and services.	World Bank (2002).
Cyclical volatility of GDP	Standard deviation of the output gap for the period.	Authors' calculations.
Real exchange rate overvaluation	Real effective exchange rate, with the level adjusted such that the average for 1976–1985 equals Dollar's (1992) index of overvaluation (based on the ratio of actual to income-adjusted Summers-Heston purchasing power parity comparisons).	Easterly (2001).
Systemic banking crises	Number of years in which a country underwent a systemic banking crisis, as a fraction of the number of years in the corresponding period.	Authors' calculations, based on data from Caprio and Klingebiel (1999) and Kaminsky and Reinhart (1999).
External conditions		
Terms-of-trade shocks	Log difference of the terms of trade. Terms of trade are defined as customary.	World Bank (2000).
Period-specific shift	Time dummy variable.	Authors' construction.

Appendix B
Sample of Countries

The database is constructed of observations from a five-year panel sample for the period 1961-1999. The sample includes seventy-nine countries, but not all countries have observations for all of the subperiods. The table below shows the available observations per country and time period. The first two observations per country are reserved for differencing and serve as instruments. The regression sample thus comprises 350 observations in levels and an equal number in first differences.

	Period							
Country	*1961–1965*	*1966–1970*	*1971–1975*	*1976–1980*	*1981–1985*	*1986–1990*	*1991–1995*	*1996–1999*
Algeria			x	x	x	x	x	
Argentina	x	x	x	x		x	x	x
Australia	x	x	x	x	x	x	x	
Austria	x	x	x	x	x	x	x	x
Bangladesh						x	x	x
Belgium	x	x	x	x	x	x	x	x
Bolivia				x	x	x	x	x
Botswana					x	x	x	x
Brazil					x	x	x	x
Burkina Faso					x	x	x	x
Canada			x	x	x	x	x	x
Chile	x	x	x	x	x	x	x	x
Colombia	x	x	x	x	x	x	x	x
Congo, Democratic Rep. of the (Zaire)		x	x	x	x	x	x	

Appendix B (continued)

Country	*Period*							
	1961–1965	*1966–1970*	*1971–1975*	*1976–1980*	*1981–1985*	*1986–1990*	*1991–1995*	*1996–1999*
Congo, Republic of the	x	x	x	x	x	x	x	x
Costa Rica		x	x	x	x	x	x	x
Côte d'Ivoire	x	x	x	x	x	x	x	x
Denmark	x	x	x	x	x	x	x	x
Dominican Republic				x	x	x	x	x
Ecuador	x	x	x	x	x	x	x	x
Egypt, Arab Republic of		x	x	x	x	x	x	x
El Salvador	x	x	x	x	x	x	x	x
Finland	x	x	x	x	x	x	x	x
France	x	x	x	x	x	x	x	x
Gambia				x	x	x	x	
Ghana	x	x	x	x	x	x	x	x
Greece	x	x	x	x	x	x	x	x
Haiti					x	x	x	x
Honduras			x	x	x	x	x	x
Iceland	x	x	x	x	x	x	x	
India		x	x	x	x	x	x	x
Indonesia		x	x	x	x	x	x	x
Iran, Islamic Republic of				x	x	x	x	x
Ireland	x	x	x	x	x	x	x	x
Israel	x	x	x	x	x	x	x	x

Appendix B (continued)

Country	Period							
	1961–1965	*1966–1970*	*1971–1975*	*1976–1980*	*1981–1985*	*1986–1990*	*1991–1995*	*1996–1999*
Italy	x	x	x	x	x	x	x	x
Jamaica	x	x	x	x	x	x	x	x
Japan	x	x	x	x	x	x	x	x
Jordan					x	x	x	x
Kenya	x	x	x	x	x	x	x	x
Korea, Republic of			x	x	x	x	x	x
Madagascar	x	x	x	x	x	x	x	x
Malawi					x	x	x	x
Malaysia	x	x	x	x	x	x	x	x
Mexico	x	x	x	x	x	x	x	x
Morocco	x	x	x	x	x	x	x	x
Netherlands	x	x	x	x	x	x	x	x
Nicaragua				x	x	x	x	x
Niger		x	x	x	x	x	x	x
Nigeria					x	x	x	x
Norway	x	x	x	x	x	x	x	x
Pakistan	x	x	x	x	x	x	x	x
Panama				x	x	x	x	x
Papua New Guinea			x	x	x	x	x	
Paraguay	x	x	x	x	x	x	x	x
Peru	x	x	x	x	x	x	x	x

Appendix B (continued)

Country	Period							
	1961–1965	*1966–1970*	*1971–1975*	*1976–1980*	*1981–1985*	*1986–1990*	*1991–1995*	*1996–1999*
Philippines	x	x	x	x	x	x	x	x
Portugal	x	x	x	x	x	x	x	
Senegal		x	x	x	x	x	x	x
Sierra Leone				x	x	x	x	
South Africa	x	x	x			x	x	x
Spain	x	x	x	x	x	x	x	x
Sri Lanka	x	x	x	x	x	x	x	x
Sweden	x	x	x	x	x	x	x	x
Switzerland	x	x	x	x	x	x	x	
Syrian Arab Republic		x	x	x	x	x	x	x
Thailand		x	x	x	x	x	x	x
Togo				x	x	x	x	x
Trinidad and Tobago	x	x	x	x	x	x	x	x
Tunisia						x	x	x
Turkey						x	x	x
Uganda						x	x	x
United Kingdom	x	x	x	x	x	x	x	x
United States	x	x	x	x	x	x	x	
Uruguay	x	x	x	x	x	x	x	x
Venezuela			x	x	x	x	x	x
Zambia						x	x	x
Zimbabwe				x	x	x	x	x

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Fifteen Years of New Growth Economics: What Have We Learned?

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Paul Romer's paper, "Increasing Returns and Long-Run Growth," is now fifteen years old. This pathbreaking contribution led to a resurgence in research on economic growth. The resulting literature has had a number of important impacts. In particular, it shifted the research focus of macroeconomists. From the time when Lucas, Barro, Prescott, and Sargent led the rational expectations revolution until Romer, Barro, and Lucas started the new literature on economic growth, macroeconomists devoted virtually no effort to the study of long-run issues; they were all doing research on business cycle theory. In this sense, the new growth theory represented a step in the right direction.

The new growth literature has had a similar impact on macroeconomics classes and textbooks. Until 1986, most macroeconomics classes and textbooks either relegated economic growth to a marginal role or neglected it altogether. Things are very different now. Modern undergraduate textbooks devote more than a third of their space to economic growth, and both graduate and undergraduate macroeconomics classes devote a substantial amount of time to this important subject. The impact of these two changes on the training of young economists is very important, and this should be viewed as another contribution of the new economic growth literature.

The contributions I wish to highlight in this conference, however, are the substantial ones: I want to discuss the most significant ways in which the new economic growth literature has expanded our understanding of economics.

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1. The Empirical Touch

One of the key differences between the current and the old literature is that this time around, growth economists address empirical issues much more seriously. This has led to the creation of a number of extremely useful data sets. The Summers and Heston data set tops the list. Summers and Heston (1988, 1991) construct national accounts data for a large cross-section of countries for a substantial period of time (for some countries the data start in 1950; for most countries they start in 1960). In principle, the data are adjusted for differences in purchasing power across countries, which allows for strict comparability of levels of gross domestic product (GDP) at a given point in time. Even though some researchers have complained about the quality of this data set, overall it represents one of the main contributions of this literature because it allows researchers to confront their theories with actual data. This was not true the last time growth economics was a popular area of research in the 1960s (perhaps because they did not have access to the data that we have today).

The Summers-Heston data set is not the only data set that has been created recently. Barro and Lee (1993), for example, also construct a large number of variables, mainly related to education and human capital. This is especially important because the first generation of endogenous growth theories emphasize the role of human capital as the main (or at least one of the main) engines of growth. Other recently constructed data sets include social and political variables that are especially useful for one of the newest lines of research, which emphasizes institutions (see, for example, Knack and Keefer, 1995; Deininger and Squire, 1996).

1.1 Better Relation between Theory and Empirics

A second important innovation of the new growth literature is that it has brought empirical studies closer to the predictions of economic theory. The neoclassical literature of the 1960s links theory and evidence by simply mentioning a number of stylized facts (such as the Kaldor "facts") and showing that the theory being proposed is consistent with one, two, or perhaps several of these so-called facts.[1]

1. Some of these facts, including the Kaldor facts, did not really come from careful empirical analysis, but they were quoted and used as if they were widely proved empirical facts.

Today's research, on the other hand, tends to derive more precise econometric specifications, and these relationships are taken to the data. The best example can be found in the convergence literature. Barro and Sala-i-Martin (1992) use the Ramsey-Cass-Koopmans growth model (Ramsey, 1928; Cass, 1975; Koopmans, 1965) to derive an econometric equation that relates the growth of Per capita GDP to the initial level of GDP. Mankiw, Romer, and Weil (1992) derive a similar equation from the Solow-Swan model (Solow, 1956; Swan, 1956). These researchers derive a relationship of the form

$$\gamma_{i,t,t+T} = \beta_0 - \beta \ln y_{it} + \beta \ln y_i^* + \varepsilon_{it}\ , \tag{1}$$

where $\gamma_{i,t,t+T}$ is the growth rate of per capita GDP for country i between time t and time $t + T$, y_{it} is per capita GDP for country i at time t, and y_i* is the steady-state value of per capita GDP for country i. The term ε_{it} is an error term. The coefficient is positive if the production function is neoclassical, and it is zero if the production function is linear in capital (which is usually the case in the first generation one-sector models of endogenous growth, also known as AK models).[2] In particular, if the production function is Cobb-Douglas with a capital share given by α then, the parameter β (also known as the speed of convergence) is given by $\beta = (1 - \alpha)(\delta + n)$, where d is the depreciation rate and n is the exogenous rate of population growth.[3] (Notice that when $\alpha = 1$, which corresponds to the AK model, the speed of convergence is $\beta = 0$.)

My main point is that the modern literature took equation 1 as a serious prediction of the theory and used it to test the new models of endogenous growth (the AK models, which predict $\beta = 0$) against the old neoclassical models (which predict $\beta > 0$.) Initially, some researchers mistakenly took equation 1 to suggest that neoclassical theory predicted absolute convergence. In other words, if $\beta > 0$ (that is, if the world is best described by the neoclassical model), then poor countries should be growing faster than others. People therefore started running regressions of the type

$$\gamma_{i,t,t+T} = \hat{b}_0 - \hat{b} \ln y_{it} + \omega_{it}, \tag{2}$$

2. Paul Romer's seminal paper (Romer, 1986) is an example of an AK model. See also Rebelo (1991); Jones and Manuelli (1990); Barro (1990).

3. The derivation of this equation assumes constant savings rates à la Solow-Swan.

and tested whether the coefficient $\hat{b}$ was positive. Notice that if $\hat{b} > 0$, then poor countries grow faster than rich ones, such that there is convergence across countries. On the other hand, if $\hat{b} = 0$, then the growth rate and the level of income are not related, and the neoclassical model was rejected in favor of the AK model of endogenous growth. The main empirical results found were that the estimated $\hat{b}$ was not significantly different from zero. This was thought to be good news for the new theories of endogenous growth and bad news for the neoclassical model.

Researchers quickly realized, however, that this conclusion is erroneous. Regressions of the form of equation 2 implicitly assume that all countries approach the same steady state, or at least that the steady-state is not correlated with the level of income. If $y_i^* = y^*$ in equation 1, then this term gets absorbed by the constant $\hat{b}_0$ in equation 2 and disappears from the regression. The problem is that if researchers assume that countries converge to the same steady state when, in fact, they don't, then equation 2 is misspecified and the error term becomes $\omega_{it} = \varepsilon_{it} + \ln y_i^*$. If the steady state is correlated with the initial level of income, then the error term is correlated with the explanatory variable, which biases the estimated coefficient toward zero. In other words, the early finding that there is no positive association between growth and the initial level of income could be a statistical artifact resulting from the misspecification of equation 2.

Researchers proposed various solutions to this problem, such as considering data in which the initial level of income is not correlated with the steady-state level of income. Many researchers therefore started using regional data sets (like states within the United States, prefectures within Japan, or regions within European, Latin American, and other Asian countries).[4]

Another solution is to use cross-country data but—instead of estimating the univariate regression as in equation 2—to estimate a multivariate regression in which, on top of the initial level of income, the researcher also holds constant proxies for the steady state. This came to be known as conditional convergence. Further research shows that the conditional convergence hypothesis is one of the strongest and most robust empirical regularities found in the data. Hence, by taking the theory seriously, researchers arrived at the exact opposite empirical conclusion: the neoclassical model is not rejected by the data, whereas the AK model is.

4. See Barro and Sala-i-Martin (1992; 1998, chaps. 10–12).

My reason for highlighting these results is not to emphasize the concepts of convergence or conditional convergence. Rather, my point is that the new growth economists took the theory seriously when they took it to the data. This was a substantial improvement over the previous round of economic growth research.

1.2 Models That Are Consistent with Convergence

The results from the convergence literature are interesting for a variety of reasons. Most importantly, the literature finds that conditional convergence is a strong empirical regularity, indicating that the data are consistent with the neoclassical theory based on diminishing returns. This was the initial and most widespread interpretation. These empirical results also mean that the simple closed-economy, one-sector model of endogenous growth (the AK model) is easily rejected by the data. However, more sophisticated models of endogenous growth that display transitional dynamics are also consistent with the convergence evidence.[5] For example, the two-sector models of endogenous growth proposed by Uzawa (1965) and Lucas (1988) were later shown to be consistent with this evidence. AK models of technological diffusion (where the A flows slowly from rich countries to poor countries) also tend to make similar predictions.

1.3 Other Findings from the Convergence Literature

The first reason for studying convergence is to test theories. A second reason is to discover whether the world is such that the standard of living of the poor tends to improve more rapidly than that of the rich or whether the rich get richer while the poor become poorer. In dealing with these questions, perhaps the concept of conditional convergence is not as interesting as the concept of absolute convergence. Another relevant concept is that of σ-convergence, which looks at the level of inequality across countries (measured, for example, as the variance of the log of per capita GDP) and checks whether this level increases over time. The key result here is that inequality across countries tends to increase over time.[6]

5. See Barro and Sala-i-Martin (1998, chaps. 6 and 8).

6. This led Lance Pritchett to write a paper entitled “Divergence Big Time.” The title is self-explanatory.

This analysis has recently come under criticism from two fronts. The first is the so-called Twin Peaks literature led by Danny Quah (1996, 1997). These researchers are interested in the evolution of the world distribution of income, and the variance is only one aspect of this distribution. Quah notices that in 1960, the world distribution of income was unimodal, whereas it became bimodal in the 1990s,. He then uses Markov transitional matrices to estimate the probabilities that countries improve their position in the world distribution and to forecast the evolution of this distribution over time. He concludes that in the long run, the distribution will remain bimodal, although the lower mode will include a lot fewer countries than the upper mode.

Although Quah's papers triggered a large body of research, his conclusion does not appear to be very robust. Jones (1997) and Kremer, Onatski, and Stock (2001) show that a lot of these results depend crucially on whether the data set includes oil-producing countries. For example, the exclusion of Trinidad and Tobago or Venezuela from the sample changes the prediction of a bimodal steady-state distribution to a unimodal distribution: because these two countries were once relatively rich but have now become poor, excluding them from the sample substantially lowers the probability that a country will move down in the distribution.

The second line of criticism comes from researchers who claim that the unit of analysis should not be a country. Countries are useful units for testing theories because many of the policies or institutions considered by the theories are countrywide. But if the question is whether poor people's standard of living improves more rapidly than rich people's, then the correct unit may be a person rather than a country. In this sense, the evolution of per capita income in China is more important than the evolution of per capita income in Lesotho, because China has a lot more people. In fact, China has almost twice as many citizens as all African countries combined, even though Africa has around 35 independent states. A better measure of the evolution of personal inequality, therefore, is the population-weighted variance of the log of per capita income (as opposed to the simple variance of the log of per capita income, which gives the same weight to all countries, regardless of population). The striking result is that the weighted variance does not increase monotonically over time. As shown by Schultz (1998) and Dowrick and Akmal (2001), the weighted variance increases for most of the 1960s and 1970s, but it peaks in 1978. After that, the weighted variance declines, rooted in the fact that China, with 20 percent of the world's population, has experienced large increases in per capita income. This effect was reinforced in the 1990s when India (with another billion inhabitants) started its process of rapid growth.

Population-weighted variance analysis assumes that each person within a country has the same level of income, while some countries have more people than others.[7] This obviously ignores the fact that inequality within countries may increase over time. In particular, it has been claimed that inequality within China and India increased tremendously after 1980, which may more than offset the process of convergence of the per capita income of these two countries to that of the United States.

1.4 Cross-Country Growth Regressions

Another important line of research in the empirical literature follows Barro (1991) in using cross-country regressions to find the empirical determinants of the growth rate of an economy:[8]

$$\gamma_{i,t,t+T} = \beta\, \mathbf{X}_{it} + \omega_{it}\,, \tag{3}$$

where $\mathbf{X}_{it}$ is a vector of variables thought to reflect determinants of long-term growth. In the context of the theory that predicts equation 1, if one of the variables in the vector $\mathbf{X}$ reflects the initial level of income, then the rest of the variables can be thought of as proxies for the steady-state, $\ln y_i^*$.

The cross-country regression literature is enormous. A large number of papers claim to have found one or more variables that are partially correlated with the growth rate: from human capital to investment in research and development (R&D), to policy variables such as inflation or the fiscal deficit, to the degree of openness, to financial variables, to measures of political instability. In fact, the number of variables claimed to be correlated with growth is so large that it raises the question of which of these variables are actually robust.[9]

Some important lessons from this literature include the following:

—There is no simple determinant of growth.

—The initial level of income is the most important and robust variable (so conditional convergence is the most robust empirical fact in the data).

7. The unweighted analysis assumes that each person has the same income and that all countries have the same population.

8. For surveys of the literature, see Durlauf and Quah (1999); Temple (1999).

9. See the work of Levine and Renelt (1992) and, more recently, Sala-i-Martin, Doppelhoffer and Miller (2001) for some analysis of robustness in cross-country growth regressions.

—The size of the government does not appear to matter much, whereas the quality of government does. (For example, governments that produce hyperinflation, distortions in foreign exchange markets, extreme deficits, or inefficient bureaucracies are detrimental to an economy.)

—The relation between most measures of human capital and growth is weak, although some measures of health (such as life expectancy) are robustly correlated with growth.

—Institutions (such as free markets, property rights, and the rule of law) are important for growth.

—More open economies tend to grow faster.

2. Technology, Increasing Returns, and Imperfect Competition

If one important set of contributions of the economic growth literature is empirical, another is theoretical: the endogenization of technological progress. The main physical characteristic of technology is that it is a nonrival good. This means that the same formula, the same blueprint may be used by many people simultaneously. This concept should be distinguished from that of nonexcludability. A good is excludable if its use can be prevented.

Romer (1993) provides a simple matrix that helps clarify the issues. The first column in the matrix shows rival goods, while the second displays nonrival goods. The three rows are ordered by the degree of excludability: goods in the upper rows are more excludable than goods in the lower rows.[10] In the upper left corner, for example, cookies are categorized as both rival and excludable. They are rival goods because when someone eats a cookie, no one else can eat it at the same time. They are excludable because the owner of the cookies can prevent anyone else from using them unless they pay for them.

	Rival	*Nonrival*
More excludable	Cookies	Cable television signal
Intermediate excludable		Software
Less excludable	Fish in the sea	Pythagorean theorem

10. The concept of rivalry is a discrete or 0–1 concept (goods can either be used by more than one user or they cannot). The concept of excludability is more continuous.

The bottom row of column one lists fish in the sea. The fish are rival because if someone catches a fish, no one else can catch it. The fish are nonexcludable, however, because it is virtually impossible to prevent people from going out to the sea to catch fish. The goods in this box (rival and nonexcludable) are said to be subject to the tragedy of the commons. This term comes from medieval times, when the land surrounding cities was common land used for pasture; this meant that everyone could take their cows to pasture in the fields. The grass that a person's cow ate could not be eaten by other cows, so it was rival. Yet the law of the land allowed everyone's cows to pasture, so the grass was nonexcludable. The result was, of course, that the city overexploited the land and everyone ended up without grass, which was a tragedy. Hence the name.

These two types of goods are important, but they are not the goods that I want to discuss here. The second column—nonrival goods—is the relevant one. In the top box, a cable television signal, such as HBO, is nonrival in the sense that many people can watch HBO simultaneously. It is excludable, however, because the owners can prevent anyone from seeing HBO if they don't pay the monthly fee. In the bottom box, basic knowledge is represented by the Pythagorean theorem: many people can use it at the same time so it is a nonrival piece of knowledge, but the formula is also nonexcludable since it is impossible for anyone to prevent its use.

The middle box contains technological goods that are nonrival and partially excludable. This category includes goods such as computer software. Many people can use Microsoft Word at the same time, so the codes that make this popular program are clearly nonrival. In principle, people cannot use the program unless they pay a fee to Microsoft, but in practice, people frequently install a copy of the program that a friend or relative bought, and it is very hard to prevent this from happening. It is thus not fully excludable. This is why it occupies an intermediate position.

Whether a good is more or less excludable depends not only on its physical nature, but also on the legal system. The economic historian and Nobel Prize winner, Douglas North, argued that the industrial revolution occurred in England in the 1760s precisely because it was then and there that the institutions to protect intellectual property rights were created. Intellectual property rights are a way to move technological goods up the excludability ladder in column 2. The existence of such institutions that make goods excludable allow inventors to charge for and profit from their inventions, which provides incentives to do research.

2.1 Modeling Technological Progress

The old neoclassical literature points out that the long-run growth rate of the economy is determined by the growth rate of technology. The problem is that it is impossible to model technological progress within a neoclassical framework in which perfectly competitive price-taking firms have access to production functions with constant returns to scale in capital and labor. The argument goes as follows. Since technology is nonrival, a firm should be able to double its size by simply replicating itself—creating a new plant with exactly the same inputs. The firm would need to double capital and labor, but it could use the same technology in both places. This means that the concept of constant returns to scale should apply to capital and labor only. That is,

$$F(\lambda K, \lambda L, A) = \lambda F(K, L, A), \tag{4}$$

where A is the level of technology, K is capital, and L is labor.

Euler's theorem says that

$$Y_t = K F_K + L F_L . \tag{5}$$

Perfectly competitive neoclassical firms pay rental prices that are equal to marginal products. Thus,

$$Y_t = R_t K_t + w_t L_t . \tag{6}$$

In other words, once the firm has paid for its inputs, the total output is exhausted. The firm therefore cannot devote resources to improving technology. It follows that if technological progress exists, it must be exogenous to the model in the sense that R&D cannot be induced and financed by neoclassical firms.

Since technology is nonrival, it must be produced only once (because once it is produced, many people can use it over and over). This suggests that a large fixed cost (the R&D cost) is associated with its production, which leads to the notion of increasing returns. The average cost of producing technology is always larger than the marginal cost. Under perfect price competition (a competition that leads to the equalization of prices with marginal costs), the producers of technology who pay the fixed R&D costs will always lose money. The implication is that no firm will engage in research in a perfectly competitive environment. Put another way, endogenously modeling technological progress requires abandoning the perfectly competitive, Pareto-optimal world that is the foundation of neoclassical theory and allowing for imperfect competition.[11] Therein lies another contribution of the literature: unlike the neoclassical researchers of the 1960s, today's economists deal with models that are not Pareto optimal.

Romer (1990) introduced these concepts in a Dixit and Stiglitz (1977) model in which innovation took the form of new varieties of products. Aghion and Howitt (1992, 1998) extended the theory to a Schumpeterian framework in which firms devote R&D resources to improving the quality of existing products. The quality ladder framework differs from the product variety framework in that the improvement of the quality of a product tends to make the previous generation of products obsolete. This leads to the Schumpeterian notion of creative destruction, by which firms create new ideas in order to destroy the profits of the firms that had the old ideas (Schumpeter, [1942] 1975).

The new growth models of technological progress have clarified some important issues when it comes to R&D policies, perhaps the most important being that despite market failures (caused by imperfect competition, externalities, and increasing returns), it is not at all obvious whether the government should intervene, what this potential intervention should look like, and, in particular, whether it should involve R&D subsidies. This is important given the widespread popular notion that countries tend to underinvest in technology and that the government should do something about it. The R&D models highlight a number of distortions, but subsidizing R&D is not necessarily the best way to deal with them. For example, the one distortion that is common across models is that arising from imperfect competition: prices tend to be above marginal cost and the quantity of ideas generated tend to be below optimal. The optimal policy to offset this distortion, however, is not an R&D subsidy, but rather a subsidy for the purchase of the overpriced goods.

A second distortion may arise from the externalities within the structure of R&D costs. If the invention of a new product affects the cost of invention of the new generation of products, then there is a role for market intervention. The problem is that it is not clear whether a new invention will increase or decrease the cost of future inventions: while it can persuasively be argued that the cost of R&D declines with

11. The path-breaking paper by Romer (1986) uses an alternative trick to get around the problem: it assumes that firms do not engage in purposefully financed R&D. Instead, knowledge is generated as a side product of investment. This line of research, however, was quickly abandoned.

the number of things that have already been invented (following Newton's idea of shoulders of giants), it can also be argued that easy inventions are pursued first, such that R&D costs increase with the number of inventions. If the cost declines, then firms doing R&D tend not to internalize all the benefits of their inventions (in particular, they do not take into account the fact that future researchers will benefit by the decline in R&D costs), so they tend to underinvest in R&D. In this case, the correct policy is an R&D subsidy. If the costs increase with the number of inventions, however, then current researchers exert a negative externality on future researchers and they tend to overinvest. The required policy becomes an R&D tax rather than an R&D subsidy.

The Schumpeterian approach brings in additional distortions, because current researchers tend to exert a negative effect on past researchers through the process of creative destruction. These effects tend to call for taxes on R&D (rather than subsidies), as current researchers tend to perform too much, not too little, R&D. Finally, government intervention is not required at all if the firm doing current research is the technological leader. For example, Intel owns the Pentium II and performs research to create the Pentium III and then the Pentium IV, thereby destroying the profits generated by its past investments. When the new inventor is also the technological leader, the inventor will tend to internalize the losses of current research on past researchers, so no government intervention is called for.

Although the new generation of growth models is based on strong departures from the old Pareto-optimal neoclassical world, the models do not necessarily call for strong government intervention, and when they do, the recommended intervention may not coincide with the popular view that R&D needs to be subsidized.

2.2 Markets for Vaccines

An influential idea that has come out of the economic growth literature is Michael Kremer's recommendation to create a market for vaccines to help solve the new African pandemics of AIDS and malaria (Kremer, 2000). Kremer emphasizes that financing public research is not the best way to provide incentives for R&D related to diseases that mainly affect the poor. Rather, the best solution is to create a fund with public money (donated by rich governments and rich private philanthropists). This fund would not be used to finance research directly, but to purchase vaccines from the inventor. The price paid would be above marginal cost, which would provide incentives for pharmaceutical companies to devote resources to investigating and developing vaccines against malaria and AIDS, which is something they do not currently do.

3. Merging Economic Literatures

Another important contribution of the new economic growth literature is that it has exerted some influence on other economic literatures and, in turn, has benefited from them. One of the most prominent examples of this symbiosis is the discipline's interaction with the new development literature, which traditionally was largely institutional and centered around economic planning. Growth economists who used to rely almost exclusively on Pareto-optimal, complete-market, perfectly competitive neoclassical models now systematically abandon their traditional paradigms, and they discuss the role of institutions without thinking they are doing second-rate research. At the same time, development economists have learned the value of incorporating general equilibrium and macroeconomic features into their traditional models.

This kind of cross-discipline interaction with growth economics can also be observed in other fields such as economic geography (see Krugman, 1991; Matsuyama, 1991; Fujita, Krugman, and Venables, 1999), macroeconomics and trade theory (Grossman and Helpman, 1991), industrial organization (Aghion and Howitt, 1992, 1998; Peretto, 1998), public finance (Barro, 1990; Barro and Sala-i-Martin, 1998), econometrics (Quah, 1993; Durlauf and Quah, 1999; Sala-i-Martin, Doppelhoffer, and Miller, 2001), and economic history and demography (Kremer, 1993; Hansen and Prescott, 1998; Jones, 1999; Lucas, 1999; Galor and Weil, 1998).[12]

4. Institutions

Another important lesson to be learned from the new economic growth literature is that institutions are important empirically, and they can be modeled. By institutions, I mean various aspects of law

12. Following the influential paper by Kremer (1993), a number of researchers attempt to model the history of the world over the last million years with a single model that explains the millennia-long periods of stagnation, the industrial revolution and the subsequent increase in the rate of economic growth, and the demographic transition that led families to become smaller, which allowed them to increase their per capita income. This literature has made use of long-term data (and I mean really long-term data, dating back to 1 million B.C.). The insights from these historical analyses are perhaps another interesting contribution of the growth literature.

enforcement (property rights, the rule of law, legal systems, peace), the functioning of markets (market structures, competition policy, openness to foreign markets, capital and technology), political institutions (democracy, political freedom, political disruption, political stability), the health system (as previously mentioned, life expectancy is one of the variables most robustly correlated with growth), financial institutions (an efficient banking system, a good stock market), government institutions (the size of the bureaucracy, the extent of red tape, government corruption), and inequality and social conflicts,[13] .

Institutions affect the efficiency of an economy much in the same way as technology does: an economy with bad institutions is more inefficient, in the sense that it takes more inputs to produce the same amount of output. In addition, bad institutions lower incentives to invest (in physical and human capital as well as technology) and to work and produce. Despite their similar effects on the economy, however, the promotion or introduction of good institutions differs substantially from the promotion of new technologies. In fact, it is hard to develop new and better technologies in an economy that does not have the right institutions.

Although the new economic growth literature has quantified the importance of having the right institutions, it is still in the early stages when it comes to understanding how to promote them in practice. For example, the empirical level-of-income literature mentioned above demonstrates that the institutions left behind in liberated colonies directly affect the level of income enjoyed by the country one half century later: colonies in which the colonizers introduced institutions that helped them live a better life in the colony tend to have more income today than colonies in which the colonizers introduced predatory institutions. This seems to be a robust empirical phenomenon. The lessons for the future are not clear, however. Is it possible to undo the harm done by the colonial predators? If so, what sort of actions would be effective, and how should they be implemented? Although these important questions are currently being addressed in the literature, the answers are still unclear.

Indeed, the process of incorporating institutions into growth theories is itself still in the early stages. Empirically, however, it is becoming increasingly clear that institutions are an important determinant of growth.[14]

13. The relation between inequality and growth has been widely studied. See Aghion, Caroli, and Garcia-Peñalosa (1999); Barro (1999a); Perotti (1996).

14. Excellent examples include the recent of work of Hall and Jones (1999); Acemoglu, Johnson, and Robinson (2000); McArthur and Sachs (2001).

5. Conclusions

The recent economic growth literature has produced a number of important insights at both the theoretical and empirical levels. This paper has analyzed some of the most salient. Although this might seem as pessimistic, let me close with a confession of ignorance. Economists have learned a lot about growth in the last few years, but we still do not seem to understand why Africa turned out to have such a dismal growth performance. The welfare of an entire continent—with close to 700 million citizens—has deteriorated dramatically since independence, and the main reason is that the countries in which these people live have failed to grow. Understanding the underlying reasons for this gargantuan failure is the most important question the economics profession faces as we enter the new century.

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IT'S NOT FACTOR ACCUMULATION: STYLIZED FACTS AND GROWTH MODELS

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The central problem in understanding economic development and growth is not, in fact, to understand the process by which an economy raises its savings rate and increases the rate of physical capital accumulation.[1] Many development practitioners and researchers continue to target capital accumulation as the driving force in economic growth.[2] This paper, however, presents evidence regarding the sources and patterns of economic growth, the patterns of factor flows, and the impact

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1. This is a reversal and slight rewording of Arthur Lewis's (1954, p. 155) famous quote, "The central problem in the theory of economic development is to understand the process by which a community which was previously saving and investing 4 or 5 percent of its national income or less, converts itself into an economy where voluntary saving is running at about 12 to 15 percent of national income or more. This is the central problem because the central fact of development is rapid capital accumulation (including knowledge and skills with capital)." While Lewis recognizes the importance of knowledge and skills and later in his book highlights the importance of institutions, many development economists who followed Lewis adopted the more limited focus on saving and physical capital accumulation.

2. Academic researchers in the 1990s started a neoclassical revival (in the words of Klenow and Rodríguez-Clare, 1997b). The classic works in the academic

(continued)

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of national policies on economic growth that suggest that something other than capital accumulation is critical for understanding differences in economic growth and income across countries. The paper does not argue that factor accumulation is unimportant in general; nor do we deny that factor accumulation is critically important for some countries at specific junctures. The paper's more limited point is that when comparing growth experiences across many countries, something besides factor accumulation plays a prominent role in explaining differences in economic performance. As Robert Solow argued in 1956, economists construct models to reproduce crucial empirical regularities and then use these models to interpret economic events and make policy recommendations. This paper documents important empirical regularities regarding economic growth in the hopes of highlighting productive directions for future research and improving public policy.

A growing body of research indicates that after accounting for physical and human capital accumulation, something else accounts for the bulk of cross-country growth differences. This "something else" accounts for the majority of cross-country differences in both the level of per capita gross domestic product (GDP) and the growth rate of per capita GDP. The profession typically uses the term total factor productivity (TFP) to refer to the "something else" (other than physical factor accumulation) that accounts for economic growth differences. We follow the convention of using the term TFP to refer to this unexplained part of growth.

Different theories provide very different conceptions of TFP. Some model TFP as changes in technology (the "instructions" for producing

literature's focus on factor accumulation are Mankiw, Romer and Weil (1992), Barro, Mankiw, and Sala-i-Martin (1995), Mankiw (1995), and Young (1995). The summary of the Global Development Network conference in Prague in June 2000, representing many international organizations and development research institutes, says "physical capital accumulation was found to be the dominant source of growth both within and across regions. Total factor productivity growth (TFPG) was not as important as was previously believed" (www.gdnet.org/pdfs/GRPPragueMtgReport.pdf). A leading development textbook (Todaro, 2000) says that an increase in investment is "a necessary condition" for economic takeoff. Another development textbook (Ray, 1998) refers to investment and saving as "the foundations of all models of economic growth." Many development practitioners also stress investment. For example, the International Monetary Fund argues, "The adjustment experience of sub-Saharan Africa has demonstrated that to achieve gains in real per capita GDP an expansion in private saving and investment is key" (see Easterly, 1999). The Bank for International Settlements concludes, "recent experience has underlined the central importance of national saving and investment rates in promoting growth" (Easterly, 1999). The International Labor Organization argues that "policies to raise the rate of investment... are critical for raising the rate of growth and goods and services); others highlight the role of externalities. Some focus on changes in the sector composition of production; still others see TFP as reflecting the adoption of lower cost production methods. These theories thus provide very different views of TFP. Empirically distinguishing among these different theories would provide clearer guidance to policymakers and growth theorists. We do not have empirical evidence, however, that confidently assesses the relative importance of each of these conceptions of TFP in explaining economic growth. Economists need to provide much more shape and substance to the amorphous term, TFP.

This paper examines five stylized facts. While we examine each individually, we emphasize a simple theme: researchers need a better understanding of TFP and its determinants to more precisely model long-run economic growth and design appropriate policies.

Stylized fact 1: Factor accumulation does not account for the bulk of cross-country differences in the level or growth rate of per capita GDP; something else—TFP—accounts for a substantial amount of cross-country differences. The search for the secrets of long-run economic growth must therefore place a high priority on rigorously defining the term TFP, empirically dissecting TFP, and identifying the policies and institutions most conducive to TFP growth.

Stylized fact 2: The huge, growing differences in per capita GDP worldwide indicate that divergence—not conditional convergence—is the big story. An emphasis on TFP growth with increasing returns to technology is more consistent with divergence than models of factor accumulation with decreasing returns, no scale economies, and some

employment in an economy" (Easterly, 1999). The United Nations boldly claims that "additional investment is the answer—or part of the answer—to most policy problems in the economic and social arena" (Easterly, 1999). Similarly, the World Bank states that in East Asia, "accumulation of productive assets is the foundation of economic growth" and promises that in Latin America, "enhancing saving and investment by 8 percentage points of GDP would raise the annual growth figure by around 2 percentage points" (Easterly, 1999). World Bank (2000a)a says the saving rate of the typical African country "is far below what is needed to sustain a long-term boost in economic performance." The World Bank (2000c) says that South Eastern Europe can only seize trade opportunities if "domestic and foreign entrepreneurs increase their investment dramatically." For more citations, see Easterly (1999) and King and Levine (1994).Although common, the stress on capital accumulation is far from universal among development practitioners and researchers. For example, the World Bank (2000b) report on East Asia's recovery suggests "future growth hinges less on increasing physical capital accumulation and more on raising the productivity growth of all factors." Collier, Dollar, and Stern (2000) stress policies, incentives, institutions, and exogenous factors as the main drivers in growth with little mention of investment, as does the *World Development Report* (World Bank, 2000–2001, pp. 49–52).

fixed factor of production. The big story of the past two centuries is that the difference between the richest countries and poorest countries is growing. Moreover, the growth rates of the rich are not slowing, and returns to capital are not falling. Just as business-cycles look like little wiggles around the big story when viewed over a long horizon, understanding slow, intermittent conditional convergence seems far less pertinent than uncovering why the United States has enjoyed very steady growth for two hundred years while much of the earth's population still lives in poverty.

Stylized fact 3: Growth is not persistent over time—some countries take off, others are subject to peaks and valleys, a few grow steadily, and others have never grown—but capital accumulation is persistent, much more so than overall growth. Changes in factor accumulation do not match up closely with changes in economic growth. This finding is consistent across very different frequencies of data. This stylized fact further suggests that models of steady-state growth, whether based on capital externalities or technological spillovers, will not capture the experiences of many countries. While the United States has grown very consistently over time, other countries have had very different experiences. Steady-state growth models may thus fit the United States' experience over the last two hundred years, but they will not fit the experiences of Argentina, Venezuela, Korea, or Thailand. In contrast, models of multiple equilibria do not fit the U.S. data very well. Our models thus tend to be country-specific rather than general theories. Meanwhile, the profession's empirical work still centers on discovering why the United States is the United States, how a country like Argentina can go from being like the United States early in this century to struggling as a middle-income country today, and how a country like Korea or Thailand can go from being like Somalia to enjoying a thriving economy.

Stylized fact 4: All factors of production flow to the same places, suggesting important externalities. This fact is noted and modeled by Lucas (1988), Kremer (1993), and others. Our paper further demonstrates the powerful and pervasive tendency for all factors of production, including physical and human capital, to bunch together. The consequence is that economic activity is highly concentrated. The tendency holds whether considering the globe, countries, regions, states, ethnic groups, or cities. This force—this "something else"—needs to be fleshed out and then firmly imbedded in economic theories and policy recommendations.

Stylized fact 5: National policies influence long-run growth. In models with zero productivity growth, diminishing returns to the factors of production, and some fixed factor, national policies that boost physical or human capital accumulation have only a transitional effect on growth. In models emphasizing total factor productivity growth, however, national policies that enhance the efficiency of capital and labor or alter the endogenous rate of technological change can boost productivity growth and thereby accelerate long-run economic growth. The finding that policy influences growth is thus consistent with theories that emphasize productivity growth and technological externalities, and it makes one increasingly wary of theories that focus excessively on factor accumulation.

Although many authors examine total factor productivity growth and assess growth models, this paper makes a number of new contributions. Besides conducting traditional growth accounting based on capital stock data from the new Penn World Table (Summers and Heston, 1991), this paper fully exploits the panel nature of the data. Specifically, we use the international cross-section of countries to address two questions: what accounts for cross-country growth differences, and what accounts for growth differences over time? Overwhelmingly the answer is total factor productivity, not factor accumulation. The paper also examines differences in the level of gross domestic product per worker across countries. We update Denison's (1962) original level accounting study, and we extend Mankiw, Romer, and Weil's (1992) study by allowing technology to differ across countries and by assessing the importance of country-specific effects. Unlike Mankiw, Romer, Weil, we find that huge differences in total factor productivity account for the bulk of cross-country differences in per capita income, even after controlling for country-specific effects. In terms of divergence, the paper compiles and presents new information that further documents massive divergence in the level of per capita income across countries. We show that although many authors frequently base their modeling strategies on the U.S. experience of steady long-run growth (for example, Jones, 1995a, 1995b; Rebelo and Stokey 1995), the U.S. experience is the exception rather than the rule. Much of the world is characterized by miracles and disasters, by changing long-run growth rates, and not by stable long-run growth rates. Finally, the paper presents an abundance of new evidence on the concentration of economic activity. We draw on cross-country information, data from counties within the United States, developing country studies, and information on the international flow of capital, labor, and human capital to demonstrate the geographic concentration of activity and relate it to models of economic growth. The overwhelming concentration of economic activity is consistent with some theories of economic growth and inconsistent with others, in that specific countries at specific points in their development processes fit different models of growth. The big picture emerging from cross-country growth comparisons, however, is the simple observation that creating the incentives for productive factor accumulation is more important for growth than factor accumulation per se. In assembling and presenting these stylized facts of economic growth, we hope to stimulate growth research and thereby enhance public policy and poverty alleviation.

1. It's Not Factor Accumulation

Physical and human capital accumulation play key roles in igniting and accounting for economic progress in some countries, but factor accumulation does not account for the bulk of cross-country differences in the level or growth of per capita GDP in a broad cross-section of countries. Something else—namely, total factor productivity (TFP)—accounts for the bulk of cross-country differences in both the level and growth rate of per capita GDP.

The empirical importance of TFP has motivated many economists to develop models of TFP. Some models focus on technological change (Aghion and Howitt, 1998; Grossman and Helpman, 1991; Romer, 1990), others on impediments to adopting new technologies (Parente and Prescott, 1996). Some highlight externalities (Romer, 1986; Lucas, 1988), while others focus on disaggregated models of sectoral development (Kongsamut, Rebelo, and Xie, 1997) or cost reductions (Harberger, 1998). The remainder of this section briefly presents evidence on factor accumulation and growth and discusses the implications for models and policy.

1.1 Growth Accounting and Variance Decomposition

We consider three questions. First, what part of a country's growth rate is accounted for by factor accumulation and TFP growth? We thus examine the sources of growth in individual countries over time. Second, what part of cross-country differences in economic growth rates is accounted for by cross-country differences in growth rates of factor accumulation and TFP? Here, we examine the ability of the sources of growth to explain cross-country differences in growth rates. Third, what part of the intertemporal difference in economic growth rates is accounted for by time-series differences in growth rates of factor accumulation and TFP? We address this question later in the paper, fully exploiting the cross-country, time-series nature of the data as the basis for our assessment. Traditional growth accounting forms the basis for answering these questions.

Growth accounting

The organizing principle of growth accounting is the Cobb-Douglas aggregate production function. Let y represent national output per person, k the physical capital stock per person, n the number of units of labor input per person (reflecting work patterns, human capital, etc.), α a production function parameter (that equals the share of capital income in national output under perfect competition), and A technological progress:

$$y = Ak^{\alpha}\left(n^{1-\alpha}\right). \tag{1}$$

The standard procedure in growth accounting is to divide output growth into components attributable to changes in the factors of production. To demonstrate this, we rewrite equation 1 in growth rates:

$$\frac{\Delta y}{y} = \frac{\Delta A}{A} + \alpha\frac{\Delta k}{k} + \left(1-\alpha\right)\frac{\Delta n}{n}. \tag{2}$$

Consider a hypothetical country with the following characteristics: a growth rate of output per person of 2 percent, a capital per capita growth rate of 3 percent, a growth rate of human capital of 0, and a share of capital in national income of 40 percent ($\alpha = 0.4$). In this example, TFP growth is 0.8 percent, and therefore, TFP growth accounts for 40 percent (0.8/2) of output growth in this country.

Many authors conduct detailed growth accounting exercises of one or a few countries, using disaggregated data on capital, labor, human capital, and capital shares of income. Early, detailed growth accounting exercises of a few countries by Solow (1957) and Denison (1962, 1967) find that the rate of capital accumulation per person accounted for between one-eighth and one-fourth of GDP growth rates in the United States and other industrialized countries, while TFP growth accounted for more than half of GDP growth in many countries. Subsequent detailed studies highlight the importance of accounting for changes in the quality of labor and capital. For example, if growth accountants fail to consider improvements in the quality of labor inputs stemming from changes in education and health, then these improvements would be assigned to TFP growth. Unmeasured improvements in physical capital would similarly be inappropriately assigned to TFP. Nonetheless, to the extent that TFP comprises quality improvements in capital, then a finding that TFP explains a substantial amount of economic growth will properly focus our attention on productivity, rather than on factor accumulation per se.

Subsequent detailed growth accounting exercises of a few countries incorporate estimates of changes in the quality of human and physical capital. These studies also find that TFP growth tends to account for a large component of the growth of output per worker. Christenson, Cummings, and Jorgenson (1980) carry out this exercise for a few member countries of the Organization for Economic Cooperation and Development (OECD), albeit prior to the productivity growth slowdown. Dougherty (1991) includes the slow productivity growth period in a study of some OECD countries. Elias (1990) conducts a rigorous growth accounting study for seven Latin American countries, while Young (1995) focuses on fast-growing East Asian countries. Table 1 summarizes some of these results.[3] Some general patterns emerge despite large cross-country variations in the fraction of growth accounted for by TFP growth. The fraction of output growth accounted for by TFP growth hovers around 50 percent for OECD countries. Latin American countries exhibit greater variation, with the average accounted for by TFP growth around 30 percent. Finally, factor accumulation appears to have been a key component of the growth miracle in some of the East Asian economies (Young, 1995).

These detailed growth accounting exercises may seriously underestimate the role of TFP growth in accounting for growth in output per worker, as emphasized by Klenow and Rodríguez-Clare (1997a). The studies summarized in table 1 examine output growth. If, however, the analysis is adjusted to focus on output per worker, then TFP growth accounts for a much larger share of growth than indicated by the figures presented in table 1. In particular, Klenow and Rodríguez-Clare (1997a) show, in an extension of Young (1995), that factor accumulation plays the crucial role only in Singapore (a small city-state) and that none of the other East Asian miracles suggest that factor accumulation played a dominant role in accounting for economic growth. In addition, the share attributed to capital accumulation may be exaggerated, because it does not take into account how much TFP growth induces capital accumulation.[4] In sum, while factor accumulation is

3. We use the summary in Barro and Sala-i-Martin (1995, p.380–81).
4. This point is due to Barro and Sala-i-Martin (1995, p. 352).

Table 1. Selected Growth Accounting Results for Individual Countries

Period and country	*Share of capital in output*	*GDP growth (in percent)*	*Share of growth component (in percent)*		
			Capital	*Labor*	*TFP*
OECD, 1947–1973					
France	0.40	5.40	41	4	55
Germany	0.39	6.61	41	3	56
Italy	0.39	5.30	34	2	64
Japan	0.39	9.50	35	23	42
United Kingdom	0.38	3.70	47	1	52
United States	0.40	4.00	43	24	33
OECD, 1960–1990					
France	0.42	3.50	58	1	41
Germany	0.40	3.20	59	–8	49
Italy	0.38	4.10	49	3	48
Japan	0.42	6.81	57	14	29
United Kingdom	0.39	2.49	52	–4	52
United States	0.41	3.10	45	42	13
Latin America, 1940–1980					
Argentina	0.54	3.60	43	26	31
Brazil	0.45	6.40	51	20	29
Chile	0.52	3.80	34	26	40
Mexico	0.69	6.30	40	23	37
Venezuela	0.55	5.20	57	34	9
East Asia, 1966–1990					
Hong Kong	0.37	7.30	42	28	30
Singapore	0.53	8.50	73	32	–5
South Korea	0.32	10.32	46	42	12
Taiwan	0.29	9.10	40	40	20

Source: OECD: Christenson, Cummings, and Jorgenson (1980) and Dougherty (1991); Latin America: Elias (1990); East Asia: Young (1995).

very closely tied to economic success in some cases, detailed growth accounting examinations suggest that TFP growth frequently accounts for the bulk of output per worker growth.

A second group of studies carries out aggregate growth accounting exercises of a large cross-section of countries using a conglomerate measure of capital and an average value of the capital share parameter from microeconomic studies. Aggregate growth accounting faces the unenviable task of estimating capital stocks for a broad cross-section of countries. King and Levine (1994) and Nehru and Dhareshwar (1993) make some initial estimates of the capital stocks of countries in 1950.

They then use aggregate investment data and assumptions about depreciation rates to compute capital stocks in later years for over a hundred countries. The importance of the estimate of the initial capital stock diminishes over time as a result of depreciation.

We use the capital stock data from the new Penn World Tables 5.6, based on disaggregated investment and depreciation statistics (such as equipment and machines, structures, and so forth) for sixty-four countries (Summers and Heston, 1991). While these data exist for a smaller number of countries, the Penn World Tables 5.6 capital data suffer from less aggregation and measurement problems than the aggregate growth accounting exercises using less precise data.[5]

The aggregate growth accounting results for a broad selection of countries also emphasize the role of TFP in accounting for economic growth. There is enormous cross-country variation in the fraction of growth accounted for by capital and TFP growth. In the average country, if we consider only physical capital accumulation, TFP growth accounts for about 60 percent of output per worker growth using the Penn World Tables 5.6 capital data and setting α equal to 0.4, which is consistent with individual country-studies. Other measures of the capital stock from King and Levine (1994) and Nehru and Dhareshwar (1993) yield similar results. The aggregate growth accounting results are illustrated in figure 1 using data from Penn World Tables 5.6 over the period 1980–1992. We divide countries into ten groups according to their output per capita growth. The first decile represents the slowest-growing group of countries. Figure 1 depicts output growth,

5. The paper reports results using the capital stock estimates from the Penn World Tables, version 5.6 (Summers and Heston, 1991). The Penn World Tables document the construction of this data. We also constructed capital stock figures for more countries using aggregate investment figures. For some countries, the data start in 1951. These data use real investment in 1985 prices and real per capita GDP (chain index) in constant 1985 prices. We use a perpetual inventory method to compute capital stocks. Specifically, let $K(t)$ equal the real capital stock in period t. Let $I(t)$ equal the real investment rate in period t. Let d equal the depreciation rate, which we assume equals 0.07. Thus, the capital accumulation equations states that $K(t + 1) = (1 - d)\ K(t) + I(t)$. To compute the capital per worker ratio we divide $K(t)$ by $L(t)$, where $L(t)$ is the working age population in period t as defined in the Penn World Tables. To compute the capital-output ratio, we divide $K(t)$ by $Y(t)$, where $Y(t)$ is real per capita GDP in period t. To make an initial estimate of the capital stock, we make the assumption that the country is at its steady-state capital-output ratio. Thus, in terms of steady-state value, let $k = K/Y$, let g equal the growth rate of real output, and let $I = I/Y$. Then, from the capital accumulation equation plus the assumption that the country is at its steady state, we know that $k = i/[g + d]$. If we can obtain reasonable estimates of the steady-state values of i, g, and d, then we can compute a reasonable estimate of k. The Penn World Tables have data on output going back to 1950,

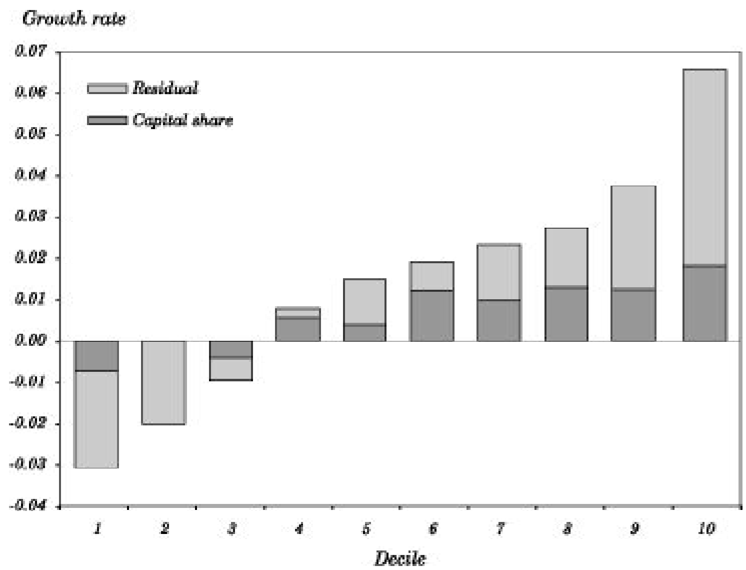
highlighting that part attributable to per capita capital stock growth. The figure indicates that capital growth generally accounts for less than half of output growth. Furthermore, the share of growth accounted for by TFP growth is frequently larger in the faster-growing countries. Finally, there are large differences across countries in the relationship between capital accumulation and growth. For example, output growth in some countries is negative over the period 1980–1990, while the capital stock per person ratio rose through the decade. Costa Rica, Ecuador, Peru, and Syria all saw real per capita GDP fall during the 1980–1992 period at more than one percent per year, while at the same time their real per capita capital stocks were growing at over one percent per year and educational attainment was also increasing. Clearly, these factor injections were not being used productively. These cases are not representative, but they illustrate the shortcoming of focusing too heavily on factor accumulation.[6]

Incorporating estimates of human capital accumulation into these aggregate growth accounting exercises does not materially alter the findings. TFP growth still accounts for more than half of output per worker growth in the average country. Moreover, the data suggest a weak—and sometimes inverse—relationship between improvements in the educational attainment of the labor force and output per worker growth. Benhabib and Spiegel (1994) and Pritchett (1997) use cross-country data on economic growth rates to show that increases in human capital resulting from improvements in the educational attainment of the work force have not positively affected the growth rate of

which we use to compute the initial capital stock estimate as $k*Y$(initial). To make the initial estimate of k, the steady-state capital output ratio, we set $d = 0.07$. We construct g—the steady-state growth rate—as a weighted average of the countries' average growth rate during the first ten years for which we have output and investment data and the world growth rate. The world growth rate is computed as 0.0423. Based on Easterly and others (1993), we give a weight of 0.75 to the world growth rate and 0.25 to the country growth rate in computing an estimate of the steady-state growth rate for each individual country, g. We then compute i as the average investment rate during the first ten years for which we have data. With values for d, g, and i for each country, we can estimate k for each country. To reduce the influence of business-cycles in making the estimate of Y(initial), we use the average real output value between 1950–1952 as an estimate of initial output, Y(initial). The capital stock in 1951 is thus given as Y(initial)$*k$. If output and investment data do not start until 1960, everything is moved up one decade for that country. Given depreciation, the guess at the initial capital stock becomes relatively unimportant decades later.

6. It may be that the conventional measure of investment effort is a cost-based measure that does not necessarily translate into increasing the value of the capital stock. Pritchett (1999) makes this point, especially—but not exclusively—with regard to public investment.

Figure 1: Growth Accounting, with Growth Rates by Decile



Source: Summers and Heston (1991).

output per worker. It may be that, on average, education does not effectively provide useful skills to workers engaged in activities that generate social returns. There is disagreement, however. Krueger and Lindahl (1999) argue that measurement error accounts for the lack of a relationship between per capita growth and human capital accumulation. Hanushek and Kimko (2000) find that the quality of education is very strongly linked with economic growth. Klenow (1998), however, demonstrates that models highlighting the role of ideas and productivity growth do a much better job of matching the data than models focusing on the accumulation of human capital. More work is clearly needed on the relationship between education and economic development.

Variance decomposition

While traditional growth accounting measures the portion of a country's growth rate that may be attributed to factor accumulation, we construct indicators of the portion of cross-country differences in economic growth rates accounted for by cross-country differences in TFP and factor growth. A variance decomposition of growth provides

Table 2. Variance Decomposition[a]

Specification and period	*Contribution of growth component*		
Without human capital	$g(tfpk)$	$g(k)$	$\text{cov}[g(tfpk), g(k)]$
1960–1992	0.58	0.41	0.01
1980–1992	0.65	0.21	0.13
With human capital	$g(tfpkh)$	$g(kh)$	$\text{cov}[g(tfpkh), g(kh)]$
1960–1992 (44)	0.94	0.52	–0.45
1980–1987 (50)	0.68	0.20	0.12

a. Based on a sample of sixty non-oil-producing countries. The decomposition with human capital includes forty-four countries in the longer period (1960–1992) and fifty countries in the 1980s subperiod.

useful information on the relative importance of cross-country differences in TFP growth in accounting for cross-country differences in long-run GDP growth (Jones, 1997). Assuming that $\alpha = 0.4$, the following holds for the cross-section of countries:

$$\text{var}\left(\frac{\Delta y}{y}\right)=\text{var}\left(\frac{\Delta \text{TFP}}{\text{TFP}}\right)+\left(0.4\right)^2\left[\text{var}\left(\frac{\Delta k}{k}\right)\right]+2\left(0.4\right)\left[\text{cov}\left(\frac{\Delta \text{TFP}}{\text{TFP}},\frac{\Delta k}{k}\right)\right].$$

After we decompose the sources of growth across countries using different datasets, cross-country variations in TFP growth account for more that 60 percent of output growth (see table 2). Furthermore, the cross-country variation in physical capital alone—excluding the covariance with TFP growth—never accounts for more than 25 percent of the cross-country variation in per capita GDP growth.

Researchers also incorporate human capital accumulation into these types of decomposition exercises. We rewrite the variance-decomposition equations as

$$\text{var}\left(\frac{\Delta y}{y}\right)=\text{var}\left(\frac{\Delta \text{TFP}}{\text{TFP}}\right)+\left(0.7\right)^2\left[\text{var}\left(\frac{\Delta f}{f}\right)\right]+2\left(0.7\right)\left[\text{cov}\left(\frac{\Delta \text{TFP}}{\text{TFP}},\frac{\Delta f}{f}\right)\right],$$

where $\Delta f/f$ refers to factor accumulation per worker and is defined as the average of the growth rate of physical capital per worker and educational attainment per worker. Specifically,

$$\frac{\Delta f}{f}=\frac{\Delta k/k+\Delta h/h}{2},$$

where h is educational attainment per worker.[7]

Incorporating human capital does not alter the basic result: TFP growth differentials account for the bulk of cross-country growth differences. Klenow and Rodríguez-Clare (1997b) estimate that differences in TFP growth account for about 90 percent of the variation in growth rates of output per worker across a sample of 98 countries over the period 1960-1995 after accounting for human capital accumulation.[8] We obtain similar results using the newly constructed capital stock series from disaggregated investment data from the Penn World Tables and estimates of the growth rate human capital from Benhabib and Spiegel (1994): differences in TFP growth account for about 90 percent of cross-country differences in real per capita GDP growth over the period 1960–1992. Thus, as we seek to explain cross-country differences in long-run growth rates, differences in TFP growth—rather than differences in factor accumulation rates—seem like the natural place to start.

Before continuing, it is important to stress the limits of growth accounting. Growth accounting is a mechanical procedure. Using it to elucidate a causal story is dangerous. In Solow's (1956) model, for instance, if A grows at the exogenously given steady-state rate x, then y and k grow at the steady-state rate x, too. Growth accounting will, therefore, attribute αx of output growth to capital growth and then yield the conclusion that (α*100) percent of growth is due to physical capital accumulation. Also, growth accounting does not test the statistical significance of the relationship between output growth and capital accumulation. We discuss the temporal (Granger-causal) relationship between growth and savings, investment, and education later in the paper. Here, we simply note this inherent feature of growth accounting before turning to level accounting.

1.2 Level Accounting and the *K/Y* Ratio

Hall and Jones (1999) renew the level-accounting question: what part of cross-country differences in per capita income is accounted for by differences in per capita physical capital? They find that productivity differences across countries account for the bulk of cross-country differences in output per worker. We address this question using both the traditional Denison approach and a modified Mankiw, Romer, and Weil (1992) approach.

7. Again, different authors use different weights, though this tends not to change the basic findings.

8. These estimates are based on schooling and job experience.

Denison level accounting

To conduct Denison level accounting, take the ratio of two national incomes of output per person from equation 1:

$$\frac{y_i}{y_j} = \left(\frac{A_i}{A_j}\right)\left(\frac{k_i}{k_j}\right)^{\alpha}\left(\frac{n_i}{n_j}\right)^{1-\alpha}. \qquad (3)$$

Given data on the factors of production, we can then measure cross-country differences in total factor productivity:

$$\frac{A_i}{A_j} = \left(\frac{y_i}{y_j}\right) \Big/ \left[\left(\frac{k_i}{k_j}\right)^{\alpha}\left(\frac{n_i}{n_j}\right)^{1-\alpha}\right]. \qquad (4)$$

Now, note that the fraction of differences in national output levels stemming from capital equals the ratio, ϕ_{ki}:

$$\phi_{ki} = \frac{\alpha \log\left(k_i / k_j\right)}{\log\left(y_i / y_j\right)}. \qquad (5)$$

Equation 5 can be rewritten as

$$\phi_{ki} = \alpha + \frac{\alpha \log\left(\kappa_i / \kappa_j\right)}{\log\left(y_i / y_j\right)}, \qquad (6)$$

using the fact that $\log(k_i/k_j) = \log(\kappa_i/\kappa_j) - \log(y_i/y_j)$ and letting $\kappa = k/y$. This allows us to measure the extent to which the contribution of capital is due to capital share, α, and the extent to which it is due to differences in the capital-output ratio equations. If capital-output ratios are constant across countries i and j, then the contribution of capital toward accounting for differences in per capita output in countries i and j simply equals α.

To conduct level accounting, first calculate the percentage shortfall in output of country i relative to the reference country j: $P_i = 100^*(y_j - y_i)/y_j$. Then we construct the contribution of capital to accounting for the output difference as, $P_i\,\phi_{ki}$. As in King and Levine

(1994), we conduct the level accounting using figures on aggregate capital stocks, though we use the Penn World Tables 5.6 capital numbers. The world is divided into five groups of countries ranging from the poorest to the richest. The richest group is the reference group of countries.

Figure 2 summarizes the level accounting results: TFP accounts for the bulk of cross-country differences in levels of per capita income. Group 1 is the poorest group; it has more than a 90 percent shortfall in per capita GDP relative to the reference group. The very dark area shows that part of the shortfall in per capita income from the reference group is due to capital share of output (α), assuming that capital-output ratios are constant. The other marked areas indicate the additional amount resulting from the fact that capital-output ratios tend to rise with per capita income. TFP differences are indicated by the clear part of the bar. As shown, TFP accounts for a large fraction of the huge differences in per capita income. Even accounting for systematic cross-country differences in capital-output ratios, the data indicate that capital differences account for less than 40 percent of the cross-group differences in per capita income.[9]

Mankiw, Romer, and Weil's approach to level accounting

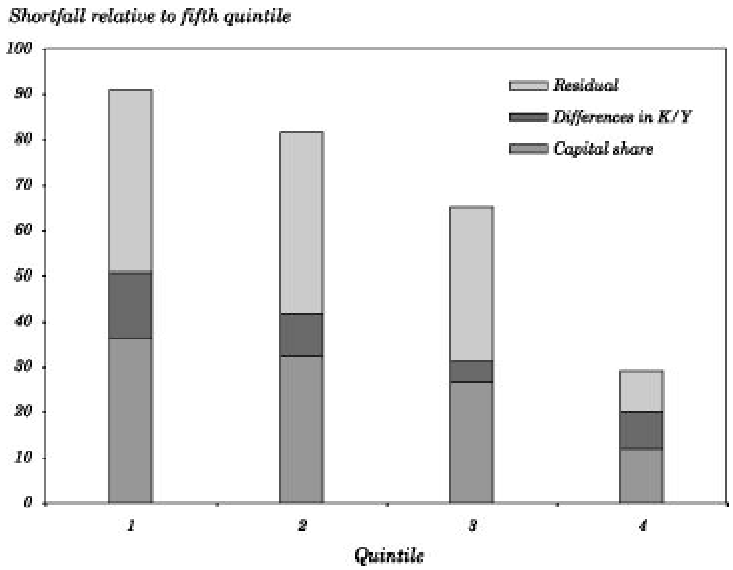
We consider a second approach to level accounting, suggested by Mankiw, Romer ,and Weil (1992). They argue that the Solow model does a good job of accounting for cross-country differences in the level of

9. The K/Y ratio systematically varies with per capita income. Capital-output ratios are systematically larger in richer countries, and they tend to rise as countries grow, which is inconsistent with Kaldor's stylized fact on capital-output ratios. Consider the regression of the capital-output ratio (κ_i) on a measure of per capita income relative to that in the United States in the 1980s (y_i/y_{USA}). The regression yields the following result:

$$\kappa_i = \underset{(0.10)}{0.76} + \underset{(0.18)}{0.59}(y_i/y_{\mathrm{USA}}),$$

where κ_i is the capital-output ratio in country i, standard errors are in parentheses, and the regression includes fifty-seven non-oil-producing countries. There is a strong positive relationship between per capita output relative to the United States and the K/Y ratio. Also, figure 3 shows that K/Y ratio tends to rise in fast-growing countries. Here, we take countries that grew faster than 3.5 percent per year in per capita terms over the period 1960–1992. We then plot, year by year, the average value of their K/Y ratios. As shown, the K/Y ratio rises rapidly over this period of fast growth. While these differences might be due to transitional dynamics, past work suggests that physical capital accumulation along the transition path is unlikely to fully explain level and growth differences (King and Rebelo, 1993).

Figure 2: Development Accounting, by Income Quintile[a]



a. Fifty-seven non-oil-producing countries.

per capita income. In the steady state of the Solow model, output per person is given by

$$\frac{Y}{L} = A\left(\frac{s}{x+\delta+n}\right)^{\alpha/(1-\alpha)}, \tag{7}$$

where Y/L is output per person, A is the level of labor-augmenting productivity, s is the investment-to-GDP ratio, x is the rate of labor-augmenting productivity growth, δ is depreciation, n is population growth, and α is the share of capital income in GDP. We assume productivity growth of 2 percent and a depreciation rate of 7 percent. Following Mankiw, Romer ,and Weil, we take logs of both sides and regress the log of output per person on a constant (ln A) and the log of the second multiplicative term in equation 7:

$$\ln\left(\frac{Y}{L}\right) = \ln A + \frac{\alpha}{1-\alpha}\left[\ln s - \ln\left(x+\delta+n\right)\right]. \tag{8}$$

We call this second term MRW.

Table 3. MRW Regression with Continent Dummies[a]

Variable	*Coefficient*	*Standard error*	*t statistic*	*Probability*
OECD	1.087817	0.107084	10.15857	0.0000
East Asia	7.559995	0.176696	42.78525	0.0000
South Asia	7.065895	0.139239	50.74634	0.0000
Sub-Saharan Africa	6.946945	0.090968	76.36658	0.0000
Western Hemisphere	7.838313	0.102363	76.57349	0.0000
Middle East and North Africa	7.777138	0.143632	54.14642	0.0000
Europe	7.717543	0.133190	57.94384	0.0000
OIL	0.691058	0.157605	4.384760	0.0000
MRW	0.442301	0.096847	4.567031	0.0000
Summary statistics				
R^2	0.752210			
Adjusted R^2	0.738969			
Standard error of regression	0.508076			
Sum squared residuals	33.81651			
Log likelihood	–98.99247			
Mean dependent variable	7.79			
Standard deviation dependent variable	0.994			
Akaike information criterion	1.539			
Schwarz information criterion	1.708			
F statistic	56.810			
Prob (*F* statistic)	0.000			

a. Dependent variable is the average log per capita income 1960–1995. Estimation method is ordinary least squares, with 139 included observations. Standard errors and covariance are White heteroskedasticity consistent.

We extend the MRW approach by allowing *A* to differ across continents, across oil-producing versus non-oil-producing countries, and across OECD versus non-OECD countries (the regions are all inclusive; the OECD and OIL dummies measure shifts relative to their respective regions). The results are in table 3.

While there is a significant correlation of income with the MRW investment term (consistent with the Solow model), we refute the original MRW idea that productivity levels are the same across countries. South Asia and sub-Saharan Africa have significantly lower productivity than other regions (that is, income differences that are not explained with the MRW term). The OECD group has higher productivity than the rest of the world by a factor of 3 ($e^{1.087}$). Once we allow the productivity level to vary, the coefficient on MRW implies a capital share of 0.31, which is in line with most estimates from national income accounting.

Table 4. MRW Regression with Continent Dummies, Including Human Capital[a]

Variable	*Coefficient*	*Standard error*	*t statistic*	*Probability*
OECD	0.999172	0.126361	7.907255	0.0000
East Asia	8.040507	0.212161	37.89818	0.0000
South Asia	7.593671	0.184937	41.06093	0.0000
Sub-Saharan Africa	7.636055	0.207923	36.72545	0.0000
Western Hemisphere	8.285468	0.136361	60.76117	0.0000
Middle East and North Africa	8.345100	0.192838	43.27516	0.0000
Europe	8.222288	0.161656	50.86290	0.0000
OIL	0.618785	0.179383	3.449517	0.0008
MRW	0.168531	0.095305	1.768343	0.0796
MRWH	0.433868	0.089235	4.862086	0.0000
Summary statistic				
R^2	0.812286			
Adjusted R^2	0.797722			
Standard error of regression	0.460689			
Sum squared residuals	24.61913			
Log likelihood	-75.92250			
Mean dependent variable	7.779659			
Standard deviation dependent variable	1.024315			
Akaike information criterion	1.363849			
Schwarz information criterion	1.588951			
F statistic	55.77363			
Prob (*F* statistic)	0.000000			

a. Dependent variable is LQAV6095. Estimation method is ordinary least squares, with 126 included observations. Standard errors and covariance are White heteroskedasticity consistent.

Mankiw, Romer ,and Weil report that they are even more successful at explaining cross-country income differences when they include a measure of human capital investment, which they define as $[\ln s_h - \ln(x + \delta + n)]$. They define the flow of investment in human capital, s_h, as the secondary enrollment ratio times the proportion of the labor force of secondary school age. Klenow and Rodríguez-Clare (1997b) and Romer (1995) criticize this measure as overestimating the cross-country variation in human capital by ignoring primary enrollment, which varies much less across countries than secondary enrollment. Nevertheless, we reproduce this calculation for the period 1960–1995 and call the resultant term MRWH. This new regression is reported in table 4.

Although the human capital investment term is highly significant, the original physical capital investment term is only marginally significant. The OECD productivity advantage and the continental differences in productivity are of the same magnitude as before.

We go on to estimate equation 8 in first differences from the first half of the period to the second half of the period to eliminate country fixed effects. These results indicate that the change in the MRW variable is not statistically significant. We also find that TFP growth—the constant in the equation in first differences—varies significantly across continents. This is consistent with our earlier finding that most of the cross-country variation in per capita growth rates is due to differences in TFP growth and not to transitional dynamics between steady states.

1.3 Causality

Growth accounting is different from causality. Factor accumulation could ignite productivity growth and overall economic growth. Factor accumulation could thus cause growth even though it does not account for much of the cross-country differences in growth rates or cross-country differences in the level of per capita GDP. If this were the case, then it would be both analytically appropriate and policy-wise to focus on factor accumulation. There is also the well-known cross-section correlation between the investment share and growth (see, for example, Levine and Renelt, 1992).

Available evidence, however, suggests that physical and human capital accumulation do not cause faster growth. For instance, Blomstrom, Lipsey, and Zejan (1996) show that output growth Granger-causes investment. Injections of capital do not seem to be the driving force of future growth. Similarly, Carroll and Weil (1994) show that causality tends to run from output growth to savings, not the other way around. Evidence on human capital tells a similar story. Bils and Klenow (2000) argue that the direction of causality runs from growth to human capital, not from human capital to growth. Thus, in terms of both physical and human capital, the data do not provide strong support for the contention that factor accumulation ignites faster growth in output per worker.

1.4 Remarks

Although there are important exceptions, as Young (1995) makes clear, something other than factor inputs accounts for the bulk of cross-country differences in both per capita income and growth rates. Furthermore, while growth accounting does not equal causality, research suggests that increases in factor accumulation do not ignite faster output growth in the future. More work is certainly needed in this area, but the available evidence does not suggest that the direction of causality runs from physical or human capital accumulation to economic growth in the broad cross-section of countries. Finally, measurement error may reduce the confidence that we have in growth and level accounting. The residual is large, however, in both level and growth accounting. Also, growth and level accounting in the 1950s and 1960s produce similar estimates to those generated in the 1990s. This implies that measurement error would have to have two systematic components: the growth rate of measurement error would have to be positive and large in fast-growing countries, and the level component of measurement error would have to be positive and large in rich countries. A considerable body of evidence suggests that while measurement problems may play a role, "something else" besides factor accumulation is critical for understanding cross-country differences in the level and growth rate of per capita GDP.

The profession uses the rather vague term, TFP, to refer to the "something else" that accounts for growth and level differences across countries. In giving theoretical content to this residual, Grossman and Helpman (1991), Romer (1990), and Aghion and Howitt (1998) focus on technology; that is, better instructions for combining raw materials into useful products and services. Others take a different approach for providing economic meaning to the residual. Romer (1986), Lucas (1988), and others focus on externalities, including spillovers, economies of scale, and various complementarities in explaining the large role played by TFP in accounting for differences in the level and growth rates of GDP per worker.[10] Alternatively, Harberger (1998) views the residual in terms of real cost reductions. He argues that "there are at least 1001 ways to reduce costs and that most of them are actually followed in one part or other of any modern complex economy" (p. 3). He urges economists not to focus on one underlying cause of the residual, since several factors may produce real cost reductions in different sectors of the economy at different times.[11] This is consistent with industry studies that reveal considerable cross-sector variation in TFP growth (Kendrick and Grossman, 1980). Prescott (1998), who also focuses on technology,

10. Burnside (1996) presents evidence that suggests that physical capital externalities seem to be relatively unimportant. Klenow (1998) reports evidence that is consistent with technological change based model of growth.

11 . Costello (1993) shows that TFP has a strong country component and is not specific to particular industries.

suggests that cross-country differences in resistance to the adoption of better technologies (arising from politics and policies) help explain cross-country differences in TFP.[12] Empirically determining the relative importance of each of these conceptions of TFP would be very useful for the design of both models and policies.

2. Divergence, Not Convergence

Over the very long run, the world's economies have undergone "divergence, big time," in the words of Pritchett (1997). Figure 3 shows that the richest nations in 1820 subsequently grew faster than the countries that ranked poorest that year. The ratio of richest to poorest grew from 6 to 1 in 1820 to 70 to 1 in 1992. If we look back even further in time, prior to the Industrial Revolution (1700–1750) the difference between the richest and poorest countries was probably only about 2 to 1 (Bairoch, 1993, p. 102–6). The big story over the last 200 or 300 years is thus one of massive divergence in the levels of per capita income of the rich and the poor.[13] While the poor are not getting poorer, the rich are getting richer a lot faster than the poor.

The rich continue to grow faster than the poor. Absolute divergence has continued over the last thirty years, though not as dramatically as in earlier periods When countries are classified into quintiles based on per capita income in 1960, the average growth of per capita income for each quintile in the period 1960–1992 is as follows: the poorest fifth of countries grew by 1.4 percent, the second poorest fifth by 1.2 percent, the middle fifth by 1.8 percent, the second richest by 2.6 percent, and the richest by 2.2 percent. China and India—two countries with very large populations—have performed well recently, which improves the distribution. Nevertheless, growth differences have diverged significantly even using recent data.[14]

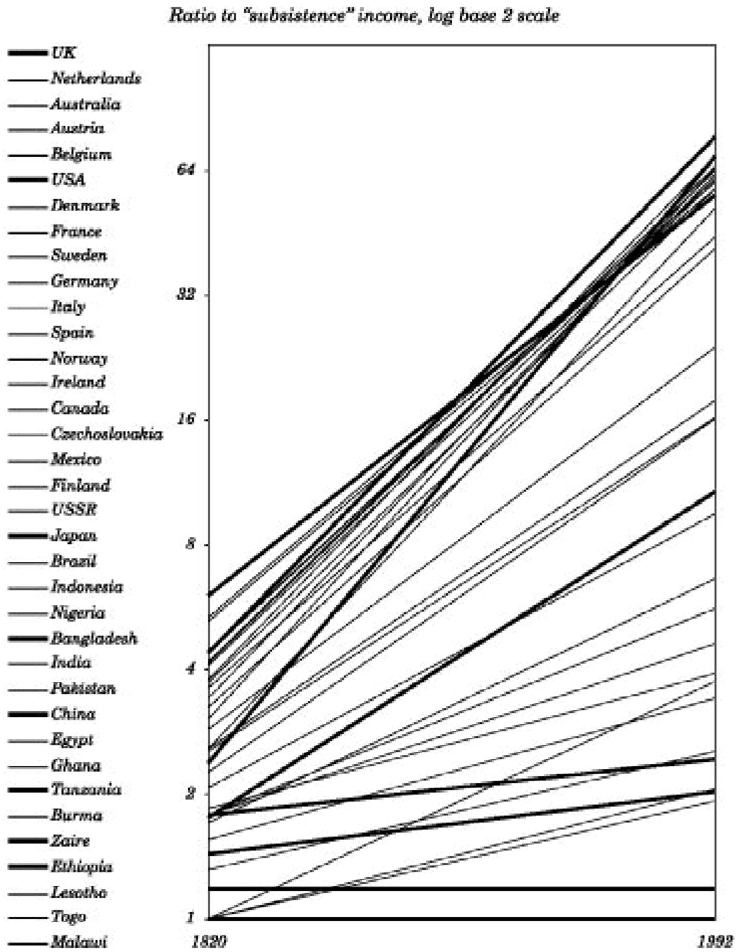
Measures of divergence understate the degree of absolute divergence over 1960–1992. Many countries that the World Bank classified as low or middle income in the 1990s do not have complete data, whereas all

12 . See Holmes and Schmitz (1995); Parente (1994); Parente and Prescott (1996); and Shleifer and Vishny (1993).

13. See Lucas (1998) for an extensive discussion of this divergence, which he interprets as reflecting different takeoff times for various economies and which he predicts will decrease as new countries take off.

14. The usual finding that initial income and growth are uncorrelated relies on data that go through 1981 or 1985 and a linear regression of growth on initial income. The use of more recent data (through 1992) and the analysis of quintiles account for our finding of absolute divergence.

Figure 3: Growth Rates Divergence between Rich and poor, 1820–1992



industrial countries have complete data. This imparts a bias toward convergence in the data, as DeLong (1988) points out with regard to Baumol's (1986) finding of convergence among industrial countries. When the countries that are rich at the end are overrepresented in the sample, this biases the sample toward convergence. The growth rates of the lower three-fifths of the sample would be even lower if we had data on some of the disasters that were classified by the World Bank as low or middle income in the 1990s.

This tendency toward divergence if anything has become more pronounced with time. Easterly (2001) finds that the bottom half of countries ordered by per capita income in 1980 registered zero per capita growth over 1980–1998, while the top half continued to register positive growth. This was not because of divergence in policies; the study shows that policies in poor countries converged toward those of rich countries over 1980–1998.

While conditional convergence (Barro and Sala-i-Martin, 1992) is certainly a feature of many cross-economy datasets, it is difficult to look at the growing differences between the rich and poor and not focus on divergence. The conditional convergence findings hold only after conditioning on an important mechanism for divergence—spillovers from the initial level of knowledge (for which conditional convergence regressions may be controlling with initial level of schooling). Conditional convergence also could follow mechanically from mean reversion (Quah, 1993). Since most growth models are closed economy models, it is worth looking at what happens to convergence in closed economies. Kremer (1993) and Ades and Glaeser (1999) find absolute divergence in the majority of developing economies that are closed economies, suggesting an extent-of-the-market effect on growth in closed economies.

These findings of divergence should be seen within the context of other stylized facts. Romer (1986) shows that the growth rates of the richest countries have not slowed over the last century. King and Rebelo (1993) show that return to capital in the United States has not fallen over the last century. Taken together, these observations do not naturally focus one's attention on a model that emphasizes capital accumulation and that has diminishing returns to factors, some fixed factor of production, and constant returns to scale. At the same time, these observations do not provide unequivocal support for any particular conception of what best explains the "something else" producing these stylized facts.

3. Growth Is Not Persistent, But Factor Accumulation Is

Growth is remarkably unstable over time. The correlation of per capita growth in 1977–1992 with per capita growth in 1960–1976 across 135 countries is only 0.08.[15] This low persistence of growth is not just a characteristic of the postwar era. For the twenty-five countries for

15. Data on per capita growth are taken from Summers and Heston. The low persistence of growth rates and the high persistence of investment and education were previously noted in Easterly and others (1993).

which data are available, there is a correlation of only 0.097 across 1820–1870 and 1870–1929.[16]

In contrast, the cross-period correlation of per capita capital growth is 0.41 For models that postulate a linear relationship between growth and investment-to-GDP (thus using investment-to-GDP as an alternative measure of capital accumulation), the mismatch in persistence is even worse.[17] The correlation of investment-to-GDP in 1977–1992 with investment-to-GDP in 1960–1976 is 0.85. Models that postulate per capita growth as a function of human capital accumulation do no better. The correlation across 1960–1976 and 1977–1992 for primary enrollment is 0.82, while the cross-period correlation for secondary enrollment is 0.91. This suggests that much of the large variation of growth over time is not explained by the much smaller variation in physical and human capital accumulation.

3.1 Inconsistent Patterns of Growth

The typical model of growth, in both the old and new growth literatures, features a steady-state growth rate. Historically, this was probably inspired by the U.S. experience of remarkably steady growth of about 2 percent per capita over nearly two centuries (as noted by Jones, 1995a, 1995b; Rebelo and Stokey, 1995).

Since all countries must have had prior histories of stagnation, another characterization of the typical growth path is the so-called takeoff into self-sustained growth.[18] The prevailing image is a smooth acceleration from stagnation into steady-state growth. The developing countries are supposed to have taken off beginning in the 1960s, when their growth was rapid and exceeded expectations.

Subsequent experience did not bear out the idea of steady growth beginning in the 1960s. Booms and crashes characterized the growth experiences of many countries (Pritchett, 1998; Rodrik, 1998). Suppose we take ten-year average growth rates, which should be long enough to iron out cyclical swings. The cross-section standard deviation of these decade averages is about 2.5 percentage points. The variation over time

16. Data are from Maddison (1995).

17. Models supposing a linear relationship between growth and investment have a long history in economics. See Easterly (1999) for a review of the Harrod-Domar tradition, which continues down to the present. For a new growth theory justification of this relationship, see McGrattan (1998).

18. The phrase is originally from Rostow (1960). More recent theoretical modeling of takeoff includes Baldwin (1998); Krugman and Venables (1995); Jones (1999); Lucas (1998); Hansen and Prescott (1998).

swamps the cross-section variation. In forty-eight out of 119 countries with twenty years or more of data over 1960–1997, one can find a breakpoint such that the subsequent decade's per capita growth is more than 5 percentage points—two cross-section standard deviations—above or below the previous decade's growth.[19] Figure 4 illustrates the roller coaster ride of Côte d'Ivoire, Guyana, Jamaica, and Nigeria. All of the countries with growth booms or crashes were developing countries, except for Greece and Portugal. Stable growth may be a better description of industrial than developing countries.

How many countries have exhibited consistently stable and respectable growth? Out of eighty-eight industrial and developing countries with complete data for 1960–1997, only twelve countries had growth above 2 percent per capita in every decade. Half of these were in East Asia.

3.2 Variance Decomposition over Time

This supposition of unstable growth is confirmed by an intertemporal variance-decomposition exercise. This time, we conduct the decomposition over time rather than across countries. In conjunction with the cross-country variance decomposition presented above, this analysis represents a full exploration of the panel data we have constructed on growth and its factors. We set up a panel of seven five-year time periods for each country for per capita growth and physical capital per capita growth. We then subtract off the country means and analyze the variance using the same formula as before:

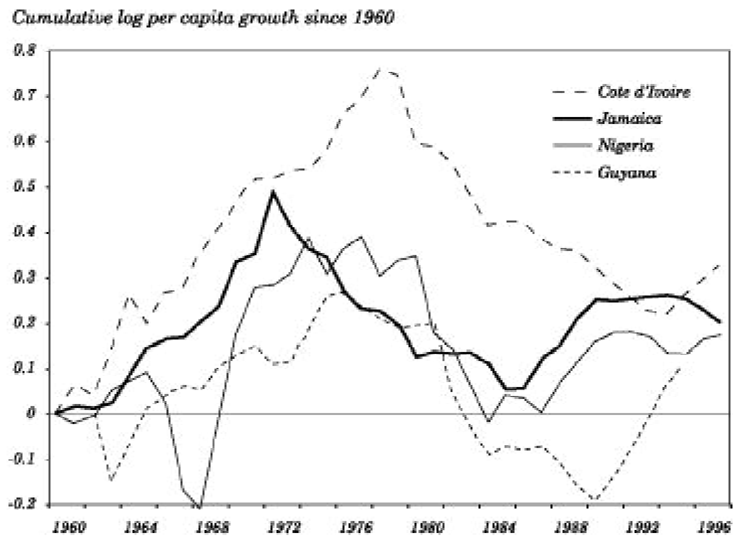
$$\mathrm{var}\left(\frac{\Delta y}{y}\right)=\mathrm{var}\left(\frac{\Delta \mathrm{TFP}}{\mathrm{TFP}}\right)+(0.4)^2\left[\mathrm{var}\left(\frac{\Delta k}{k}\right)\right]+2(0.4)\left[\mathrm{cov}\left(\frac{\Delta \mathrm{TFP}}{\mathrm{TFP}},\frac{\Delta k}{k}\right)\right].$$

We find that TFP accounts for 86 percent of the intertemporal variation in overall growth and that TFP growth accounts for 61 percent of the cross-sectional variation. In other words, growth is much more unstable over time than physical capital growth.

In addition to highlighting the importance of TFP for explaining long-run development patterns, the findings that growth is not persistent and that growth patterns are very different across countries complicate the challenge for economic theorists. Existing models miss important develop-

19. Thirty-seven countries had a growth drop of 5 percentage points or more, nineteen countries had a growth increase of 5 percentage points or more, and eight countries were included in both groups.

Figure 4: Examples of Variable per Capita Income over Time



ment experiences. Some countries grow steadily (for example, the United States). Some grow steadily and then stop for long periods (Argentina). Some do not grow for long periods and then suddenly take off (Korea and Thailand). Others have basically never grown (Somalia). Sole reliance on either steady-state models or standard multiple equilibria models will have a difficult time accounting for these very different growth experiences. Different models may be needed for different patterns of growth across countries. Steady-state models fit the U.S.-type experience. The unstable growth cases fit more naturally into multiple equilibria models, since the long-run fundamentals of the countries are stable.[20]

20. The nonpersistence of growth rates does not inherently contradict the stylized fact of divergence or the stylized fact that national policies influence long-run growth rates. While policies are both persistent and significantly associated with long-run growth (which is not persistent), the *R* squared of the growth regression is generally smaller than 0.50. Thus, something else (besides national policies) is very important for explaining cross-country differences in long-run growth rates. In terms of divergence, the stylized fact on the nonpersistence of growth rates emphasizes that growth follows very different paths across countries and that there is a high degree of volatility. Nevertheless, some countries have achieved comparatively greater success over the long run. While England, France, and Germany have experienced growth fluctuations, they have enjoyed a steeper—and less volatile—growth path than Argentina and Venezuela, for example. The growth paths of Argentina, Venezuela, and other countries have not only been more volatile, but have experienced dramatic changes in trends.

4. When It Rains, It Pours

This section presents a large array of new information on the degree to which economic activity is highly concentrated. We use cross-country data, data from counties within the United States, information from individual developing countries, and data on international flows of capital, labor, and human capital to examine economic concentration. This concentration has a fractal-like quality: it recurs at all levels of analysis, from the global level down to the city level. This concentration suggests that some regions have something that attracts all factors of production, while other regions do not.

One can speculate on the "something else" driving factor flows. Better policies in area *Z* than in area *Y* could explain factor flows. These policies could include legal systems, property rights, political stability, public education, infrastructure, taxes, regulations, macroeconomic stability, and so forth. Such policies, however, are national in nature, whereas we document within-country concentration. Externalities may play an important role in congregating factors. Policy differences, or externalities, or differences in "something else" do not have to be large: small TFP differences can have dramatic long-run implications. Thus, while we do not offer a specific explanation, our results further motivate work on economic geography as a vehicle for better understanding economic growth.

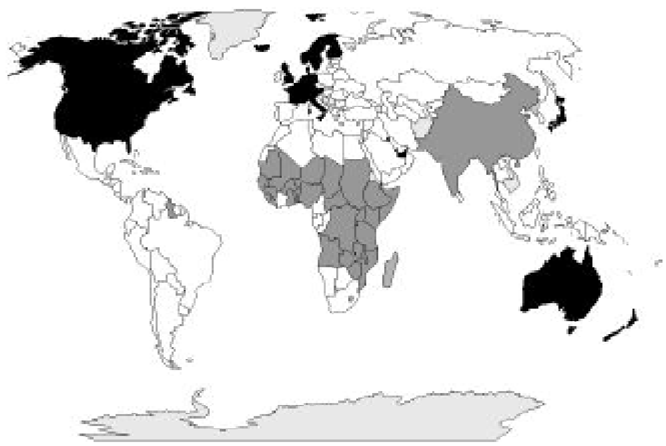
4.1 Concentration

At the global level, high income status is concentrated among a small number of nations. The top twenty nations of the world have only 15 percent of the world's population but produce 50 percent of world GDP. The poorest half of the world's population account for only 14 percent of global GDP.[21]

Map 1 shows the richest nations in black and the poorest in gray. These concentrations of wealth and poverty have an ethnic and geographic dimension: eighteen of the top twenty nations are in Western Europe or in areas settled primarily by Western Europeans. Seventeen of the poorest twenty nations are in tropical Africa. The richest nation in 1985 (the United States) had an income fifty-five times that of the

21. These calculations omit the oil-producing countries, in which GDP is not properly measured because all of oil extraction is treated as current income rather than asset depletion.

Map 1. The Rich and the Poor[a]



a. The countries in black contain 15 percent of world population but produce 50 percent of world GDP. The countries in gray contain 50 percent of world population but produce 14 percent of world GDP.

poorest nation (Ethiopia). Taking into account the inequality within countries, the international income differences are even starker. The richest quintile in the United States had an income that was 528 times the income of the poorest quintile in Guinea-Bissau.

Income at the global level is highly concentrated in space also. Sorting by GDP per square kilometer, the densest 10 percent of the world's land area accounts for 54 percent of its GDP; the least dense half of nations' land area produces only 11 percent of world GDP.[22]

These calculations are done assuming that income is evenly spread among people and land area within nations, so they understate the degree of concentration. Wealth and poverty are highly concentrated within nations, as well. We illustrate this point with the nation for which we have the most detailed data: the United States.

22. An alternative explanation is that some land areas have a large productivity advantage although they account for a small share of the earth's surface. Mellinger, Sachs, and Gallup (1999) argue that this is the case with temperate coastal zones. If this were true, economic activity would be distributed fairly evenly along temperate coastal zones (adjusting for any small intrinsic differences among such zones). However, casual observation suggests high bunching of activity even along temperate coastal zones.

Map 2. Wealth and Abundance of Land

a. Counties shown in black take up 2 percent of U.S. land area but account for half of U.S. GDP.

We used the database of 3,141 counties in the United States to examine income and poverty concentration. When we sorted counties by GDP per square mile, we found a 50 and 2 rule: 50 percent of GDP is produced in counties that account for only 2 percent of the land, while the least dense counties that account for 50 percent of the land produce only 2 percent of GDP. This result is not just a consequence of the large unsettled areas of the West and Alaska. If we restrict the calculation to land east of the Mississippi, we still find extreme concentration: 50 percent of GDP is produced on 4 percent of the land. The densest county is New York, NY, which has a GDP per square mile of $1.5 billion. This is about 55,000 times higher than the least dense county east of the Mississippi ($27,000 per square mile in Keweenaw, MI). Even this comparison understates the degree of concentration, since the most casual empiricism detects rich and poor areas within a given county. (New York county contains Harlem as well as Wall Street.)

Map 2 shows these concentrations of counties accounting for half of U.S. GDP. Obviously, another name for these concentrations is cities. This concentration is explained by the fact that most economic activity takes place in densely populated metropolitan areas. Metropolitan counties are $3,300 richer per person than rural counties (the difference is statistically significant, with a t statistic of 29). More generally, there is a strong correlation between per capita income of U.S. counties and their population density (correlation coefficient of 0.48 for the log of both concepts, with a t statistic of 30 on the bivariate association). Restricting the sample to metropolitan counties still yields concentration: 50 percent of metropolitan GDP is produced in counties accounting for only 6 percent of metropolitan land area.[23]

There are also regional income differences between metropolitan areas. Metropolitan areas in the Boston-to-Washington corridor have a per capita income that is $5,874 higher, on average, than other metropolitan areas. This is a huge difference: it is equal to 2.4 standard deviations in the metropolitan area sample. Although there may be differences in the cost of living, they are unlikely to be so large as to explain this difference.[24]

Other possible explanations of geographic concentration include inherent geographic advantages of some areas. Like Mellinger, Sachs, and Gallup (1999), Rappaport and Sachs (1999) argue that spatial concentration of activity in the United States has much to do with access to the coast. However, casual observation suggests high concentration even within coastal areas (there are sections of the BosWash corridor in which a radio cannot even pick up a station). It also could come about because of high transport costs and low congestion costs (Krugman, 1991, 1995, 1998; Fujita, Krugman, and Venables, 1999). These latter authors also point to locations of particular industries in certain locales (such as the Silicon Valley phenomenon) as evidence of other types of geographic spillovers, including technology spillovers and specialized producer services that have high fixed costs. The high rents in downtown metropolitan areas suggest that congestion costs are very significant. As Lucas (1988) says, "what can people be paying Manhattan or downtown Chicago rents *for*, if not for being near other people?"

4.2 Poor Areas

Not only riches are concentrated in the United States, but poverty is regionally concentrated, as well. These concentrations have an ethnic dimension. As map 3 shows, four ethnic-geographic clusters of counties have poverty rates above 35 percent: counties in the

23. Metropolitan counties are those that belong to a PMSA or MSA in the census classification of counties.

24. The rent component of the cost of living may reflect either the productivity or the amenity advantages of the area. It seems unlikely that amenities are different enough among areas to explain these differences.

Map 3. Poverty traps in U.S. counties[a]

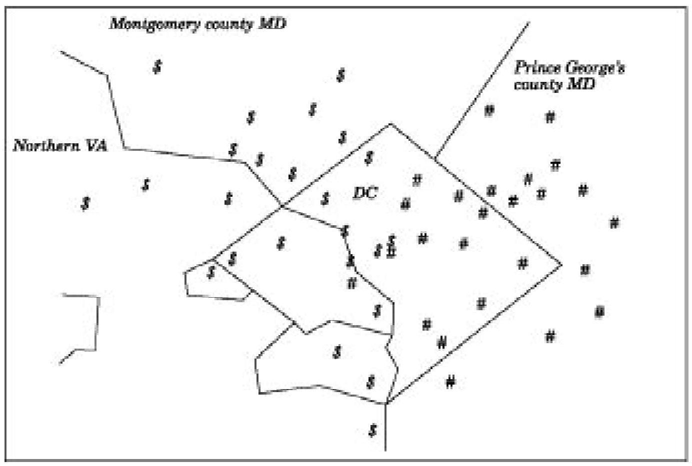
a. Counties in black have a poverty rate of over 35 percent.

West that have large proportions (>35 percent) of native Americans; counties along the Mexican border that have large proportions (>35 percent) of Hispanics; counties adjacent to the lower Mississippi River in Arkansas, Mississippi, and Louisiana and in the “black belt” of Alabama, all of which have large proportions of blacks (>35 percent); counties with virtually all whites in the mountains of eastern Kentucky.

The county data did not pick up the well-known inner-city form of poverty, which affects mainly blacks, because counties that include inner cities also include rich suburbs.[25] Of course, poverty is concentrated in the inner city, as well. An inner-city zip code in Washington, DC—namely, College Heights in Anacostia—has only one-fifth of the income of a rich zip code (20816) in Bethesda, MD. This has an ethnic dimension again, since College Heights is 96 percent black whereas the rich zip code in Bethesda is 96 percent white. The Washington metropolitan area as a whole features a striking East-West divide between poor and rich zip codes, which again roughly corresponds to the black-white ethnic

25. An isolated example of an all-black city is East St. Louis, IL, which is 98 percent black and has a poverty rate of 44 percent.

Map 4. Rich and Poor Zip Codes in the Washington Metropolitan Area[a]



a. Dollar signs indicate richest fourth of zip codes in metropolitan area; pound signs indicate poorest fourth of zip codes.

divide (see map 4).[26] Borjas (1995, 1999) suggests that strong neighborhood and ethnic externalities may help explain poverty and ethnic clusters within cities. Sorting 1990 census tracts by percent of blacks, the census tracts with the highest shares of blacks account for fifty percent of the black population but contain only one percent of the white population.[27] While this segregation by race and class could simply reflect the preferences of rich white people for living next to each other, economists usually prefer to explain economic phenomena through economic motivations rather than exogenous preferences. Bénabou (1993, 1996) stresses that the endogenous sorting between rich and poor allows the rich to take advantage of externalities like locally funded schools.

26. Brookings Institution (1999) notes that this East-West geographic divide of the Washington area is reflected in many socioeconomic variables like poverty rates, free and reduced-price school lunches, road spending, and so forth.

27. From the Urban Institute's Underclass Database, which contains data on white, black, and "other" population numbers for 43,052 census tracts in the United States.

Poverty areas exist in many countries: northeast Brazil, southern Italy, Chiapas in Mexico, Balochistan in Pakistan, and the Atlantic Provinces in Canada. Researchers have found externalities to be part of the explanation of these poverty clusters. Bouillon, Legovini, and Lustig (1999) find that there is a negative Chiapas effect in Mexican household income data—and that this effect has gotten worse over time. Households in the poor region of Tangail/Jamalpur in Bangladesh earn less than identical households in the better-off region of Dhaka (Ravallion and Wodon, 1998). Ravallion and Jalan (1996) and Jalan and Ravallion (1997) likewise find that households in poor counties in southwest China earn less than households with identical human capital and other characteristics in rich Guangdong Province. Finally, Rauch (1993) analyzes U.S. data and finds that individuals with identical characteristics earn less in low human capital cities than in high human capital cities.

4.3 Ethnic Differentials

A number of theories stress in-group externalities to explain the continuity of patterns of wealth distribution (Borjas, 1992, 1995, 1999; Bénabou, 1993, 1996). Poverty and riches are concentrated among certain ethnic groups; it would not be appealing to explain these differences by exogenous savings preferences. Discrimination and intergenerational transmission could also explain ethnic differences, but in terms of growth models, such differences seem more consistent with in-group spillovers than with individual factor accumulation.

The purely ethnic differentials in the United States are well known. Blacks earn 41 percent less than whites; Native Americans earn 36 percent less; Hispanics earn 31 percent less; Asians earn 16 percent more.[28] There are also more subtle ethnic earnings differentials. Third-generation immigrants with Austrian grandparents had 20 percent higher wages in 1980 than third-generation immigrants with Belgian grandparents (Borjas, 1992). Among Native Americans, the Iroquois earn almost twice the median household income of the Sioux.

Other ethnic differentials appear by religion. Episcopalians earn 31 percent more income than Methodists (Kosmin and Lachman, 1993, p. 260) Twenty-three percent of the Forbes 400 richest Americans are

28. U.S. Government (1996, tables 52 and 724).

Table 5. Poverty among Indigenous Peoples in Latin America

Country	*Poverty rate for indigenous people*	*Poverty rate for nonindigenous people*
Bolivia	64.3	48.1
Guatemala	86.6	53.9
Mexico	80.6	17.9
Peru	79.0	49.7

Source: Psacharopoulos and Patrinos (1994, p. 6).

Jewish, although only two percent of the U.S. population is Jewish (Lipset, 1997).[29]

In Latin America, the main ethnic divide is between indigenous and nonindigenous populations, as table 5 illustrates. Even within indigenous groups in Latin America, however, ethnic differentials play a strong role in explaining income differences. Guatemala's indigenous population, for instance, comprises four main language groups. Of these, the Quiche-speaking indigenous groups earn 22 percent less on average than Kekchi-speaking groups (Patrinos, 1997).

In Africa, there are widespread anecdotes about income differentials among ethnic groups, but little hard data. The one exception is South Africa. South African whites earn 9.5 times the income of blacks. More surprisingly, among all-black traditional authorities (an administrative unit something like a village) in the state of KwaZulu-Natal, the ratio of the richest traditional authority to the poorest is 54 (Klitgaard and Fitschen, 1997).

4.4 Factor Movements

The movement of all factors of production toward the richest areas reinforces the concentration of economic activity. A related fact is that each factor of production flows to where it is already abundant.

The migration of labor is overwhelmingly directed toward the rich-

29. Ethnic differentials are also common in other countries. The ethnic dimension of rich trading elites is well-known: the Lebanese in West Africa, the Indians in East Africa, and the overseas Chinese in Southeast Asia. Virtually every country has its own ethnographic group noted for their success. For example, in the Gambia a tiny indigenous ethnic group called the Serahule is reported to dominate business out of all proportion to their numbers; they are often called Gambian Jews. In Zaire, Kasaians have been dominant in managerial and technical jobs since the days of colonial rule; they are often called "the Jews of Zaire" (*New York Times*, 18 September 1996).

est countries. The three richest countries alone (the United States, Canada, and Switzerland) receive half of the net immigration of all countries reporting net immigration. Countries in the richest quintile are all net recipients of migrants. Only eight countries in the ninety countries that constitute the bottom four-fifths of the sample are net recipients of migrants. Barro and Sala-i-Martin (1995, pp. 403–10) find that migration goes from poorer regions to richer regions in samples of U.S. states, Japanese prefectures, and European regions.

Labor also migrates from sparsely populated areas to densely populated areas. County data for the United States yield a statistically significant correlation of 0.20 between the in-migration rate of counties from 1980 to 1990 and the population density in 1980. Hence, labor is flowing to areas where it is already abundant. Our county data also confirm Barro and Sala-i-Martin's (1995) finding for migration among states: people migrate from poor counties to rich counties, with a statistically significant correlation of 0.21 between initial income and the in-migration rate. These two finds are related, as there is a significant positive correlation between population density and per capita income across counties.[30] A regression of the in-migration rate in 1980–1990 by county on population density and per capita income in 1980 finds both factors to be highly significant.[31]

Embodied in this flow of labor are flows of human capital toward the rich countries—the so-called brain drain. We used Grubel and Scott's (1977) data to calculate that in the poorest fifth of nations, the probability that an educated person will immigrate to the United States is 3.4 times higher than that for an uneducated person. Since we know that education and income are strongly and positively correlated, human capital is flowing to where it is already abundant—namely, the rich countries.

A more recent study by Carrington and Detragiache (1998) finds that those with tertiary education were more likely to migrate to the United States than those with a secondary education in fifty-one out of the sixty-one developing countries in their sample. Migration to the United States among workers with only a primary education or less was lower than among workers with either secondary or tertiary education in all sixty-one countries. Their data yield lower bound estimates for the highest rates of migration by those with tertiary education as high as 77 percent (Guyana). Other countries with exceptionally high

30. Ciccone and Hall (1996) report a related finding for U.S. states.

31. The t statistics are 8.2 for the log of population density in 1980 and 8.9 for the log of per capita income in 1979. The equation has an R squared of 0.065 and 3,133 observations. The county data are from Alesina, Baqir, and Easterly (1999).

rates of migration among the tertiary educated are Gambia (59 percent), Jamaica (67 percent), and Trinidad and Tobago (57 percent).[32] None of the migration rates for the group with primary education or less exceed 2 percent. The disproportionate weight of the skilled population in U.S. immigration may reflect U.S. policy, although as Borjas (1999) notes, U.S. immigration policy has tended to favor unskilled labor with family connections in the United States rather than skilled labor. In the richest fifth of nations, moreover, the probability is roughly the same that educated and uneducated will emigrate to the United States. Borjas, Bronars, and Trejo (1992) find that the more highly educated are more likely to migrate within the United States than the less educated.[33]

Capital also flows mainly to areas that are already rich (see Lucas, 1990). In 1990, the richest 20 percent of world population received 92 percent of portfolio capital gross inflows; the poorest 20 percent received 0.1 percent of portfolio capital inflows. The richest 20 percent of the world population received 79 percent of foreign direct investment; the poorest 20 percent received 0.7 percent of foreign direct investment. Altogether, the richest 20 percent of the world population received 88 percent of private capital gross inflows; the poorest 20 percent received 1 percent of private capital gross inflows.

4.5 Evidence on Skill Premiums and Human Capital

Skilled workers earn less, rather than more, in poor countries. This seems inconsistent with the open economy version of the neoclassical factor accumulation model developed by Barro, Mankiw, and Sala-i-Martin (1995). In their model (which we call the BMS model), capital flows equalize the rate of return to physical capital across countries, while human capital is immobile. Immobile human capital explains the difference in per worker income across nations in Barro, Mankiw, and Sala-i-Martin. As pointed out by Romer (1995), this implies that both the skilled wage and the skill premium should be much higher in

32. These are all small countries. Carrington and Detragiache (1998) point out that U.S. immigration quotas are less binding for small countries, since the legal immigration quota is 20,000 per country regardless of a country's population size (with some exceptions).

33. Casual observation suggests brain drain within countries. The best lawyers and doctors congregate within a few metropolitan areas like New York, where skilled doctors and lawyers are abundant, while poorer areas where skilled doctors and lawyers are scarce have difficulty attracting top-level professionals.

poor countries than in rich countries. To illustrate this, we specify a standard production function for country *i* as

$$Y_i = AK_i^{\alpha} L_i^{\beta} H_i^{1-\alpha-\beta}.$$

Assuming technology (A) is the same across countries and that rates of return to physical capital are equated across countries, we solve for the ratio of the skilled wage in country *i* to that in country *j*, as a function of their per capita incomes, as follows:

$$\frac{\partial Y_i / \partial H_i}{\partial Y_j / \partial H_j} = \left(\frac{Y_i / L_i}{Y_j / L_j} \right)^{\frac{-\beta}{1-\alpha-\beta}}.$$

Using the physical and human capital shares suggested by Mankiw (1995)—which are 0.3 and 0.5, respectively—we calculate that skilled wages should be five times greater in India than in the United States (to correspond to a fourteen-fold difference in per capita income). In general, the equation above shows that skilled wage differences across countries should be inversely related to per capita income if human capital abundance explains income differences across countries, à la Barro, Mankiw, and Sala-i-Martin. The skill premium, in turn, should be seventy times higher in India than in the United States. If the ratio of skilled to unskilled wages is about 2 in the United States, then it should be 140 in India. This would imply a fantastic rate of return to education in India, seventy times larger than the return to education in the United States.

The facts do not support these predictions: skilled workers earn more in rich countries. Fragmentary data from wage surveys indicate that engineers earn an average of $55,000 in New York, compared with $2,300 in Bombay (Union Bank of Switzerland, 1994). Instead of skilled wages being five times higher in India than in the United States, skilled wages are twenty-four times higher in the United States than in India. The higher wages across all occupational groups is consistent with a higher *A* in the United States than in India. Figure 5 shows that the skilled wage (proxied by salaries of engineers, adjusted for purchasing power) is positively associated with per capita income across countries, as a productivity explanation of income differences would imply, and not negatively correlated, as a BMS human capital explanation of income differences would imply. The correlation between skilled wages and per capita income across forty-four countries is 0.81.

Within India, the wage of engineers is only about three times the wage of building laborers. Rates of return to education are similarly only about twice as high in poor countries—about 11 percent versus 6 percent from low income to high income (Psacharopoulos, 1994, p. 1332)—not forty-two times higher. Consistent with this evidence, we also see that the incipient flow of human capital, despite barriers to immigration, is toward the rich countries.

4.6 Evaluating Growth Models Given the Concentration of Wealth and Poverty

The high concentration of income, reinforced by the flow of all factors toward the richest areas, is inconsistent with the neoclassical growth model. The distribution of income across space and across people at all levels is highly skewed to the right: the skewness coefficient is 2.58 across countries in 1980, and it is 2.2 across U.S. cities and 1.60 across U.S. counties in 1990, where 0 is symmetry. There is no reason to think that the determinants of income in the neoclassical model (namely, saving and population growth) are skewed to the right. In contrast, models of technological complementarities (such as Kremer, 1993) can explain this skewness.

The concentration of all factors in the rich, densely populated areas even within countries is similarly incompatible with a version of the neoclassical model that includes land as a factor of production. With land in fixed supply, physical capital, human capital, and labor should all want to flow to areas abundant in land (adjusting for land quality) but scarce in other factors. Furthermore, in the neoclassical model, physical and human capital should flow from rich to poor areas, while unskilled labor should move from poor to rich. In fact, physical and human capital flows toward already rich areas, while unskilled labor is less mobile but also tends to flow to rich countries. This is inconsistent with the neoclassical model as presented by Mankiw, Romer, and Weil (1992).

As demonstrated by this fourth stylized fact, we concur with Klenow and Rodríguez-Clare (1997b) that the "neoclassical revival in growth economics" has "gone too far." The neoclassical model has no explanation for why riches and poverty are concentrated in certain regions within countries. The neoclassical model also does not explain why there are such pronounced income differences among ethnic groups. Stylized fact 4 is consistent with poverty trap models like those of Azariadis and Drazen (1990), Becker, Murphy, and Tamura (1990), Kremer (1993), and Murphy, Shleifer, and Vishny (1989). It also supports models of in-group ethnic and neighborhood externalities (Borjas 1992, 1995, 1999; Bénabou 1993, 1996) and geographic externalities (Krugman 1991, 1995, 1998; Fujita, Krugman, and Venables, 1999).

Stylized fact 4 is also more consistent with a productivity explanation of income differences than with a factor accumulation story. If a rich area is rich because *A* is higher, then all factors of production will tend to flow toward this rich area, reinforcing the concentration. Spillovers between agents also seem more natural with technological models of growth, since technological knowledge is inherently more nonrival and more nonexcludable than factor accumulation. Technological spillovers among agents will lead to endogenous matching of rich agents with each other, while their matches will reinforce the poverty of the poor with other poor people (as in the O-ring story of Kremer, 1993, or the inequality model of Bénabou, 1996). A better understanding of economic geography and externalities would help shape models of economic growth.

5. Policy Matters

The empirical literature on national policies and economic growth is huge, and it encompasses considerable disagreement about which policies are most strongly linked with economic growth. Some authors focus on openness to international trade (Frankel and Romer, 1999), others on fiscal policy (Easterly and Rebelo, 1993), others on financial development (Levine, Loayza, and Beck, 2000), and still others on macroeconomic policies (Fischer, 1993). These papers have at least one common feature: they all find that some indicator of national policy is strongly linked with economic growth, which confirms the argument made by Levine and Renelt (1992).

This section uses recent econometric techniques to examine the linkages between economic growth and a range of national policies. Most empirical assessments of the growth-policy relationship are plagued by three shortcomings. First, existing work does not generally confront the issue of endogeneity. Even when authors use instrumental variables, they frequently assume that many of the regressors are exogenous and only focus on the potential endogeneity of one variable of interest. By not fully confronting the issue of causality, existing work may produce biased assessments. Second, traditional cross-country regressions may suffer from omitted variable bias. That is, cross-country growth regressions may omit an important country-specific effect and thereby produce biased coefficient estimates. Third, almost all cross-country regressions include lagged real per capita GDP as a regressor. Since the dependent variable is the growth rate of real per capita GDP, this specification may produce biased coefficient estimates. This paper uses new statistical procedures that ameliorate these potential biases so that we can draw more accurate inferences on the impact of national policies on economic growth.

The paper does not aim to identify the most important policies influencing growth—we still disagree with one another on that issue. Rather, this paper compiles key stylized facts associated with long-run growth and employs the latest econometric techniques to confirm earlier findings that national policies are strongly linked with economic growth. The regression results are consistent with policies having significant long-run effects on national growth rates or on steady-state levels of national output. Furthermore, the regression results show that national policies are strongly linked with TFP growth (Beck, Levine, and Loayza, 2000).

5.1 Econometric Methodology

This subsection briefly describes the generalized method of moments (GMM) dynamic panel estimator that we use to assess the relationship between policy and economic growth. Readers who are less technically inclined can skip this subsection. We begin by constructing a panel that consists of data for seventy-three countries over the period 1960–1995. We average the data over seven nonoverlapping five-year periods.

Consider the following equation,

$$y_{it} - y_{it-1} = (\alpha - 1)\, y_{it-1} + \beta' X_{it} + \eta_i + \varepsilon_{it} \tag{9}$$

where y is the logarithm of real per capita GDP, X represents the set of explanatory variables (other than lagged per capita GDP), η is an unobserved country-specific effect, ε is the error term, and the subscripts i and t represent country and time period, respectively. We also include time dummies to account for time-specific effects.

We can rewrite equation 9:

$$y_{it} = \alpha y_{it-1} + \beta' X_{it} + \eta_i + \varepsilon_{it}\,. \tag{10}$$

To eliminate the country-specific effect, we take first-differences of equation 10:

$$y_{it} - y_{it-1} = \alpha\left(y_{it-1} - y_{it-2}\right) + \beta'\left(X_{it} - X_{it-1}\right) + \left(\varepsilon_{it} - \varepsilon_{it-1}\right). \tag{11}$$

The use of instruments is required to deal with, first, the likely endogeneity of the explanatory variables and, second, the problem that by construction the new error term, $\varepsilon_{it} - \varepsilon_{it-1}$, is correlated with the lagged dependent variable, $y_{it-1} - y_{it-2}$. Under the assumptions (which we test) that the error term, ε, is not serially correlated and the explanatory variables, X, are weakly exogenous (that is, the explanatory variables are assumed to be uncorrelated with future realizations of the error term), appropriately lagged values of the regressors can be used as instruments, as specified in the following moment conditions:

$$E\left[y_{it-s}\left(\varepsilon_{it} - \varepsilon_{it-1}\right)\right] = 0 \text{, for s = 2; t = 3,..., T, and} \tag{12}$$

$$E\left[X_{it-s}\left(\varepsilon_{it} - \varepsilon_{it-1}\right)\right] = 0 \text{, for s = 2; t = 3,..., T.} \tag{13}$$

We refer to the GMM estimator based on these conditions as the difference estimator.

This difference estimator, however, has conceptual and statistical shortcomings. Conceptually, we would also like to study the cross-country relationship between national policies and per capita GDP growth, which is eliminated in the difference estimator. Statistically, when the regressors in equation 11 are persistent, lagged levels of X and y are weak instruments. Instrument weakness influences the asymptotic and small-sample performance of the difference estimator. Asymptotically, the variance of the coefficients rises. Weak instruments can produce biased coefficients in small samples.

To reduce the potential biases and imprecision associated with the usual difference estimator, Arellano and Bover (1995) and Blundell and Bond (1997) develop a system of regressions in differences and levels. The instruments for the regression in differences are the same as above; the instruments for the regression in levels are the lagged differences of the corresponding variables. These are appropriate instruments under the following additional assumption: although there may be correlation between the levels of the right-hand-side variables and the country-specific effect in equation 10, there is no correlation between the differences of these variables and the country-specific effect. This assumption results from the following stationarity property:

$$E\left[y_{it+p}\cdot\eta_i\right]=E\left[y_{it+q}\cdot\eta_i\right]\text{ and} \tag{14}$$

$$E\left[X_{it+p}\cdot\eta_i\right]=E\left[X_{it+q}\cdot\eta_i\right]\text{, for all } p \text{ and } q.$$

The additional moment conditions are

$$E\left[\left(y_{it-s}-y_{it-s-1}\right)\cdot\left(\eta_i+\varepsilon_{it}\right)\right]=0\text{ , for } s = 1\text{, and} \tag{15}$$

$$E\left[\left(X_{it-s}-X_{it-s-1}\right)\cdot\left(\eta_i+\varepsilon_{it}\right)\right]=0\text{ , for } s = 1. \tag{16}$$

Thus, we use the moment conditions presented in equations 12, 13, 15, and 16 and employ a GMM procedure to generate consistent and efficient parameter estimates.

Consistency of the GMM estimator depends on the validity of the instruments. To address this issue, we consider two specification tests suggested by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1997). The first is a Sargan test of overidentifying restrictions, which tests the overall validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation process. The second test examines the hypothesis that the error term, ε_{it}, is not serially correlated. In both the difference regression and the system regression, we test whether the differenced error term is second-order serially correlated. (By construction, the differenced error term is probably first-order serially correlated even if the original error term is not). We use this system estimator to assess the impact of policies on economic growth. In addition, we conduct all of these analyses using (1) purely cross-section, ordinary least squares regressions with one observation per country, (2) the pure different estimator described above, and (3) the panel estimator using only the level component of the system estimator. All of these exercises yield very similar results and parameter values (Levine, Loayza, and Beck, 2000).

5.2 Regressions

To assess the relationship between the exogenous component of national policies and economic growth, we use a set of conditioning information and policy indicators suggested by theory and past empirical work. Specifically, we include the initial level of real per capita income to control for convergence. The standard neoclassical growth model predicts convergence to the steady-state per capita output ratio (Barro and Sala-i-Martin, 1995). We recognize that the coefficient on initial income does not necessarily capture only neoclassical transitional dynamics. In technology diffusion models, initial income may proxy for the initial gap in TFP between economies, such that catch-up can occur in TFP as well as in traditional factors of production. We also include the average years of schooling as an indicator of the human capital stock in the economy. This can help in controlling for differences in steady-state levels of human capital (Barro and Sala-i-Martin, 1992). Schooling may also directly influence economic growth (Lucas, 1988).

We include five policy indicators. We use the inflation rate and the ratio of government expenditures to GDP as indicators of macroeconomic stability (Easterly and Rebelo, 1993; Fischer, 1993). We use the sum of exports and imports as a share of GDP and the black market exchange rate premium to capture the degree of openness of the economy (Frankel and Romer, 1999). We also include a measure of financial intermediary development that equals financial intermediary credit to the private sector as a share of GDP (Levine, Loayza, and Beck, 2000). Again, we do not suggest that these are the most important policy indicators. We simply assess whether economic growth is strongly linked with these national policy indicators after controlling for endogeneity and other biases plaguing existing empirical work. Table 6 reports the panel results.

As in much of the cross-country literature, we find evidence of conditional convergence. Contingent of the level of human capital, poorer countries tend to grow faster than richer countries as each country converges toward its steady state, which is consistent with a major implication of the textbook neoclassical growth model. The regression also shows that greater human capital—as measured by the average years of schooling of the working age population—is associated with faster economic growth. Since our GMM panel estimator controls for endogeneity, this finding suggests that the exogenous component of schooling exerts a positive impact on economic growth. These results are consistent both with models that focus on factor accumulation and with models that focus on total factor productivity growth.

The results reported in the table are consistent with—but do not prove—the idea that national policies have long-run growth effects,

Table 6. Economic Growth and National Policies[a]

Variable	*Coefficient*	*P value*
Constant	0.082	0.875
Initial per capita income[b]	-0.496	0.001
Average years of schooling[c]	0.950	0.001
Openness to trade[b]	1.311	0.001
Inflation[c]	0.181	0.475
Government size[b]	-1.445	0.001
Black market premium[c]	-1.192	0.001
Private credit[b]	1.443	0.001
Summary statistic		
Sargan test[d] (*p* value)	0.506	
Serial correlation test[e] (*p* value)	0.803	

a. Dependent variable is real per capita GDP growth. The regression has 365 total observations and is based on the analyses in Beck, Levine, and Loayza (2000).
b. In the regression, this variable is included as log(variable).
c. In the regression, this variable is included as log(1 + variable).
d. The null hypothesis is that the instruments used are not correlated with the residuals.
e. The null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

which, in turn, is consistent with an endogenous productivity growth model. In contrast, models that feature only transitional factor accumulation dynamics usually predict weaker policy effects on growth than do endogenous productivity growth models. Complementary work in Beck, Levine, and Loayza (2000) suggests a powerful connection between national policies and TFP growth. The exogenous components of international openness—as measured by the ratio of trade to GDP and by the black market exchange rate premiums—are both significantly correlated with economic growth. A higher black market exchange rate premium exerts a negative impact on growth. More international trade tends to boost economic growth. Macroeconomic policy is also important. Large government tends to hurt economic growth. Inflation does not enter significantly. While considerable research suggests a negative link between inflation and economic performance (Bruno and Easterly, 1998), recent research indicates that inflation is strongly linked with financial development (Boyd, Levine, and Smith, 2001), such that it may not enjoy an independent link with growth when controlling for financial development. Finally, we find that a higher level of financial development boosts economic growth. In sum, national policies are strongly linked with economic growth.

6. Conclusions

The major empirical regularities of economic growth emphasize the role of something other than factor accumulation. The TFP residual accounts for most of the cross-country and cross-time variation in growth. Income across countries diverges over the long-run, while the growth rates of the rich are not slowing and returns to capital are not falling. This observation is less consistent with simple models that feature diminishing returns, factor accumulation, some fixed factor of production, and constant returns to scale and more consistent with the observation that "something else" is important for explaining long-run economic success. Growth is highly unstable over time, while factor accumulation is more stable, which certainly emphasizes the role of "something else" in explaining variations in economic growth. We also note that national policies are strongly linked with long-run economic growth rates. Moreover, we show that all factors of production flow to the richest areas, suggesting that they are rich because of high A rather than high K. Finally, we note that divergence of per capita incomes and the concentration of economic activity suggest that technology has increasing returns.

The paper does not argue that factor accumulation is generally unimportant, and we do not deny that factor accumulation is critically important for some countries at specific junctures. Factor accumulation may be very important for some countries. Thus, we are not arguing that TFP explains everything, everywhere, and always. The paper's more limited point is that when comparing growth experiences across many countries, something other than factor accumulation plays a prominent role in explaining differences in economic performance.

Economists should increase research on the residual determinants of growth and income, such as technology and externalities. There is little doubt that technology is a formidable force. Nordhaus (1994) estimates that one BTU of fuel consumption today buys 900 times more lighting (measured in lumens hours) than in 1800. Computing power per dollar invested has risen by a factor of 10,000 over the past two decades. The cost of sending information over optical fiber has fallen by a factor of 1000 over the past two decades.[34] From 1991 to 1998 alone, the price of a megabyte of hard disk storage fell from five dollars to three cents.[35] Over the last forty years, computing power has increased by a factor of a million.[36] Not every technology has improved at this speed, of course, but Mokyr (1992) is right to call technology the lever of riches.

34. World Bank (1998–1999, pp. 3, 5, and 57).
35. www.duke.edu/~mccann/q-tech.htm#Death of Distance.
36. DeLong (econ161.berkeley.edu/E_Sidebars/E-conomy_figures2.html).

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REVIEWING THE EVIDENCE AGAINST ABSOLUTE CONVERGENCE

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Few subjects in applied economic research have been studied as extensively as the convergence hypothesis advanced by Solow (1956) and documented by Baumol (1986).[1] In simple terms, the hypothesis states that poor countries or regions tend to grow faster than rich ones. In its strongest version (known as absolute convergence), the hypothesis implies that in the long run, countries or regions should not only grow at the same rate, but also reach the same per capita income.[2] This hypothesis has been tested using different methodologies and datasets, and it appears to be strongly rejected by the data. In view of these results, several modifications of the absolute convergence hypothesis have been advanced and tested, although they usually lack both theoretical foundations and econometric rigor and discipline.

This paper analyzes whether the econometric methods usually applied to test for absolute convergence have given this hypothesis a fair chance. The paper is organized as follows. Section 1 presents a brief review of some of the tests for convergence advanced in the empirical literature and documents their shortcomings. Section 2 develops a simple theoretical model that implies absolute convergence. Section 3 discusses the likelihood that time series generated from the model can accommodate the results of the tests described on section 1. Finally, section 4 draws some conclusions.

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1. Representative studies in this line of research include Aghion and Howitt (1997); Barro (1991); Barro and Sala-i-Martin (1992); Mankiw, Romer, and Weil (1992); Durlauf and Johnson (1995); Jones (1995); Kocherlakota and Yi (1996,1997).
2. This interpretation has been challenged by Bernard and Durlauf (1996).

Economic Growth: Sources, Trends, and Cycles, edited by Norman Loayza and Raimundo Soto, Santiago, Chile.

1. The Empirical Literature

The first stylized fact that appears to be uncontroversial is that whatever the type of dataset used (a cross-section of countries or panel data), the data strongly reject absolute convergence (Barro and Sala-i-Martin, 1995). The simplest test that can be devised to verify this claim using cross-sectional observations takes the form

$$g_i = \varsigma + \vartheta \ln y_{i0} + \varepsilon_i , \tag{1}$$

where y_{it} is per capita GDP in period t for country i, and g_i is the average growth rate of per capita GDP in country i. That is,

$$g_i = \frac{1}{T}\sum_{t=1}^{T} \Delta \ln y_{it} = \frac{1}{T}\left(\ln y_{iT} - \ln y_{i0}\right) .$$

When pooled data are used, tests for absolute convergence usually take the form

$$\Delta \ln y_{it} = \varsigma + \vartheta \ln y_{it-1} + \varepsilon_{it} . \tag{2}$$

In both cases, the data are said to favor absolute convergence if the estimate of ϑ is negative and statistically different from zero. If the null hypothesis ($\vartheta = 0$) is rejected, it would support the conclusion not only that poor countries grow faster than rich countries, but also that they all converge to the same level of per capita GDP.

As table 1 and figure 1 show, the convergence hypothesis is strongly rejected by the data.[3] In fact, if these results are taken seriously, the evidence appears to favor divergence instead of convergence. That is, the countries that grew faster were those that had a higher initial per capita GDP.

Because the null hypothesis being tested in both cases is that ϑ is equal to zero versus the alternative that it is negative, equation 2 makes explicit that a test for absolute convergence is essentially a test for a unit root on y. As abundantly documented elsewhere, these tests not only have nonstandard asymptotic properties, but they also lack power.

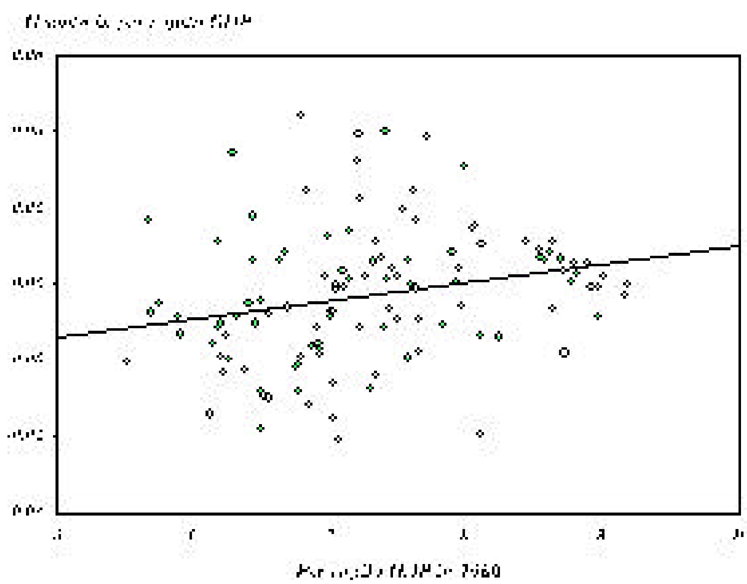
3. All tests using panel data were conducted using the latest version of the Penn World Tables dataset described in Summers and Heston (1991), with data for most variables ranging from 1960 to 1998. Cross-section regressions were conducted using the dataset described in Doppelhofer and others (2000).

Table 1. Tests for Absolute Convergence[a]

Variable or summary statistic	*Cross-section*	*Pooled data*
$\hat{\vartheta}$	0.0047 (0.0014)	0.0048 (0.0010)
Adjusted R^2	0.051	0.007
Number of countries	116	85
Number of observations	116	3,219

a. Standard errors consistent with heteroskedasticity are in parentheses.

Figure 1. Growth Rate from 1960 to 1998 versus 1960 per Capita GDP



In fact, if a traditional (augmented Dickey-Fuller) unit root test on ln*y* were performed for each country, none would reject the null at standard significance levels. Moreover, the first-order autocorrelation coefficient of ln*y* for each country ranges from 0.610 to 0.999, with an average value of 0.947. These results suggest that ln*y* is extremely persistent even in the absence of a unit root, and initial conditions take a long time to dissipate.

Barro (1991) therefore considers a modification of equation 1. Convergence is still understood as the situation in which poor countries grow faster than rich countries (unconditionally), but other factors may influence their growth rates and thereby prevent convergence in per capita GDP levels. Tests for conditional convergence using cross-sectional observations usually take the form

$$g_i = \varsigma + \vartheta \ln y_{i0} + \varphi' \mathbf{x}_i + \varepsilon_i \, , \tag{3}$$

where $\mathbf{x}$ is a vector of k variables that may influence growth. Given that the $\mathbf{x}$ variables are different for each country, incomes might never converge even if ϑ is negative.

Table 2 presents the results of cross-sectional and panel regressions that include some of the usual candidates for specifications such as equation 3.[4] Serious problems plague this strategy, as noted by Durlauf (2001). First, as economic theory is usually silent with respect to the set of $\mathbf{x}$ variables to be included, empirical studies often abuse the resulting flexibility for selecting among the potential candidates. Durlauf and Quah (1999) report that as of 1998, over ninety different variables had appeared in the literature, despite the fact that no more than 120 countries are available for analysis in the standard datasets. Second, important biases in the results may stem from the endogeneity of most of the control variables used (Cho, 1996). Third, the estimated coefficients of the convergence parameter (ϑ) are rather small, suggesting that ln*y* continues to be extremely persistent even after controlling for the $\mathbf{x}$ variables. Fourth, as a corollary of the previous observation, initial conditions may play a crucial role in the results. Fifth, the robustness of results in terms of the potential determinants of long-run growth is subject to debate (see, for example, Levine and Renelt, 1992; Sala-i-Martin, 1997; and Doppelhofer, Miller, and Sala-i-Martin 2000). Finally, several of the variables included in the $\mathbf{x}$ vector are fixed effects that cannot be modified; if these variables were actually long-run determinants of growth, convergence

4. The model that uses cross-sectional observations includes the following $\mathbf{x}$ variables (signs on the coefficients associated with the variables are in parentheses): life expectancy in 1960 (+); equipment investment (+); years of open economy (+); a rule of law index (+); a dummy variable for sub-Saharan African countries (–); and the fraction of people that profess the Muslim (+), Confucian (+), and Protestant (–) religions. The model that uses panel data was estimated using fixed effects and the following $\mathbf{x}$ variables: investment-to-GDP ratio (+); growth rate of the population (–): ratio of exports plus imports to GDP (+); ratio of liquid liabilities to GDP (–): inflation rate (–); and ratio of government consumption to GDP (–).

Table 2. Tests for Conditional Convergence[a]

Variable or summary statistic	*Cross-section*	*Pooled data*
$\hat{\vartheta}$	–0.0154 (0.0028)	–0.0456 (0.0062)
Adjusted R^2	0.811	0.181
Number of countries	79	85
Number of observations	79	2,552

a. Standard errors consistent with heteroskedasticity are in parentheses.

would never be achieved (even with $\vartheta < 0$).[5]

Durlauf and Johnson (1995) suggest that cross-sectional growth behavior may be determined by initial conditions. They explore this hypothesis using a regression tree methodology, which turns out to be a special case of a threshold regression (Hansen, 2000). The basic idea is that the level of per capita GDP on which each country converges depends on some initial condition (such as initial per capita GDP), such that some countries converge on one level and others on another, depending on this characteristic. A common specification used to test this hypothesis considers a modification of equation 1 that takes the form

$$g_i = \begin{cases} \zeta_1 + \vartheta_1 y_{i0} + \varepsilon_i & \text{if } y_{i0} < \aleph \\ \zeta_2 + \vartheta_2 y_{i0} + \varepsilon_i & \text{if } y_{i0} \geq \aleph \end{cases}, \tag{4}$$

where $\aleph$ is a threshold that determines whether country *i* belongs to the first or the second "club." In this case, convergence would not be achieved by the sample as a whole, but it would be by members of each group.

If equation 4 were the actual data-generating process, results such as those in table 1 could be easily motivated: if two regimes are present, with each regime converging to a different state and at a different rate, then estimations based on a single regime might produce a nonsignificant estimate for the convergence parameter. On the other hand, equation 4 states that if the threshold variable (in this case, initial per capita GDP) is correlated with some of the **x** variables included in equation 3, results such as those reported in table 2 are likely to be

5. A curious example of such a variable is absolute latitude, which measures how far a country is from the Equator. When statistically significant, its coefficient is usually positive, implying that one way to enhance growth would be for a country to move its population toward the North or the South Pole.

encountered, even if the **x** variables are not (necessarily) determinants of long-run growth. Equation 4 has an unequivocal implication, however, in terms of the distribution of per capita GDP across countries: if the parameters that characterize each regime are different, a threshold process should be consistent with a bimodal distribution for ln*y*.

Quah (1993, 1997) notices that relative per capita GDP (defined as the ratio of the per capita GDP of country *i* to average world per capita GDP, represented here by $\tilde{Y}_{it}$) displays such bimodality. He conjectures that if convergence clubs were present, even if the unconditional distribution of initial per capita GDP were unimodal, the existence of such clubs would imply that countries would not converge to a degenerate distribution in the long run (as absolute convergence would seem to imply). Rather, one group may converge to one level of per capita GDP and another group to another, in which case twin peaks would arise.

Figure 2 presents kernel estimators of the unconditional density of relative per capita GDP in 1960 and 1995. Consistent with Quah's claim, twin peaks are present in 1995; a bimodal distribution also appears to be present in 1960, however. If Quah is right, rich countries will converge to one distribution, while initially poor countries will never be able to catch up, converging instead to a distribution with a permanently lower per capita GDP. On the other hand, figure 3 presents surface and contour plots of the log of relative per capita GDP, which shows that a bimodal joint density does indeed appear to be consistent with the data. Given that the initial distribution is also bimodal, it is difficult to assess whether the bimodal distribution of 1995 is due to the presence of twin peaks or to the persistence of the per capita GDP level.

2. A Model with Absolute Convergence

This section presents a simple exogenous growth model in which absolute convergence holds and then asks whether the tests for convergence presented in the previous section would be robust. That is, if time-series realizations were generated using a model in which convergence holds, would tests for convergence find convergence? Simply put, the models that I discuss imply that countries should converge to a stationary distribution, that countries with initially lower GDP should grow faster, and that twin peaks should not be present in the long run. To clarify concepts, I now present the type of model to be used, describe its properties and the data-generating process that ln*y* would obey, and ask whether the tests discussed in the previous section are really tests

Figure 2. Densities of Relative per Capita GDP

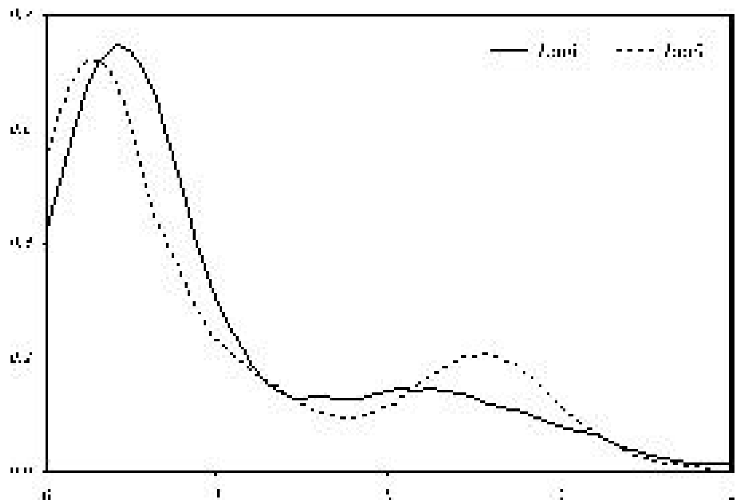
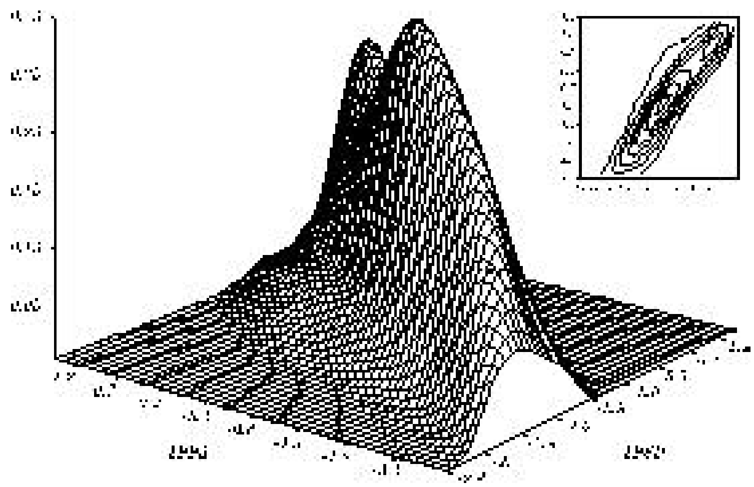


Figure 3. Surface and Contour Plots of Log of Relative per Capita GDP



for convergence. The model considers a representative, infinitely lived household that maximizes

$$u_0 = E_0 \sum_{t=0}^{\infty} \beta^t L_t \ln c_t \ ,$$

where $0 < \beta < 1$ is the subjective discount factor, c_t (= C_t / L_t) is per capita consumption, and E_t is the expectations operator conditional on information available for period t.[6] There is no utility from leisure, and the labor force is equal to L_t. Utility is maximized with respect to per capita consumption and the per capita capital stock, k_{t+1}, subject to the budget constraint:

$$K_{t+1} + C_t = e^{z_t} K_t^{\alpha} \left[\left(1+\lambda\right)^t L_t \right]^{1-\alpha} + \left(1-\delta\right) K_t \ ,$$

where α is the compensation of capital as a share of GDP. In this economy, technological progress is labor augmenting and occurs at the constant rate, λ. Note that production is affected by a stationary productivity shock, z_t. It is straightforward to show that capital and consumption per unit of effective labor, $\hat{k}_t$ and $\hat{c}_t$, are stationary.[7] In fact, one can transform the above economy to a stationary economy and obtain exactly the same solutions for $\hat{k}_t$ and $\hat{c}_t$. Such an economy can be characterized by the following maximization problem:

$$\max_{\{\hat{k}_{t+1}, \hat{c}_t\}} E_0 \sum_{t=0}^{\infty} \left[\beta \left(1+\lambda\right)^{1-\gamma} \right]^t L_t \ln \hat{c}_t \ , \tag{5}$$

subject to

$$\left(1+\eta_{t+1}\right)\left(1+\lambda\right) \hat{k}_{t+1} + \hat{c}_t = e^{z_t} \hat{k}_t^{\alpha} + \left(1-\delta\right) \hat{k}_t \ , \tag{6}$$

where η_t is the rate of population growth for period t.

Given that this model is used to compare the dynamics of different economies, I include a simple channel to induce correlation between

6. Lower case letters denote per capita values, upper case totals, and a hat above a variable denotes that the value is per unit of effective labor.

7. $\hat{k}_t = k_t \big/ \left(1+\lambda\right)^t$ and $\hat{c}_t = c_t \big/ \left(1+\lambda\right)^t$.

each economy's income (following den Haan, 1995). Specifically, I obtain correlated incomes by assuming that the law of motion of technology shocks in country *i* can be written as

$$z_{it} = \rho z_{it-1} + \varepsilon_{it}, \qquad \varepsilon_{it} = (1-\phi)v_t + \phi w_{it}, \tag{7}$$

where v_t and w_{it} are independent $N(0, \sigma_i^2)$ random variables (for $i = v, w$). If ϕ is equal to zero, all countries face the same aggregate shock; if f is equal to one, each country faces only an idiosyncratic shock.

Fully characterizing the model requires taking a stance on the rate of population growth. Here I consider the case in which fertility is exogenous and has the following law of motion:

$$\ln(1+\eta_{it}) = \overline{\eta}(1-\tau) + \tau \ln(1+\eta_{it-1}) + n_{it}, \tag{8}$$

where n_{it} is an independent $N(0, \sigma_n^2)$ random variable.

Once values for the preference and technology parameters are chosen, this dynamic programming problem can be solved using numerical methods to generate artificial realizations of the variables of interest. Here, I am interested in generating realizations of per capita GDP for several samples of countries and applying the convergence tests discussed in section 1. As shown below, this model implies convergence (in a specific sense defined below). The goal is to evaluate how likely it is for the tests to conclude otherwise, even though the main feature of this model is that countries converge.

3. Convergence Tests and the Model

To understand whether the tests discussed in section 1 are useful in testing for convergence, I tailor the model to instances in which a closed-form expression for the data-generating process of the log of per capita GDP is available. This simplification imposes a very rigid structure on the theoretical model and makes it harder for its realizations to present the features that are considered signs of rejection of the absolute convergence hypothesis.

If $\delta = 1$, an analytical expression for the capital stock policy function is available and is expressed as

$$\ln \hat{k}_{t+1} = \ln(\alpha\beta) - \ln(1+\lambda) + \ln \hat{y}_t, \tag{9}$$

where $\hat{y}_t = e^{z_t}\hat{k}_t^{\alpha}$ is GDP per unit of effective labor.

Because $\ln \hat{y}_t$ can be expressed as

$$\hat{y}_t = z_t + \alpha \ln \hat{k}_t \,, \tag{10}$$

we can substitute equations 7 and 9 into equation 10 to obtain a simple expression for $\hat{y}_t$:

$$\ln \hat{y}_{it} = A + (\alpha + \rho) \ln \hat{y}_{it-1} - \alpha\rho \ln \hat{y}_{it-2} + \varepsilon_{it} \,, \tag{11}$$

where $A = \alpha(1 - \rho)\,[\ln(\alpha\beta) - \ln(1 + \lambda)]$. Because $\hat{y}_t (1+\lambda)^t = y_{it}$ (from above), one can use equation 11 to obtain a compact representation of the data-generating process of per capita GDP, as follows:

$$\ln y_{it} = B + Dt + (\alpha + \rho) \ln y_{it-1} - \alpha\rho \ln y_{it-2} + \varepsilon_{it} \,, \tag{12}$$

where B and D are constants.[8]

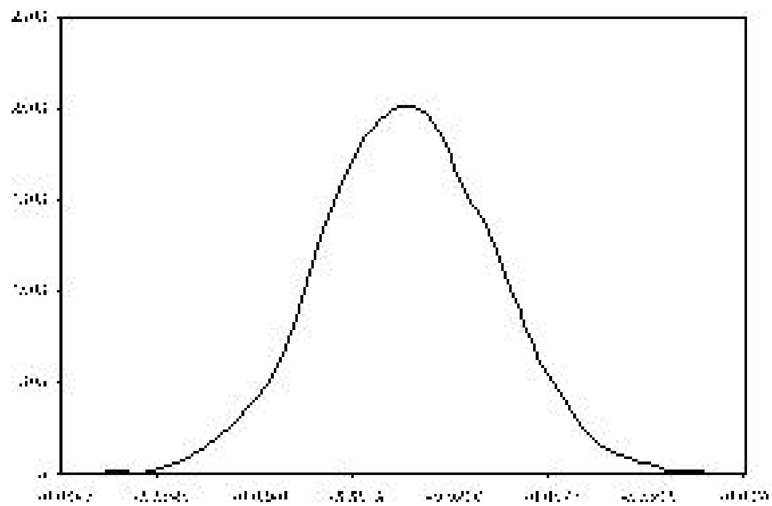
Four features of equation 12 are worth mentioning. First, as is typical of exogenous growth models, per capita GDP is trend stationary.[9] Second, given that the technology shock follows an AR(1) process, ln*y* follows an AR(2) process.[10] Third, even without exogenous growth ($\lambda = 0$), an AR(1) process for ln*y* such as equation 2 is consistent with equation 12 only if white-noise technology shocks ($\rho = 0$) are present. Finally, this model suggests that convergence on growth rates and GDP levels should eventually be achieved. The type of convergence on GDP levels depends on the characteristics of the aggregate and idiosyncratic shocks that are present in equation 7. In particular, if the only source of variation in technology shocks is the aggregate shock ($\phi = 0$), all countries should eventually converge on the same per capita GDP, independent of their initial conditions and independent of the persistence of z. On the other hand, if at least part of the variation in technology shocks is due to the idiosyncratic component ($\phi > 0$), then per capita GDP will converge to a nondegenerate distribution that does not display a mass point. In other words, *ln y* will converge to a normal distribution with positive variance, in which

8. More precisely, $B=\alpha(1-\rho)\ln(\alpha\beta)+\rho(1-\alpha)\ln(1+\lambda)$ and $D=(1-\alpha)(1-\rho)\ln(1+\lambda)$.

9. In fact, a case for divergence can only be made when ln*y* has a unit root, which requires either r = 1 (a unit root in the technology shock) or $\alpha = 1$ (a model of endogenous growth of the AK type).

10. In general, if the productive shocks follow an AR(j) process, *ln y* follows an AR(j + 1) process.

Figure 4. Distribution of $\hat{\vartheta}$ from Absolute Convergence Tests with I.I.D. Shocks[a]



a. Estimates obtained from 2,000 artificial samples for one hundred countries.

case the probability of observing identical levels of y is zero.

Next, I focus on the implications of different parameterizations of equation 12 for the convergence tests discussed in section 1.

3.1 Independently and Identically Distributed Shocks

An absolute convergence test such as equation 2 is correctly specified only when the technology shocks are independently and identically distributed (i.i.d.). In that case equation 12 reduces to

$$\ln y_{it} = \alpha \ln(\alpha\beta) + (1-\alpha)\ln(1+\lambda)t + \alpha \ln y_{it-1} + \varepsilon_{it} . \qquad (13)$$

Independent of the initial distribution of per capita GDP and population growth rates, $\hat{\vartheta}$ in equation 2 consistently estimates the coefficient $\alpha - 1$, and convergence should occur.[11]

11. That is, $\hat{\vartheta}$ should be negative and statistically different from zero, provided that $0 < \alpha < 1$. Of course, equation 2 should also include a deterministic trend.

Figure 4 presents the empirical distribution of $\hat{\vartheta}$, computed from artificial samples of countries. Each sample consists of a hundred countries, and the initial per capita GDP is obtained from bootstrapping realizations of per capita GDP in 1960. Based on these initial conditions, values of $\ln y_{it}$ are simulated from equation 13 for a thirty-six-year period. Finally, for each sample an estimate for ϑ was obtained by running a regression like equation 1.[12] The probability of obtaining estimates of $\hat{\vartheta}$ consistent with the results from section 1 is, of course, zero, because even if the distribution of per capita GDP in 1960 is considered as the initial condition, i.i.d. shocks with realistic figures for α are unable to produce enough persistence in $\ln y$.

Furthermore, the precise nature of absolute convergence is dictated by ϕ. If $\phi = 0$, then in the long run countries converge (in probability) to the same per capita GDP, whereas if some shocks are idiosyncratic, per capita GDP converges to a nondegenerate distribution in the long run.

Figures 5 and 6 reveal another characteristic of i.i.d. productivity shocks: even when they begin with a bimodal distribution for initial per capita GDP, the bimodality quickly disappears because y is not persistent enough. In fact, after thirty-six years, per capita GDP would not feature twin peaks. Thus, i.i.d. shocks are inconsistent with the evidence reported on section 1.

3.2 Persistent Shocks

If the unrealistic setup of i.i.d. technology shocks is abandoned, $\ln y$ can be made significantly persistent by choosing a value of r close to one. Persistence of technology shocks is routinely invoked in the literature on real business cycles, and it is broadly consistent with key stylized facts of modern economies. Once persistence in $\ln y$ is obtained without having to resort to unrealistic values of α, the conclusions regarding i.i.d. shocks change radically.

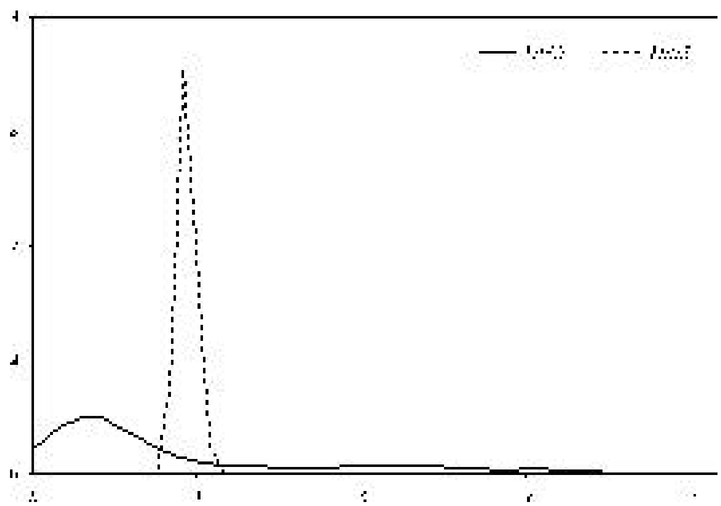
Remember that the law of motion of the univariate representation for $\ln y_{it}$ is expressed by equation 12; that is,

$$\ln y_{it} = B + Dt + (\alpha + \rho)\ln y_{it-1} - \alpha\rho \ln y_{it-2} + \varepsilon_{it} .$$

Convergence tests such as equation 2 are clearly misspecified. Furthermore, as demonstrated by den Haan (1995), the estimated value of

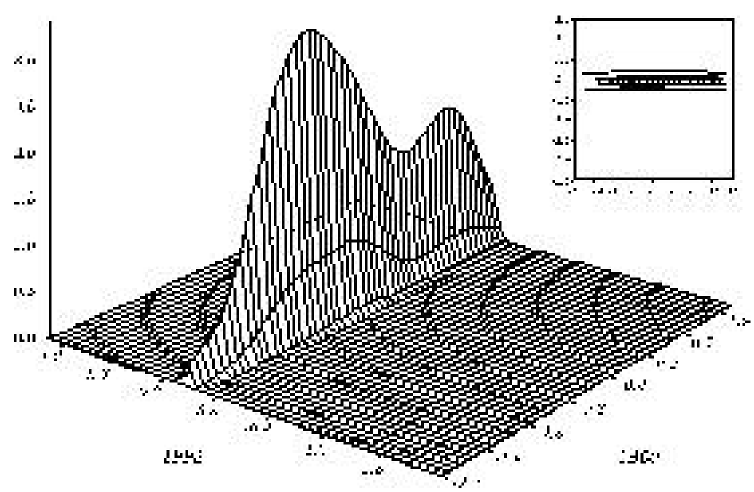
12. The parameter values for this model were set as follows: $\alpha = 0.35$, $\beta = 0.96$, $\lambda = 0$, $\phi = 1$, and $\sigma_w^2 = 0.05^2$.

Figure 5. Densities of Relative per Capita GDP with I.I.D. Shocks[a]



a. Empirical densities for an artificial realization of one hundred countries.

Figure 6. Surface and Contour Plots of Log of Relative per Capita GDP for I.I.D. Shocks[a]



a. Results for an artificial realization of one hundred countries.

ϑ in equation 1 is inconsistent and biased toward zero. In other words, even if the model implied convergence, the estimated value of ϑ is biased toward the rejection of this hypothesis. Furthermore, using pooled observations in equation 2 shows that

$$\hat{\vartheta} \xrightarrow{p} \psi - 1 = \frac{(1-\alpha)(1-\rho)}{1+\alpha\rho},$$

where $\psi = (\alpha + \rho) / (1 + \alpha\rho)$ is the first-order autocorrelation of $\ln y$. This implies that the more persistent the technology shocks, the closer the probability limit of $\hat{\vartheta}$ will be to zero.

Figure 7 presents an exercise similar to that reported in figure 4 for the i.i.d. case. Here I consider exactly the same parameterization, but I now set $\rho = 0.97$. The difference is that even when the model implies convergence, the results of estimating equation 1 by bootstrapping the initial distribution of $\ln y$ that was observed in 1960 presents a nonnegligible probability (11 percent) that the estimated coefficient would indeed be positive (implying divergence).

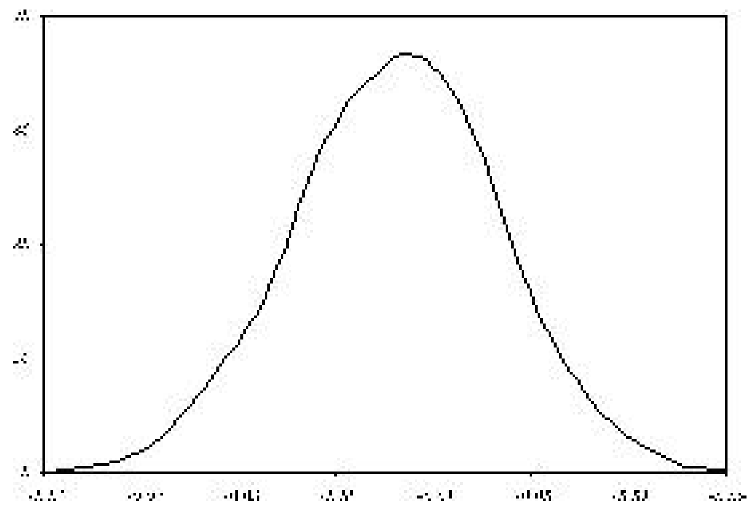
Furthermore, as figure 8 reveals, persistent technology shocks can replicate a bimodal joint distribution of the initial log of per capita GDP (consistent with that observed in 1960) and the figures that would be obtained thirty-five years later. Because initial conditions do not dissipate as fast as in the i.i.d. case, an initially bimodal distribution would persist even over long periods. Thus bimodality in the short run is not inconsistent with a model that displays convergence in the long run.

In summary, persistent technology shocks can be broadly consistent with the evidence reported in section 1, in the sense that whatever the initial conditions of the distribution of per capita GDP, they fade slowly. In particular, this simple model, which displays convergence to a unimodal distribution in the long run, is consistent with twin peaks in the distribution of per capita GDP, even over relatively prolonged horizons.

3.3 The Model and Conditional Convergence

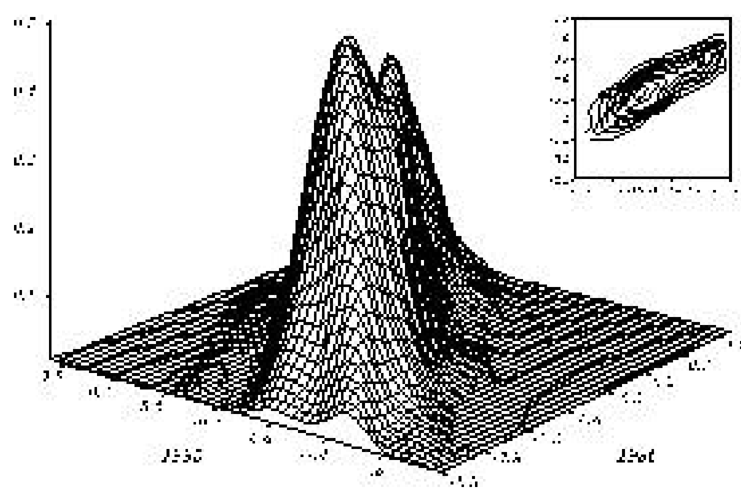
Once persistent shocks are allowed, even the simplest of the exogenous growth models can display several of the features that are considered evidence of divergence or club convergence. Given an initially bimodal distribution of the log of per capita GDP, therefore, persistence by itself could generate an illusion of bimodality for prolonged periods.

Figure 7. Empirical Density of Absolute Convergence Tests with AR(1) Shocks[a]



a. Empirical distribution of the $\hat{\vartheta}$ coefficients obtained with 2,000 artificial samples for one hundred countries.

Figure 8. Surface and Contour Plots of Log of Relative per Capita GDP for AR(1) Shocks[a]



a. Results for an artificial realization of one hundred countries.

However, the models just described are not consistent with evidence of conditional convergence. A few lags added to an equation like equation 2 would become sufficient statistics for ln*y*, and no other variable in the econometrician's information set should be informative. The results of conditional convergence (statistically significant **x** variables) can still be found when a misspecified law of motion for ln*y* is considered. In particular, if some **x** variables are correlated with the initial distribution of *y*, models that do not include as many lags of the variable as necessary can easily be found to be significant.

Furthermore, the models discussed above are among the simplest that can be generated from the theoretical model. In models in which population growth rates can be determinants of ln*y* (such as those described in Chumacero, 2002), the exclusion of ln*y* from growth regressions could generate results consistent with conditional convergence, provided that technology shocks and population growth are persistent and that the chosen **x** variables correlate with initial conditions. In fact, as stressed in section 1, most of the supposedly robust **x** variables that are included in growth regressions are both persistent and strongly correlated with initial conditions.

If the economy is better characterized using parameters that do not allow for an analytical solution for the law of motion of ln*y*, equations 1 and 2 can, at best, be viewed as linear approximations. The more nonlinear the model, the more inaccurate this approximation will be, and any omitted nonlinear terms may be approximated by any **x** variable that is correlated with the initial conditions.

4. Concluding Remarks

This paper takes issue with interpretations of cross-country growth models that contend that the convergence hypothesis is strongly rejected by the data. It shows that even the simplest exogenous growth model that in the long run displays absolute convergence can present several features that such studies argue to be evidence against convergence. In particular, if persistent and moderately volatile productivity shocks are allowed, exogenous growth models can display features such as bimodality and asymmetries in the unconditional distribution of relative per capita GDP. Furthermore, there is a nonnegligible probability that misspecified econometric models will reject absolute convergence even when it is present.

Persistence of technology shocks is not enough to generate these results, however. In this case persistence implies that initial conditions will eventually dissipate, and if bimodality is present in a given period, it will not dissipate for long periods.

The paper also presented simple (and realistic) variations of the models, which ultimately imply convergence, and showed how they can be made consistent with conditional convergence results. This occurs when the chosen determinants of growth are correlated with initial conditions and when the models being tested are misspecified (with an incorrect law of motion of per capita GDP or omission of nonlinearities).

Finally, the paper does not explain the initial bimodality that seems to be present in the data. Apparently relevant policy variables in conditional convergence regressions may have something to do with this. McGrattan and Schmitz (1999) argue that distortionary policies are at fault. If so, the model presented here implies that convergence to an ergodic distribution of per capita GDP should be achieved if these policies also converge.

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QUANTITY AND QUALITY OF ECONOMIC GROWTH

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Most cross-country studies of economic growth, including my earlier research, focus on the determinants of narrow economic variables. The variables most often studied are the growth rate of per capita gross domestic product (GDP) and the ratio of investment to GDP.

In this study, my focus is on the determination of quality dimensions of economic development. By quality, I mean factors such as life expectancy, fertility, environmental conditions, income inequality, and aspects of political institutions. The political dimensions that I consider are democracy in the sense of electoral rights, maintenance of the rule of law, and the extent of official corruption. I also look at the determinants of crime, measured by murder rates.

Religiosity, which is a key element of a nation's culture, can be viewed as another quality dimension of economic development. The last section thus examines how religiosity typically behaves during the process of economic development. To carry out this analysis, I use recently generated international data on church attendance and religious beliefs.

1. ECONOMIC GROWTH

Previous cross-country research reveals a number of empirical regularities concerning the determination of economic growth. For given policies and institutions and for given starting levels of human capital, a country tends to grow faster per capita if it starts with a lower per capita GDP. This pattern is known as conditional convergence, that is,

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the poor tend to converge toward the rich if policies and institutions are held constant. However, the strong tendency for rich countries to have better policies and institutions (which explains their being rich) eliminates the convergence tendency in an absolute or nonconditional sense.

The cross-country research isolates some specific measures of policies, institutions, and initial human capital that are systematically related to subsequent growth. For a given initial per capita GDP, growth tends to be fostered by higher starting levels of education and health, lower fertility, better maintenance of the rule of law, smaller government consumption, greater openness to international trade, lower inflation, and a higher propensity to invest. Growth is also stimulated by improvements in the terms of trade.

Table 1 illustrates these kinds of results for eighty-four countries with available data. The system is estimated as a panel, where the dependent variable is the growth rate of per capita GDP over the periods 1965–1975, 1975–1985, and 1985–1995.[1] The coefficients are estimated from instrumental variables as an attempt to isolate the effects from the explanatory variables on the growth rate. The instruments are mainly lagged values of the regressors. Different intercepts are estimated for each time period.

In system 1, the estimated coefficient on the log of per capita GDP at the beginning of the period equals –0.030 and is highly significant. This coefficient means that the estimated rate of conditional convergence is around 3 percent per year.

One result related to initial human capital is a marginally significant positive coefficient for the average years of school attainment of adult males. Also significantly positive is the log of life expectancy at birth; improved health is thus a component of human capital that

1. The GDP data are the purchasing-power-parity (PPP) adjusted values reported by Summers and Heston in their Penn World Table version 5.6, available at www.nber.org; see Summers and Heston (1991) for a general discussion. Most of the other data have been discussed in previous research; see, for example, Barro (2000). The results are similar in most respects for a system with seven five-year periods: 1965–1970, …, 1995–2000. The fits of the equations are much poorer in the five-year system, suggesting that much of economic growth over short intervals is dominated by forces—business cycles—that are unrelated to the mostly longer-term determinants of growth considered in table 1. However, the estimated standard errors of the coefficients tend to be slightly smaller in the five-year system, suggesting that a little more information about long-term growth effects is generated by observing the data at a somewhat higher frequency. The largest change occurs for the inflation rate, which has an estimated coefficient that is statistically significant and about three times as large in magnitude in the five-year system as in the ten-year system shown in table 1.

Table 1. Regressions for Economic Growth[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Log (per capita GDP)	–0.0297	–0.0279	–0.0263	–0.0297	–0.0347	–0.0316	–0.0299	–0.0294	–0.0215	–0.0328
	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0038)	(0.0037)	(0.0032)	(0.0032)	(0.0049)	(0.0051)
Years of male upper schooling	0.0035	0.0088	0.0039	0.0034	0.0016	0.0034	0.0036	0.0036	0.0036	0.0036
	(0.0019)	(0.0035)	(0.0017)	(0.0019)	(0.0017)	(0.0020)	(0.0019)	(0.0019)	(0.0020)	(0.0024)
Log (life expectancy)	0.0588	0.0578	0.0563	0.0569	0.0610	0.0574	0.0615	0.0576	0.0680	0.0667
	(0.0141)	(0.0140)	(0.0139)	(0.0143)	(0.0219)	(0.0168)	(0.0148)	(0.0141)	(0.0153)	(0.0267)
Log (fertility rate)	–0.0159	–0.0158	–0.0116	–0.0159	–0.0125	–0.0270	–0.0164	–0.0153	–0.0138	–0.0288
	(0.0058)	(0.0057)	(0.0055)	(0.0058)	(0.0064)	(0.0076)	(0.0058)	(0.0057)	(0.0060)	(0.0081)
Rule of law	0.0133	0.0138	0.0178	0.0114	0.0248	0.0033	0.0129	0.0132	0.0118	0.0138
	(0.0059)	(0.0058)	(0.0061)	(0.0075)	(0.0073)	(0.0071)	(0.0059)	(0.0059)	(0.0062)	(0.0096)
Government consumption ratio	–0.109	–0.102	–0.101	–0.111	–0.184	–0.134	–0.104	–0.106	–0.094	–0.100
	(0.025)	(0.025)	(0.027)	(0.025)	(0.030)	(0.035)	(0.026)	(0.026)	(0.026)	(0.039)
International openness	0.0149	0.0137	0.0108	0.0149	0.0080	0.00105	0.0140	0.0151	0.0178	0.0105
	(0.0044)	(0.0043)	(0.0044)	(0.0044)	(0.0038)	(0.0044)	(0.0044)	(0.0044)	(0.0046)	(0.0048)
Inflation rate	–0.0142	–0.0120	–0.0199	–0.0132	–0.0138	–0.0166	–0.0159	–0.0107	–0.0118	–0.0111
	(0.0105)	(0.0104)	(0.0097)	(0.0101)	(0.0087)	(0.0098)	(0.0106)	(0.0105)	(0.0103)	(0.0112)
Investment ratio	0.057	0.054	0.069	0.059	0.039	0.051	0.062	0.061	0.062	0.028
	(0.026)	(0.026)	(0.024)	(0.026)	(0.030)	(0.028)	(0.026)	(0.026)	(0.027)	(0.042)
Growth of terms of trade	0.079	0.085	0.093	0.081	0.086	0.045	0.082	0.081	0.096	0.063
	(0.032)	(0.032)	(0.032)	(0.032)	(0.041)	(0.038)	(0.032)	(0.032)	(0.034)	(0.050)
Years of female upper schooling		–0.0072								
		(0.0041)								
Democracy			0.100							
			(0.031)							
Democracy squared			–0.087							
			(0.026)							

Table 1. Regressions for Economic Growth[a] (continued)

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Corruption				0.0030 (0.0076)						
Murder rate					−0.00011 (0.00017)					
Gini coefficient						0.021 (0.022)				
Muslim fraction							0.0042 (0.0049)			
Log (population)								−0.0003 (0.0009)		
Log (air pollution)									−0.0053 (0.0030)	
Log (water pollution)										−0.0018 (0.0037)
Summary statistics										
R^2 values, individual periods	.59, .46, .42	.59, .49, .43	.66, .40, .44	.59, .46, .42	.63, .51, .26	.62, .60, .54	.59, .47, .42	.60, .46, .41	.51, .43, .40	.43, .42
No. countries	84	84	84	84	62	67	84	84	81	78
No. observations	244	244	239	244	143	141	244	244	231	142

a. Estimation is by three-stage least squares using mostly lagged explanatory variables as instruments. Standard errors are in parentheses. The growth rate of per capita GDP is observed, except for column 10, for 1965–1975, 1975–1985, and 1985–1995. For column 10, only the last two ten-year periods are included. Constant terms (not shown) are included for each time period in each system. For details on the data, see the text and Barro (2000).

predicts subsequent growth. A significantly negative growth effect appears for the log of the total fertility rate. Hence, there seems to be a tradeoff between a higher rate of population growth (determined in the long run, in particular, by the fertility rate) and the growth rate of per capita output.

A significantly positive effect on growth shows up for a subjective indicator of the maintenance of the rule of law. This variable (measured on a [0,1] scale, with a higher variable being more favorable) is the one provided in the *International Country Risk Guide,* published by the international consulting service Political Risk Services.[2] The indicator is intended to gauge the extent of law and order and the nature of the legal and judicial systems.

Also significantly positive for growth is a measure of international openness.[3] The government consumption ratio is significantly negative, and the inflation rate is negative but only marginally significant (see footnote 1).[4] The investment ratio and the growth rate of the terms of trade (export prices relative to import prices) also have significantly positive effects.

The remaining columns of table 1 show the effects of the introduction of additional explanatory variables as determinants of economic growth. System 2 adds the average years of school attainment of adult females at the start of the period. The estimated coefficient is negative and marginally significant. If years of primary schooling are also added, then the point estimates are negative for male primary and positive for female primary, but neither coefficient is statistically significant. Discussions of these kinds of effects from initial levels of schooling appear in Barro (1999).

Some previous research considers growth effects of democracy, measured by subjective indicators from Freedom House of electoral rights and civil liberties. These variables, available on the Internet at freedomhouse.org, are considered in addition to the indicator for maintenance of the rule of law. If the electoral rights variable is added to the system for growth, then its estimated coefficient (0.0083, s. e. = 0.0072)

2. Since this indicator is available starting only in 1982, later values of the variable are allowed to influence earlier values of economic growth. The rationale is that rule of law tends to persist substantially over time, so that later values may be satisfactory proxies for earlier ones.

3. This variable is the ratio of exports plus imports to GDP, filtered for the usual relation of this ratio to country size (measured by the logs of population and area).

4. The government consumption ratio is based on the standard measure of government consumption less outlays on defense and education.

is positive but statistically insignificantly different from zero. However, the inclusion of a quadratic term in the electoral rights measure, as in system 3 of table 1, indicates that growth is first increasing and subsequently decreasing in the extent of democracy. Similar results apply to the indicator for civil liberties. This kind of relation has been discussed in Barro (2000).

Other research has focused on the growth effects from official corruption. System 4 of table 1 adds a subjective indicator of corruption, again constructed by Political Risk Services. (The variable is defined on a [0,1] scale, with a higher number signifying a more favorable environment, that is, *less* corruption.) The estimated coefficient on the corruption variable is indistinguishable from zero. A possible interpretation for a nonpositive effect is that corruption can be favorable to growth by inhibiting the enforcement of poor laws and regulations. Note also that the effect of official corruption is estimated while holding fixed the measure of rule of law. If the rule of law variable is omitted, the estimated coefficient on corruption becomes larger and marginally significant (0.0103 [0.0061]).

System 5 of table 1 adds the country's murder rate (number per year per 100,000 inhabitants); the data are those used by Fajnzylber, Lederman, and Loayza (2000). As these authors point out, the murder data have more consistency across countries and over time than do alternative measures of violent or total crime. However, the murder rate is statistically insignificant for growth. The rule-of-law variable—which is related to the crime rate through the consideration of "law and order"—becomes *more* significant when the murder rate is added. The inclusion of the murder variable also has a substantial negative effect on the sample size, however, so the systems of columns 1 and 5 are not directly comparable.

System 6 shows that economic growth is not closely related to the extent of income inequality, as gauged by a standard measure, the Gini coefficient, obtained from Deininger and Squire (1996). As with the murder rate, the inclusion of the Gini variable substantially lowers the sample size. Further analysis of the interplay between growth and inequality is contained in Barro (2000).

I also consider the growth implications of different religious denominations. I use here an eight-way breakdown of adherence among persons professing some religion: Catholic, Muslim, Protestant, Hindu, Eastern religions (including Buddhist), Orthodox, Jewish, and other religions. The data are from Barrett (1982). I arbitrarily omitted the Catholic fraction as a normalization and then considered the effects on growth from the fractions affiliated with the other seven denominations. With the other explanatory variables shown in table 1 held constant, this religious breakdown is insignificantly related to growth. (The *p* value for the hypothesis that the seven coefficients all equal zero is 0.42.)

System 7 in the table shows the results when only the Muslim denomination fraction is added to the system. This result may be of special interest because the Muslim variable turns out to be systematically related to some other variables considered later. System 7 shows that the estimated coefficient on the Muslim variable is insignificantly different from zero. Hence, at least when initial income, schooling, fertility, rule of law, and so on are held constant, the extent of Muslim adherence does not matter significantly for growth.

I also examine the growth implications of a country's former colonial status. Four variables—dummies for whether a country is a former colony of Britain, France, Spain or Portugal, and another ruler—are jointly insignificant for growth. The *p* value here is 0.55. A country's colonial history thus is not systematically related to its growth performance, at least when per capita GDP and the other explanatory variables are held constant.

System 8 of table 1 adds the log of population as a country scale variable. (With the log of per capita GDP already included, the results would be the same if the log of GDP were entered.) The result is that country size is insignificantly related to growth. That is, with the other explanatory variables held fixed, large and small countries grow at roughly the same per capita rate.

Systems 9 and 10 consider World Bank measures of environmental conditions. System 9 includes a measure of air pollution—the log of the per capita quantity of industrial emissions of carbon dioxide. Although carbon dioxide emissions are a standard measure of environmental conditions, particularly in discussions of the greenhouse effect, the relation of these emissions to air quality as ordinarily understood is not obvious. Further, the variable measures emissions, not concentrations in the atmosphere in a particular location. In any event, the estimated coefficient on the carbon dioxide variable in system 9 is negative but statistically insignificant.

System 10 includes a measure of water pollution, namely, the log of the per capita quantity of emissions of organic water pollutants (as measured by their biological oxygen demand, or BOD). Again, the variable refers to emissions not to water quality in a particular location. The World Bank data on water pollution are available only since 1980; therefore, the sample size is substantially curtailed. The estimated coefficient of this variable in system 10 is negative but statistically insignificant. Hence, there is no evidence that the state of the environment—as gauged by these concepts of emissions of air and water pollutants—is related to economic growth in a statistically reliable way.

2. Political and Social Variables

The empirical findings in the preceding section indicate that a number of social, political, and institutional variables are important for the determination of economic growth. Many of these variables tend themselves to evolve during the process of economic development. Some of these changes—such as rises in health indicators, reductions in fertility rates, and expansions of democracy—have been described as improvements in the quality of economic growth. (The identification of diminished fertility with improved quality is common but surely debatable.) This quality dimension contrasts with the quantity of economic growth, as measured by increases in per capita GDP.

Interestingly, the associations of some of the social and political variables with economic development have been given familiar names in various research literatures. For example, the Aristotle-Lipset hypothesis (see Aristotle, 1932; Lipset, 1959) states that democracy tends to be enhanced by economic growth, particularly by expansions of income and education. This hypothesis is sometimes extended to legal and criminal institutions, measured, for example, by the maintenance of the rule of law. It is sometimes also argued that greater income inequality decreases the prospects for sustaining democracy and the rule of law.

The association of income inequality, say, the Gini coefficient, with economic development is usually expressed in terms of the Kuznets curve. In this case, the hypothesis is that inequality will first rise and later fall as per capita income increases. In a previous study (Barro, 2000), I discuss the cross-country evidence on this topic, arguing that the Kuznets curve is present in the panel data for a large number of countries.

Grossman and Krueger (1995) observe an analogous Kuznets curve for indicators of air and water pollution. That is, they find, as an average tendency, that these pollution indicators first rise and subsequently decline with per capita GDP. My analysis considers measures of emissions of air and water pollutants, rather than direct measures of conditions of air and water, as used by Grossman and Krueger. For the emissions variables, no Kuznets curve appears, that is, the quantities emitted rise monotonically with economic development.

In the sociology of religion, a famous idea—called either the secularization hypothesis or the modernization hypothesis—is that people become less religious as they become richer and better educated (see Martin, 1978, for a general discussion). This hypothesis is sometimes based on the idea that religion is primarily superstition; more educated people—who are presumably more influenced by science and rational thinking—are thus less likely to follow religious practices. On the other hand, more educated people may also have a greater capacity for abstraction and, therefore, a higher propensity to accept spiritual concepts that cannot be directly observed or verified. In any event, a recent literature, including Finke and Stark (1988) and Iannaccone (1991), argues that the secularization hypothesis conflicts with the cross-country data on church attendance and religious beliefs. In a later section, I present some preliminary results on the relation of religiosity measures to economic development.

Some of the other explanatory variables used in table 1—most notably life expectancy and fertility rates—are particularly closely related to per capita GDP and education. It is surprising that the relationships of these variables with economic development do not yet have famous names.

Table 2, carried out in the spirit of Bill Easterly's analysis in *Life During Growth* (Easterly, 1999), looks at the relation to economic development of some of the social, political, and institutional factors that were viewed as independent variables in table 1. In each case, the right-hand-side variables in table 2 include three basic measures of economic development—the log of per capita GDP, a measure of years of education, and the rate of urbanization. Also included is the Muslim denomination fraction; as mentioned before, this measure of religious adherence has interesting interactions with some of the political and social variables. The second specification in each case adds the Gini coefficient as a measure of income inequality. (Again, the inclusion of this variable substantially reduces the sample size.)

The results in table 2 bring out empirical associations between the various social and political indicators and the extent of economic development, as gauged by per capita GDP and the other right-hand-side variables. Although these associations seem interesting as summaries of regularities in the development process, I cannot claim that the findings establish clear patterns of causation. For example, a rise in per capita GDP is estimated to be positively associated with life expectancy in table 2, while table 1 implies that higher life expectancy raises economic growth and, hence, increases subsequent levels of per capita

Table 2. Regressions for Political and Social Variables (Part 1)[a]

	Dependent variable							
	Log(life expectancy)		*Log(fertility rate)*		*Democracy*		*Rule of law*	
Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Log(per capita GDP)	0.0518	0.0638	–0.082	–0.184	0.155	0.197	0.123	0.129
	(0.0049)	(0.0072)	(0.014)	(0.019)	(0.025)	(0.030)	(0.021)	(0.024)
Total years of schooling							0.0341	0.0145
							(0.0077)	(0.0086)
Years of primary schooling	0.0278	0.0169			0.0308	–0.0012		
	(0.0025)	(0.0033)			(0.0135)	(0.0153)		
Years of male primary schooling			–0.0339	–0.0359				
			(0.0113)	(0.0154)				
Years of female primary schooling			–0.0870	–0.0401				
			(0.0120)	(0.0157)				
Urbanization rate	0.234	0.091	–0.223	–0.263	–0.039	–0.060	–0.206	–0.088
	(0.024)	(0.026)	(0.063)	(0.067)	(0.099)	(0.108)	(0.074)	(0.083)
Muslim fraction	–0.020	–0.095	0.223	0.203	–0.262	–0.220	0.012	–0.077
	(0.016)	(0.017)	(0.041)	(0.044)	(0.055)	(0.061)	(0.040)	(0.045)
Gini coefficient		–0.181		1.39		–0.073		–0.508
		(0.064)		(0.17)		(0.199)		(0.148)
Summary statistics								
Average R^2	0.72	0.67	0.69	0.78	0.48	0.44	0.54	0.62
No. countries	108	85	106	85	108	85	97	73
No. observations	709	439	704	439	708	438	456	300

a. Systems (1)-(16) are estimated by the seemingly unrelated (SUR) method. Standard errors are in parentheses. Constant terms (not shown) are included for each time period for each system. The logs of life expectancy at birth and the total fertility rate are observed in 1970, 1975,..., 1995, 1998. The measure of democracy (electoral rights from Freedom House) is observed in 1972, 1975, 1980,..., 2000. The rule-of-law and official corruption variables (from Political Risk Services) are observed in 1982, 1985, 1990, 1995, and 2000. The murder rate (from Fajnzylber, Lederman, and Loayza, 2000) is observed in 1970, 1975,..., 1995. Air pollution (per capita industrial emissions of carbon dioxide) is observed as averages for 1965–1969, 1970–1974,..., 1990–1994, 1995–1996. Water pollution (per capita industrial emissions of organic water pollutants measured in accordance with their biological oxygen demand, or BOD) is observed as averages for 1980–1984, 1985–1989, 1990–1994, and 1995–1996.

Table 2. Regressions for Political and Social Variables (Part 2)[a]

	Dependent variable							
	Corruption		*Murder rate*		*Log(air pollution)*		*Log(water pollution)*	
Explanatory variable	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*
Log(per capita GDP)	0.084	0.042	2.01	1.62	2.36	2.91	3.69	2.80
	(0.021)	(0.025)	(1.10)	(1.06)	(0.43)	(0.57)	(0.58)	(0.61)
Log(per capita GDP) squared					–0.096	–0.124	–0.181	–0.134
					(0.027)	(0.035)	(0.035)	(0.038)
Total years of schooling	0.0232	0.0241	–0.84	–0.40				
	(0.0079)	(0.0091)	(0.33)	(0.30)				
Years of primary schooling					0.213	0.192	0.195	0.183
					(0.032)	(0.037)	(0.036)	(0.036)
Urbanization rate	–0.003	0.171	–4.43	–2.49	1.60	1.20	–0.06	–0.04
	(0.081)	(0.090)	(3.61)	(3.39)	(0.23)	(0.25)	(0.25)	(0.24)
Muslim fraction	–0.044	–0.022	–5.50	–1.35	0.49	0.48	–0.13	–0.14
	(0.041)	(0.049)	(1.94)	(2.02)	(0.15)	(0.15)	(0.13)	(0.15)
Gini coefficient		–0.258		17.30		–0.11		–0.82
		(0.165)		(6.1)		(0.49)		(0.52)
Summary statistics								
Average R^2	0.48	0.50	0.06	0.11	0.84	0.81	0.74	0.74
No. countries	97	73	78	63	102	86	100	74
No. observations	456	300	330	244	669	388	328	218

a. Systems (1)-(16) are estimated by the seemingly unrelated (SUR) method. Standard errors are in parentheses. Constant terms (not shown) are included for each time period for each system. The logs of life expectancy at birth and the total fertility rate are observed in 1970, 1975,…, 1995, 1998. The measure of democracy (electoral rights from Freedom House) is observed in 1972, 1975, 1980,…, 2000. The rule-of-law and official corruption variables (from Political Risk Services) are observed in 1982, 1985, 1990, 1995, and 2000. The murder rate (from Fajnzylber, Lederman, and Loayza, 2000) is observed in 1970, 1975,…, 1995. Air pollution (per capita industrial emissions of carbon dioxide) is observed as averages for 1965–1969, 1970–1974,…, 1990–1994, 1995–1996. Water pollution (per capita industrial emissions of organic water pollutants measured in accordance with their biological oxygen demand, or BOD) is observed as averages for 1980–1984, 1985–1989, 1990–1994, and 1995–1996.

GDP. These two directions of causation are mutually compatible and are likely both valid, but the present econometric analysis is inadequate for sorting out the exact patterns. The results in table 2 (and table 1) should be interpreted subject to these caveats.

Each system shown in table 2 is estimated as a panel using the seemingly unrelated, or SUR, technique. This procedure allows the error terms to vary over the time periods and to be correlated over these periods.

To illustrate the timing between the dependent and independent variables, in column 1, the dependent variable is the log of life expectancy at birth, observed at seven points in time: 1970, 1975, 1980, 1985, 1990, 1995, and 1998. The independent variables include prior values of the development variables: the log of per capita GDP (for 1965, 1970,...), the school attainment measure (for 1965, 1970,...), and the urbanization rate (for 1965, 1970,...). The Muslim denomination variable applies around 1970 for the first two equations and around 1980 for the others. The Gini coefficient, where it is included, applies around 1970 in the first two equations, 1980 for the next two, and 1990 for the last three. The precise dating for the dependent and independent variables—and the number of equations—in each system varies, as indicated in the notes to table 2.

The three development indicators have highly significantly positive coefficients for explaining life expectancy at birth in column 1 of table 2. In this case, schooling is represented by primary education. The addition of years of schooling at the secondary and higher levels does not add to the explanatory power for life expectancy. The main inference from these results is that, not surprisingly, improved life expectancy typically accompanies economic development. The Muslim denomination variable is insignificant in this system.

In column 2, the Gini coefficient has a significantly negative coefficient. That is, for a given per capita GDP and so forth, average life expectancy tends to be lower when income is more unevenly distributed. In comparison with column 1, the urbanization variable is much less important, and the Muslim fraction becomes significantly negative.

Columns 3 and 4 take the log of the total fertility rate as the dependent variable. In this case, the adult educational attainment variables that have the most explanatory power are primary schooling distinguished by males and females. The development indicators are, in this case, strongly negatively related to fertility. Moreover, in column 3, female primary schooling is substantially more important than male schooling.

In column 4, the Gini coefficient is significantly positive—that is, greater inequality goes along with a higher economy-wide fertility rate. With the Gini coefficient held constant, the negative effects of male and female primary education are now of similar magnitude. The Muslim religion fraction is significantly positive in systems 3 and 4. That is, even with per capita GDP and the other variables held constant, a higher value of the Muslim denomination fraction goes along with higher fertility.

Systems 5 and 6 look at electoral rights as a measure of democracy. The estimated coefficients of the log of per capita GDP are significantly positive, thereby supporting the Aristotle-Lipset hypothesis. The urbanization variable is not important here. Years of primary schooling have the main explanatory power related to education, and this variable is significantly positive in column 5. The variable is insignificant in column 6, however, when the Gini coefficient is held constant (and where the sample size is altered to reflect the availability of data on inequality). The Gini coefficient is itself insignificant in column 6—that is, the results fail to support the idea that greater equality of income reinforces the tendency toward democracy. The Muslim variable is significantly negative in columns 5 and 6. Hence, even with per capita GDP and the other explanatory variables held constant, a higher value of the Muslim variable is associated with less democracy.

The results for the rule of law in columns 7 and 8 are similar with respect to the effects of the log of per capita GDP. However, primary schooling now plays no special role, and the total years of schooling is the education variable with the most explanatory power. This suggests that basic education is important for maintaining electoral rights (in system 5), whereas broader education plays more of a role in sustaining law and order and a functioning legal system (in system 7).

The urbanization rate is significantly negative for the rule of law in column 7—this finding may reflect an adverse influence of urbanization on law and order. Also, in contrast with the results for democracy in columns 5 and 6, the Muslim fraction is insignificant for explaining the rule of law in columns 7 and 8. This finding is noteworthy because the rule-of-law variable tends to have a positive effect on economic growth (in table 1), whereas the level of democracy lacked a clear relationship with growth. On this count, then, a larger Muslim fraction might make democracy less likely without impeding the growth process.

The Gini coefficient has a significantly negative coefficient for explaining the rule of law in column 8. Thus, although greater inequality did not seem to impair the sustainability of electoral rights, it does seem to hinder the maintenance of the rule of law (perhaps by making it more difficult to sustain law and order).

Columns 9 and 10 deal with the indicator for official corruption (where, again, a higher value signifies less corruption). These results are broadly similar to those for the rule of law in columns 7 and 8, although the positive effects for the log of per capita GDP are weaker in the case of the corruption variable. One other difference is that the estimated coefficient on the urbanization rate is essentially zero in column 9—that is, in contrast with the tendency for urbanization to go along with weaker rule of law, there is no relationship with the extent of official corruption. Moreover, in column 10, where the Gini coefficient is held constant, the estimated coefficient of the urbanization rate is positive. The estimated negative coefficient on the Gini variable in column 10 is weaker than it was in column 8.

For the murder rate in columns 11 and 12, one immediate observation is that the fit is very poor. That is, economic development overall explains little of the observed variations in murder rates (and, presumably, in crime rates more broadly). Surprisingly, the estimated effect of per capita GDP is positive and even marginally statistically significant in column 11. The greatest explanatory power comes in column 12 from the Gini coefficient. As stressed by Fajnzylber, Lederman, and Loayza (2000), murder rates are much more related to the degree of income inequality (positively) than to the level of per capita GDP. This result makes sense from the standpoint of incentives for crime—which relate in the first instance to the difference in wealth between the victim and the perpetrator. The Muslim coefficient is significantly negative in column 11 but becomes statistically insignificant in column 12 when the Gini variable is included.

Columns 13 through 16 deal with the indicators for emissions of air and water pollutants. For air pollution, the main result in column 13 is a positive influence of economic development on the per capita quantity of industrial emissions of carbon dioxide. The estimated coefficient on the square of the log of per capita GDP is significantly negative, as in usual Kuznets curve relationships. However, even with primary schooling and the urbanization rate held fixed (and these variables are themselves strongly positively associated with per capita GDP), the implied net marginal effect of per capita GDP on the dependent variable is positive throughout the relevant range of the sample. Similarly, in column 15, the indicator for emissions of water pollutants is increasing in per capita GDP throughout the relevant range.

Table 3. Regression for Gini Coefficient[a]

Explanatory variable	*(1)*
Log (per capita GDP)	0.484 (0.091)
Log (per capita GDP) squared	–0.0305 (0.0058)
Years of primary schooling	–0.0257 (0.0051)
Years of secondary schooling	–0.0169 (0.0086)
Years of higher schooling	0.030 (0.037)
Urbanization rate	0.029 (0.036)
Muslim fraction	–0.052 (0.020)
Dummy for net income or expenditure data	–0.073 (0.011)
Dummy for individual data	–0.021 (0.010)
Summary statistics	
Average R^2	0.52
No. countries	89
No. observations	226

a. The system is estimated by the seemingly unrelated (SUR) method. Standard errors are in parentheses. The Gini coefficient, from Deininger and Squire (1996), is observed around 1960, 1970, 1980, and 1990. See Barro (2000) for further discussion of these data. Constant terms (not shown) are included for each time period.

These results on environmental variables differ markedly from those reported by Grossman and Krueger (1995). The main differences likely stem from my use of indicators of emissions of pollutants, whereas Grossman and Krueger use direct observations of air and water conditions. However, their data are much more limited in coverage by countries and over time.

Table 3 shows results with the Gini coefficient treated as the dependent variable. A Kuznets curve shows up in that the estimated coefficient on the log of per capita GDP is significantly positive, whereas that on the square of the log of per capita GDP is significantly negative. The estimated coefficients imply that the marginal effect of per capita GDP on the Gini coefficient turns from positive to negative when the level of per capita GDP reaches roughly the sample average of $2,800 (in PPP-adjusted 1985 U.S. dollars).

The results in table 3 also show a significantly negative coefficient for primary schooling, a marginally significant negative coefficient for secondary schooling, and an insignificant positive coefficient for higher schooling. The urbanization rate is insignificant. The table further indicates that the estimated coefficient on the Muslim fraction is significantly negative. That is, a higher Muslim fraction goes along with greater equality of income.

To summarize, economic development tends to be accompanied by higher life expectancy (and, presumably, better health generally), lower fertility rates, a higher propensity to democracy, and better institutions in the form of enhanced rule of law and less official corruption. Development is also associated, however, with increases in two standard measures of environmental pollution—per capita industrial emissions of carbon dioxide and organic water pollutants—although these results do not necessarily imply the same positive relationship between development and measures of air and water quality. The association of the murder rate—and, presumably, crime more broadly—with economic development is weak. Finally, the association between development and income inequality is complex. First, the estimated relation with per capita GDP is not monotonic; as suggested by Kuznets, it first rises and later falls. Second, a rise in primary education tends to lower inequality, but a rise in higher education may increase inequality.

3. Religiosity

In recent research, I study the secularization hypothesis, that is, the relation of economic development to religiosity. Table 4, which is based on preliminary results reported in Barro and McCleary (2001), shows some regression results with a measure of religiosity taken as the dependent variable. The table encompasses five systems corresponding to the different measures of religiosity—fraction of the population attending church at least weekly (column 1), monthly church attendance (column 2), fraction of the population believing in heaven (column 3), fraction believing in hell (column 4), and fraction believing in an afterlife in column 5. (The actual form of each dependent variable is a transformation of the original data; see the notes to table 4.) Each system consists of five equations corresponding to the religiosity survey data. The first system is for 1981 data from the *World Values Survey* (*WVS*), which is described in Inglehart and others (2000). The second system is for 1990 data from WVS. The third system is for 1991 data from the *International Social Survey Programme* (*ISSP*).[5] The fourth system is for 1995 data from WVS, and the fifth is for 1998 data from ISSP.

5. Available on the Internet at www.gesis.org/issp.

Table 4. Regressions for Church Attendance and Religious Beliefs[a]

	Dependent variable				
	Weekly church attendance	*Monthly church attendance*	*Belief in heaven*	*Belief in hell*	*Belief in afterlife*
Explanatory variable[b]	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Log (per capita GDP)	0.08	0.09	–0.48	–0.45	–0.55
	(0.17)	(0.17)	(0.21)	(0.19)	(0.17)
Total years of education	0.265	0.238	0.231	0.204	0.128
	(0.044)	(0.040)	(0.045)	(0.043)	(0.038)
Urbanization rate	–2.00	–1.82	–1.74	–2.28	–1.21
	(0.43)	(0.40)	(0.45)	(0.44)	(0.37)
Log (life expectancy)	–9.70	–9.40	1.70	1.80	7.20
	(2.0)	(1.9)	(2.5)	(2.1)	(2.0)
Population share	–3.60	–5.70	–14.90	–13.00	–9.00
older than 65	(2.3)	(2.1)	(2.5)	(2.3)	(2.1)
Religious pluralism	1.40	1.10	0.95	0.97	–0.27
	(0.40)	(0.36)	(0.39)	(0.39)	(0.33)
State religion (dummy)	0.61	0.64	0.84	0.49	0.11
	(0.16)	(0.15)	(0.19)	(0.17)	(0.16)
State regulation	–0.81	–0.72	–0.27	–0.05	–0.04
of religion (dummy)	(0.15)	(0.13)	(0.14)	(0.14)	(0.12)
Communist regime	–0.89	–1.17	–1.35	–1.30	–1.10
(dummy)	(0.22)	(0.21)	(0.23)	(0.22)	(0.20)
ex-Communist regime	0.08	0.29	0.54	0.90	0.35
(in 1995, dummy)	(0.20)	(0.19)	(0.24)	(0.22)	(0.21)
ex-Communist regime	0.26	0.43	0.37	0.57	0.44
(in 1998, dummy)	(0.17)	(0.14)	(0.17)	(0.18)	(0.15)
ISSP data (dummy)	–0.29	–0.16	0.11	0.38	0.12
	(0.08)	(0.08)	(0.09)	(0.09)	(0.08)
Muslim fraction	0.51	–0.31	1.46	2.18	0.75
	(0.37)	(0.36)	(0.43)	(0.38)	(0.36)
Protestant fraction	–2.76	–2.28	–1.17	–1.23	–0.49
	(0.22)	(0.21)	(0.26)	(0.24)	(0.23)
Hindu fraction	–2.04	–2.07	–2.75	–1.87	–1.49
	(0.54)	(0.51)	(0.57)	(0.52)	(0.50)
Eastern religion fraction	–3.53	–3.01	–1.34	–0.70	–1.01
	(0.31)	(0.28)	(0.33)	(0.32)	(0.26)
Jewish fraction	–1.99	–2.50	–2.00	–0.76	–1.03
	(0.57)	(0.50)	(0.42)	(0.45)	(0.38)

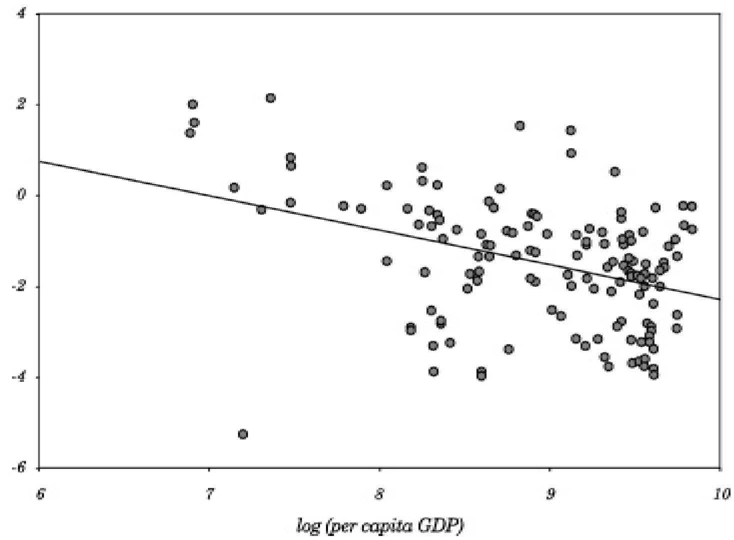
Table 4. (continued)

	Dependent variable				
	Weekly church attendance	*Monthly church attendance*	*Belief in heaven*	*Belief in hell*	*Belief in afterlife*
Explanatory variable[b]	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Orthodox fraction	–3.31	–2.08	–1.28	–0.73	–0.69
	(0.32)	(0.29)	(0.31)	(0.31)	(0.26)
Other religion fraction	–3.48	–3.95	0.91	–0.99	1.56
	(0.89)	(0.84)	(1.09)	(0.96)	(0.90)
Summary statistics					
Average R^2	0.79	0.81	0.81	0.70	0.62
No. countries	51	51	50	50	50
No. observations	140	139	130	130	130

a. Estimation of each system is by the seemingly unrelated (*SUR*) method. Constant terms (not shown) are included for each system (but do not vary over the time periods within a system). Standard errors are in parentheses. Each system, numbered 1 through 5, consists of five equations corresponding to observations for countries on the dependent variables at five points in time: 1981 (*World Values Survey* data), 1990 (*WVS*), 1991 (*International Social Survey Programme* data), 1995 (*WVS*), and 1998 (*ISSP*). See Inglehart (2000) and www.gesis.org/issp for discussions of these data. The dependent variables are population averages of weekly church attendance (1), monthly church attendance (2), and beliefs in heaven (3), hell (4), and an afterlife (5). The measured value is either the fraction of people attending or the fraction who hold the belief. For example, in system 1, weekly church attendance is observed for twenty-two countries with 1981 data, thirty-six countries with 1990 data, twenty-two countries with 1991 data, thirty-two countries with 1995 data, and twenty-eight countries with 1998 data. The form of each dependent variable used in the regressions is $\log[x/(1-x)]$, where x is the fraction of persons attending or believing. This form confines fitted values of x to the interval [0,1].

b. The explanatory variables are as follows: the log of real per capita GDP, average years of schooling of adults aged 25 and older, the urbanization rate, the log of life expectancy at birth, and the share of the population aged 65 and over are observed just prior to the dependent variable. For example, 1980 per capita GDP is matched with the dependent variables for 1981, 1990 per capita GDP with the dependent variables for 1990 and 1991, and 1995 per capita GDP with the dependent variables for 1995 and 1998. Religious pluralism (1 minus the Herfindahl index of religious denomination shares for nine categories of religions among those professing some religion) is for 1980 using data from Barrett (1982, 2001). The dummy variable for the presence of a state religion (from Barrett) applies in 1970. The dummy variable for state regulation of religion (based on whether the state appoints or approves church leaders, from Barrett, 2001) is for the 1970s. The dummy for the presence of a Communist regime applies to the pre-1990 period. The 1995 and 1998 equations also include a dummy for whether the country used to be Communist but is no longer. For example, in the 1995 equations, the total effect for a former-Communist country equals the coefficient on the Communist dummy plus the coefficient on the ex-Communist (in 1995) dummy. The dummy for the use of *ISSP* data applies to the 1991 and 1998 equations. (This variable allows for the possibility of systematic differences between the *WVS* and *ISSP* sources.) The religious denomination variables are the fractions professing each religion in 1980, according to Barrett (1982). The Catholic fraction is omitted in each case; hence, the coefficient on each denomination represents the differential effect between that denomination and the Catholic one.

Figure 1. Weekly Church Attendance[a] and GDP, Simple Relation



a. Normalized as log[x/(1 – x)], where x is the fraction of persons attending church weekly.

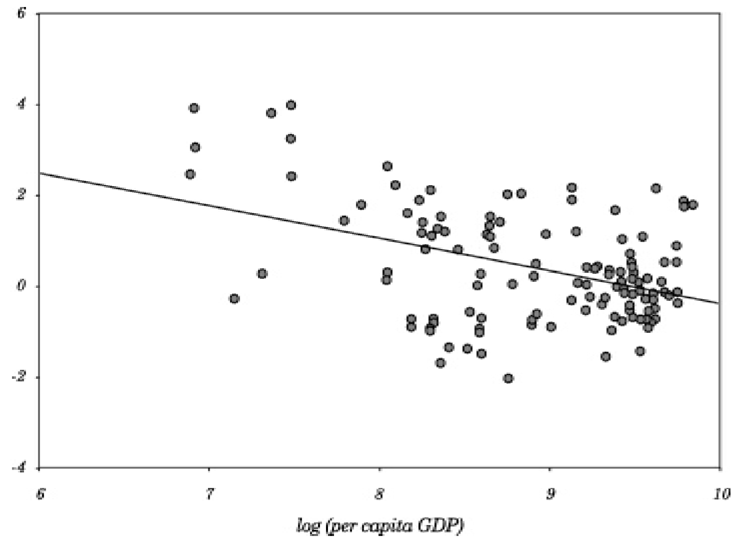
The WVS and ISSP data are aggregated measures based on samples of individuals within countries. The notes to the data indicate that, in most cases, the samples are representative of the overall population. The two data sources appear to be comparable, but the analysis allows for systematic differences in the reported levels of church attendance and beliefs. That is, different intercepts for equations based on WVS or ISSP data are included in the regressions.

The explanatory variables include five measures of economic development: per capita GDP, average years of school attainment of the adult population, the urbanization rate, the log of life expectancy at birth, and the fraction of the population aged 65 and over.

The statistical findings reveal an overall pattern in which economic development is associated with less religiosity, measured by church attendance or beliefs. This pattern can be seen by looking at simple relations (where no other variables are held constant) between a measure of religiosity and per capita GDP (viewed as the basic indicator of development). As examples, negative associations appear for weekly church attendance in figure 1 and for belief in heaven in figure 2.

The statistical results shown in table 4 reveal very different patterns for the individual dimensions of economic development. Two results that

Figure 2. Belief in Heaven[a] and GDP, Simple Relation



a. Normalized as log[x/(1 – x)], where x is the fraction of believers.

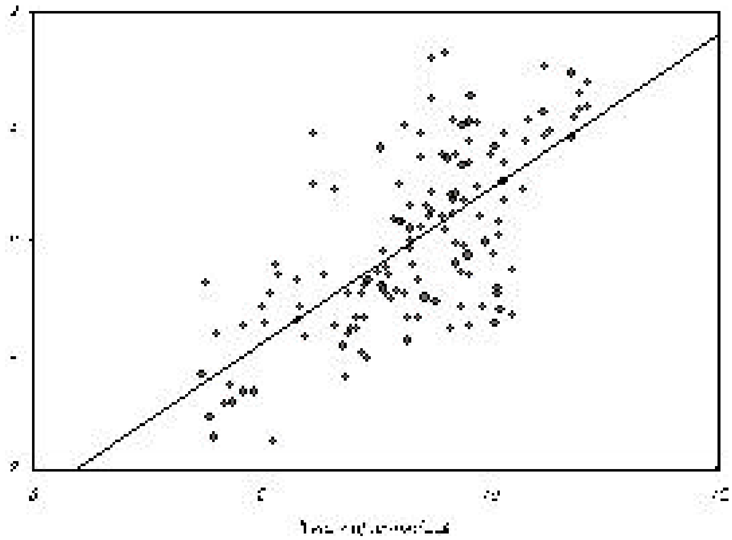
show up clearly for all five measures of religiosity are *positive* effects from education and negative effects from urbanization. These results reveal partial relationships. For example, the regression framework isolates the effect of education on church attendance, while holding constant the correlated development indicators, including per capita GDP and urbanization. The partial relation with education is shown graphically for weekly church attendance in figure 3 and for belief in heaven in figure 4.

With the other explanatory variables held constant, per capita GDP has essentially a zero relation with church attendance and relatively weak negative relations with the belief measures. More income, per se, thus does not appear to have a close relation with religiosity.

More difficult to interpret are the relations with the two health related measures, life expectancy at birth and the fraction of the population that is elderly. Church attendance is significantly negatively related to life expectancy. This result seems reasonable from an economic perspective if church attendance is related to securing a favorable life-after-death. However, it is less clear why the belief measures are significantly negatively related to the elderly population share.

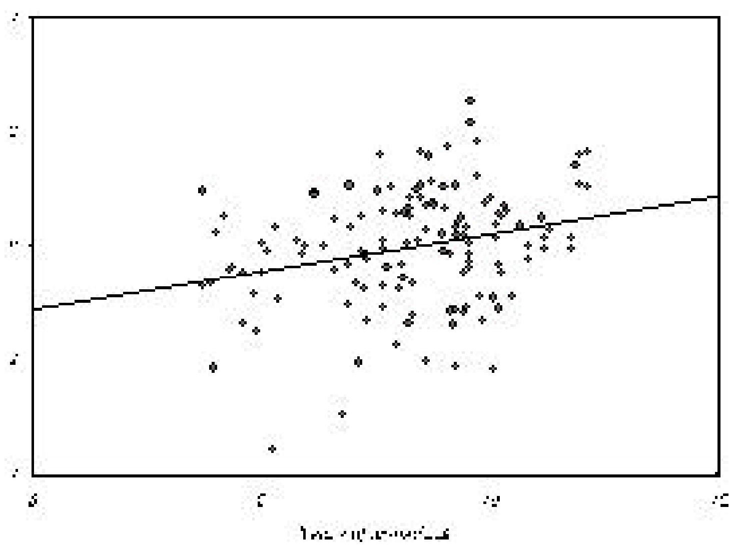
Suppose that economic development fundamentally reflects growth in per capita GDP. Empirically, this growth is typically accompanied

Figure 3. Weekly Church Attendance[a] and Education, Partial Relation



a. Normalized as log[x/(1 − x)], where x is the fraction of persons attending church weekly.

Figure 4. Belief in Heaven and Education, Partial Relation



a. Normalized as log[x/(1 − x)], where x is the fraction of believers.

by higher values of education, urbanization, life expectancy, and the elderly population share. Then one can think of the overall effect of economic development on religiosity as reflecting the direct impact of GDP—for example, the coefficient 0.08 shown for weekly church attendance in table 4—and four indirect effects that involve the other four dimensions of development. For example, the indirect effect of per capita GDP working through education on weekly church attendance is given by the coefficient 0.265 shown in table 4 multiplied by the typical response of education to GDP (which turns out to involve a coefficient of 2.3). Proceeding in this way, one can compute an overall effect of economic development on weekly church attendance as follows: 0.08 from GDP, 0.61 from education, –0.32 from urbanization, –0.82 from life expectancy, and –0.11 from the elderly population share. The total effect (coefficient of –0.56) is consistent with the simple relation between weekly church attendance and GDP that is shown in figure 1.[6]

So, what does all this say about the secularization hypothesis? The positive partial relation between education and the religiosity measures makes implausible the idea that religiosity is nonscientific and, consequently, tends to decline as societies become more modern and sophisticated. On the other hand, other features of economic development, including urbanization and aspects of improved health, seem to generate an overall negative association between economic development and religiosity. Sorting out the nature of these associations will be an important part of future research.

Table 4 also has implications for the market or supply-side theory of religiosity, as developed, for example, in Finke and Stark (1988) and Iannaccone (1991). These authors argue that government regulation of the religion market and reduced choices among religion providers (often generated by government regulation) tends to lower the quality of the religion product. Church attendance therefore falls, and beliefs decline to the extent that these beliefs depend on the efficacy of organized religion.

Table 4 shows, consistent with the supply-side view, that an index of religious pluralism (based on the composition of religious affiliations in a country) is positively related to church attendance. This pluralism index is also positively related to beliefs in heaven and hell but not with

6. Application of the same procedure to the other measures of religiosity generates the following overall coefficients for GDP: –0.61 for monthly church attendance, –0.52 for belief in heaven, –0.59 for belief in hell, and –0.10 for belief in an afterlife. Belief in an afterlife is thus the one religiosity indicator considered here that seems not to be strongly related to economic development overall.

belief in an afterlife. This suggests that more competition among religion providers tends to generate more religiosity, measured by attendance or some of the beliefs. One concern with these results, however, is that greater religiosity (caused by some unmeasured factor) may be leading to greater religious diversity, rather than the reverse. That is, if the population of a country were more religious (for reasons not explained), it would not be surprising that a more diverse group of denominations would be created in the country, at least in the long run, to meet the demand.

Table 4 also shows, contrary to the supply-side argument, that a dummy variable for the existence of an official state religion (as designated in Barrett, 2001) is positively related to church attendance. The state religion variable is also positively related to beliefs in heaven and hell, though not to belief in an afterlife. These results seem reasonable if, as is usually the case, the existence of a state church goes along with subsidies to church-going activities.

The results on state religion shown in table 4 apply when the system includes the status prevailing in 1970 (which is prior to any of the observed religiosity measures used as dependent variables). Some countries underwent changes in the status of state religion subsequent to 1970; for example, Ireland dropped the official monopoly position of the Roman Catholic church in the early 1970s. However, a later value of the state religion dummy lacks explanatory power if it is added as an independent variable.[7] This finding may indicate that people take a long time to adjust to a change in church-state relations or that some of the changes may be less substantive than they appear formally. For example, Barrett (2001) still classifies Ireland as a religious state in 1990, although not exclusively a Catholic one.

Table 4 indicates, consistent with Chaves and Cann (1992), that greater state regulation of religion (measured by whether the government appoints or approves church leaders) significantly reduces church attendance. Interestingly, this regulation variable is not significantly related to the measures of religious belief. This suggests

7. This analysis is based on very limited information because, according to Barrett (2001), the only countries in my sample that changed their official state religion between 1970 and 1990 are Ireland, which dropped an official state church, and Slovenia, which added one. Perhaps controversially, Barrett does not admit changes for Portugal and Spain, each of which is described as officially Catholic even in 1990. Changes in state religion also occurred during the 1990s in some of the former Communist countries, and Sweden recently dropped the Lutheran religion as its official state church.

that government regulation makes the provision of organized religion less efficient and thereby depresses church attendance. However, this regulatory involvement seems not to reduce religiosity as measured by beliefs, which apparently are sustained in this case despite the fall in church attendance. The results on state religion differ in that positive effects are found not only on church attendance but also for some of the beliefs.

Table 4 shows a substantial negative effect on all of the religiosity measures from the presence of a Communist regime. (The Communist countries in the sample are mainly in eastern Europe but also include China.) This pattern makes sense because the Communist governments typically attempted to suppress organized religion, which was presumably regarded as competitive with the Communist religion itself.

The presence in the sample of the eastern European countries allows an investigation of the effects of the removal of Communism in the 1990s. Table 4 provides evidence of a significant recovery of church attendance (more so for monthly than weekly data) and beliefs in the post-Communist period. The 1998 results indicate, however, that the recovery has been only by around one-third of the initial depressing influence. Thus, as with the existence of an official state church, the impact on religiosity seems to persist well beyond the change in the regime.

The empirical estimation also allows for differences in religious practices among religious denominations. The variables correspond to the eight-way breakdown of denominations used before in the analysis of economic growth. The Catholic share is again omitted, so that the coefficients shown in the table represent the effect of the indicated denomination relative to that for Catholic.

For church attendance, the results reveal that all religions other than Muslim have significantly lower participation than Catholic. For the belief measures, Muslim is significantly higher than Catholic. Significantly negative effects on beliefs (relative to those for Catholic) appear for Protestant, Hindu, eastern religions, Jewish, and Orthodox.

It would be of great interest to estimate the effects of religiosity on economic performance, in particular, economic growth. This type of relation is emphasized by Weber (1930) in his analysis of Protestantism. One problem in carrying out this research with the present data is that most of the information on religiosity applies to the 1990s, that is, subsequent to the bulk of the observations on economic growth.

Since religiosity measures tend to persist substantially over time within countries, there may be a rationale for including later values of the religion variables as "determinants" of earlier values of economic growth. That is, the later values of religiosity may proxy satisfactorily for the unobserved earlier ones. I proceeded by constructing a single cross section of weekly church attendance and the belief measures, using the earliest available observation on each measure. The basic finding, when holding fixed the explanatory variables shown in table 1, is that growth is significantly negatively related to church attendance and significantly positively related to measures of religious beliefs. The three belief measures considered thus far—in heaven, hell, and an afterlife—are hard to distinguish in terms of the relationship with economic growth. However, belief in life after death had the strongest relationship with growth. (These results on growth effects are still highly preliminary and are not reported in the tables.)

I am currently studying the relation of religiosity to economic growth while holding constant the composition of the population by religious denominations. More importantly, I am working on how to distinguish the two-way causation between religiosity and economic activity. This distinction is especially problematic when the religion data pertain mainly to the later parts of the sample period.

4. Summary of Major Findings

Some important social and political variables move in a clear and regular manner along with economic development. Health status, for example, which is measured in this study by life expectancy at birth, improves as nations get richer. This response seems to be an unambiguous improvement in the quality of life. The fertility rate also declines regularly as economies develop, but the labeling of lower fertility—and reduced population growth—as better quality is controversial.

On the political and institutional side, the Aristotle-Lipset hypothesis appears to be correct in that economic development tends to be accompanied by expansions of democracy. This pattern applies if democracy is measured by indicators of electoral rights and civil liberties. Increases in the standard of living are also associated with increased maintenance of the rule of law and with reductions in the extent of official corruption.

Economic development is positively associated with two standard measures of environmental pollution. These indicators are per capita industrial emissions of carbon dioxide and organic water pollutants. These indicators measure emissions, however, and are not direct measures of air and water quality.

The overall relation of income inequality to economic development is complex. First, the estimated relation with per capita GDP is not monotonic: as suggested by Kuznets, it first rises and later falls. Second, education is also a standard indicator of economic development, and a rise in primary education tends to lower inequality. However, a rise in higher education—also related to economic development—may increase inequality.

Crime rates, measured empirically by murder rates, have no regular association with economic development. An increase of inequality tends to generate more crime, but as already noted, the relation of inequality to economic development is complex.

Finally, the secularization hypothesis argues that economic development is accompanied by reduced religiosity, measured by church attendance and religious beliefs. The data do reveal a pattern in which people in more advanced countries tend to be less religious. However, as with the reduction in fertility, it is unclear that the decrease in religiousness should be characterized as an improvement in the quality of the human condition. In addition, the partial effect of education on religious practices turns out empirically to be positive. This pattern contradicts the usual rationalization of the secularization hypothesis, namely, that religiosity is supported by ignorance and superstition. The relationships between religion and economic variables seem to be an important area for future research.

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Policy Evaluation and Empirical Growth Research

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This paper explores the implications of the vast body of studies of cross-country growth determinants for the evaluation of alternative policies. Empirical growth studies have experienced a remarkable flowering in the last fifteen years, and innumerable insights have unquestionably been uncovered concerning similarities and differences in the growth experiences of various groups of countries. This empirical work was stimulated by—and, in turn, has been an essential complement to—the revival of growth theory initiated by the seminal papers of Lucas (1988) and Romer (1986). It constitutes one of the great successes of recent macroeconomic research.

In addition to identifying empirical regularities in growth, the empirical literature makes numerous claims concerning the impacts of alternative policies on the growth trajectories of different countries. This focus on policy implications is natural given the huge welfare implications of changes in a country's growth rate. A recent graduate-level textbook remarks

> "If large cross-sections of country experiences are interesting, it should mainly be because they ought to reveal the global impact of other growth determinants than the proximate factors of increases in productivity, factors about which we have other sources of evidence. Policy-oriented macroeconomists pay particular attention to the various components of government interventions" (Malinvaud, 1998, p. 781).

Durlauf and Quah (1999) survey the empirical growth literature and identify an enormous number of policy variables whose growth implications are analyzed in the new empirical literature. Among these

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variables are government consumption (Barro, 1991), inflation (Barro, 1997), political instability (Alesina and others, 1996), civil liberties (Kormendi and Meguire 1985), financial repression (Easterly, 1993), tariffs (Lee, 1993), and trade openness (Harrison, 1995). And this list does not include variables such as human capital, for which the government's role is fundamental.

The argument of this paper, however, is that this empirical literature largely fails from the perspective of policy evaluation. Current econometric practice has yielded a body of evidence that is not policy relevant, in that a policymaker cannot readily translate the findings of the literature into implications for the evaluation of alternative policy trajectories. In making this argument, I focus on cross-country growth regressions of the type pioneered by Kormendi and Meguire (1985), Barro (1991), and Mankiw, Romer, and Weil (1992). While this style of empirical research does not exhaust the ways in which data have been brought to bear on growth questions, it does constitute the primary approach to empirical work in this literature. Furthermore, cross-country growth regressions have become a conventional mechanism through which policy recommendations are justified.

In what sense are cross-country growth regressions not policy relevant? I focus on two issues. First, when these regressions are used to make policy recommendations, the recommendations typically are based on the statistical significance of some regression coefficient. I argue that this way of using regressions does not have a natural decision-theoretic basis, because there is no simple relationship between statistical significance levels and policy evaluation. Second, growth regressions as conventionally constructed do not provide credible evidence of economic structure, so even if one is trying to use the regressions to solve a decision theory problem, it is unclear what information the regression actually contains.

It would be a gross caricature of the policymaking process to claim that there is a mechanical mapping from the statistical significance of certain regression parameters to specific policy decisions. The arguments in this essay apply more to the ways in which statistical evidence on growth are used for policy discussions among scholars. The two processes are, of course, linked. This essay describes more effective ways of translating statistical results into policy advice, so as to strengthen the contributions of academic discourse to policymaking.

My analysis is hardly the first critique of the empirical growth literature. Criticisms of the ways in which growth regressions are implemented and interpreted, as well as proposals for alternative approaches to analyzing growth data, may be found in Brock and Durlauf (2001), Durlauf (2000), Quah (1996, 1997), and Temple (2000), to name a few examples. The discussion here, of course, relies on my previous work, especially for technical justification and the development of the various arguments. In particular, much of the discussion represents an extension of Brock and Durlauf (2001). Relative to other critiques of growth empirics, my focus is on the specific failings of cross-county growth regressions in providing policy guidance. Nevertheless, many of the criticisms I make call into question not only whether evidence from growth regressions is actually informative for policy, but whether such regressions provide structural information on the sources of growth. I do not question the value of the empirical growth literature in terms of identifying stylized facts that theoretical models should address. Rather, the empirical growth literature fails when it moves in an insouciant fashion from stylized facts to causal claims.

I do not intend to be wholly nihilistic in this paper, and it is certainly not my belief that growth regressions have no place in the evaluation of policies. My goal is to highlight why claims based on such regressions should be modest. I also discuss some recent developments in statistics that I believe can enhance the utility of these regressions. In doing so, I strongly endorse two recent papers, Doppelhofer, Miller, and Sala-i-Martin (2000) and Fernandez, Ley, and Steel (2001b). My own previous work in Brock and Durlauf (2001) develops many of the arguments here at more length and constitutes a more formal statement of my views on how to conduct empirical growth analyses.

Section 1 discusses the basic question of growth regressions and policy evaluation, arguing that the appropriate link between the two processes is not reflected in conventional academic practice. What empirical work on growth should do is provide posterior densities for growth rates under alternative policy scenarios. I argue that the exercise of policy evaluation depends on these posterior densities, combined with an explicit statement of a policymaker's objectives. Section 2 then addresses why conventional approaches to growth econometrics do not provide credible estimates of the posterior densities needed for the type of policy evaluation exercise I advocate. The section argues that growth regressions suffer two basic problems: theory uncertainty and country heterogeneity. These problems have not been adequately addressed in the empirical growth studies. Section 3 describes a technique, Bayesian model averaging, that addresses the problems raised in section 2. Section 4 presents an empirical exercise to illustrate how Bayesian model averaging can influence the way one thinks about the effects of policies in light of empirical results. Finally, section 5 provides a summary and conclusions.

1. Regressions and Policy Analysis

This section describes the basics of growth regressions and suggests a general language for thinking about how regressions should influence policy evaluations. While growth regressions come in many forms, a canonical representation is

$$g_i = X_i\beta + Z_i\gamma + p_i\delta + \varepsilon_i \,, \tag{1}$$

where g_i is real per capita growth across some fixed time interval, X_i is a set of regressors suggested by the Solow growth model (population growth, technological change, physical and human capital, and savings rates, transformed in ways implied by the model), Z_i is a set of additional control variables suggested by new growth theories, p_i is the policy variable of interest, and ε_i is an error. The distinction between X_i and Z_i is important in econometric practice, because while X_i variables are essentially constant across empirical studies, there is no consensus on which Z_i variables should be included. Many growth studies use panel rather than cross-section data, but this difference has relatively little bearing on issues of interpretation and so is ignored here.[1]

What does it mean to use this type of regression to evaluate a policy? A policymaker presumably wishes to compare the effects of setting a policy variable at some fixed level, $\bar{p}$, with the effects of an alternative setting, $\bar{\bar{p}}$. Supposing that the policymaker has a payoff function,

$$V\left(y_i, R_i, p_i\right), \tag{2}$$

then the policy problem is essentially a comparison of the payoffs associated with the alternative policies. If the policymaker has a payoff function, V, the policy evaluation amounts to computing

$$EV\left(y_i, R_i, \bar{p} \middle| D\right) - EV\left(y_i, R_i, \bar{\bar{p}} \middle| D\right). \tag{3}$$

1. My argument is not intended to dismiss the utility of panels in studying growth across countries, but rather focuses on issues that apply in both cross-section and panel contexts. For example, while panels allow the elimination of fixed effects that correspond to constant differences in growth rates across countries, they do not provide any natural solution to the more general issue of parameter heterogeneity that I address below.

In this representation, E is an expected value operator, y_i represents per capita income in country i, R_i represents some set of characteristics of country i that affect the policymaker's assessments, and D denotes all data available to the policymaker. I have written the payoff function in terms of levels of per capita output, but if lagged per capita output is part of R_i, then this function can accommodate the case in which the growth rate is the relevant argument in the payoff function for the policymaker.

With regard to policy analysis, the key question is simple. How one can use regressions of the form in equation 1 to inform calculations of equation 3? This question is hardly an unusual one; indeed it is precisely this type of question that underlies the development of statistical decision theory, beginning with the seminal work of Abraham Wald (1950). From the Wald perspective, one evaluates a policy by calculating equation 3, using equation 1 to compute the conditional expectations that are a part of this calculation. Put differently, the relevance of equation 1 for policy analysis is that it allows for the computation of the distribution of growth rates under alternative choices of the policy variable, p_i. These distributions matter only in how they affect the expected payoff of the policymaker.

Surprisingly, this is not how policy implications are usually drawn from growth regressions. Instead, policy evaluations are drawn as an implication of hypothesis tests made on the coefficient associated with the policy variable of interest. In the context of equation 1, this amounts to using the statistical significance of δ in equation 1 to determine whether one can recommend a change in the magnitude of p_i to enhance growth in country i. A good example of this approach is the assessment of alternative policy variables in Barro and Sala-i-Martin (1995, chap. 12). In this survey of the empirical growth literature, the empirical evaluation of various policy variables in the growth process is virtually always related to statistical significance, typically assessed at the 5 percent level. (Significance at 10 percent but not 5 percent is apparently considered to be sufficiently weak evidence that a variable can be ignored.)

There is a vast statistical literature debating the use of statistical significance levels in evaluating statistical models; much of this debate revolves around frequentist versus Bayesian approaches to statistical analysis. My concern is somewhat different. The question is whether the statistical significance of a variable provides much insight into calculations of equation 3. As the form of equation 3 makes clear, the general answer is no. In order for there to be such a relationship, the payoff function would have to possess a functional form such that the implied policy recommendation would be, "implement the policy if the coefficient on the policy variable is statistically significant; otherwise do not implement the policy." Suppose that the question is whether to move from $\bar{p}$ to $\bar{\bar{p}}$. Assume that the ordinary least squares (OLS) estimate of δ, $\hat{\delta}$, can be interpreted as its expected value and that the OLS variance of the parameter estimate of δ is the variance of the parameter. (The conditions under which these assumptions hold are discussed below.) Finally, assume that the "statistical significance" rule is that one should only implement a policy change if the *t* statistic for the policy coefficient is greater than or equal to 2 and the sign of the policy change is the same as the coefficient estimate. Then, for the payoff function implicitly defined by

$$EV\left(y_i, R_i, \bar{p} \middle| D\right) - EV\left(y_i, R_i, \bar{\bar{p}} \middle| D\right) = E\left[\delta\left(\bar{p} - \bar{\bar{p}}\right)\right] - 2\,\mathrm{var}\left[\delta\left(\bar{p} - \bar{\bar{p}}\right)\right]^{1/2}, \tag{4}$$

one would only increase the policy variable from $\bar{p}$ to $\bar{\bar{p}}$ if the *t* statistic in the OLS regression is at least equal to 2 and the sign of the coefficient is positive. (The use of 2 versus some other value is immaterial.)

This is a very special case and embodies several unintuitive assumptions. First, the policymaker must only care about the component of growth affected by the control variable, rather than the effect of the control variable on growth per se. In other words, the policymaker considers the effect of the policy in isolation from all other determinants of growth. Second, the policymaker must only care about the mean and variance of the policy's effect on growth. While I do not wish to speculate on the objective functions employed in practice by policymakers, this function would seem inappropriate in many contexts. For example, political stability issues might render a policymaker more sensitive to negative growth rates than to positive growth rates, or there might be asymmetries in the effects of growth on poverty that should be accounted for in the social evaluation of changes in growth rates. Third, the mean and standard deviation of the growth effect in the payoff function must present a 2-to-1 tradeoff. This is where the significance level for the *t* statistic is implicitly embedded in the payoff function. The point, of course, is that there is no reason to expect any of these assumptions to hold in practice.

Is there a straightforward way to reduce the gap between the statistical decision theory approach to evaluating growth regressions and the use of statistical significance levels to evaluate policies? The message of the statistical decision theory literature is that no simple link exists. As demonstrated quite clearly in Chamberlain (2000), decision theory imposes powerful restrictions on how one analyzes data. Hence, one message for policymakers who must evaluate growth policies is that what they should ultimately care about is the posterior density of growth rates (or income levels) under alternative policy scenarios.

I therefore turn to a second question, namely, the interpretation of the posterior density of parameters in growth regressions. In interpreting the goal of an empirical exercise as the computation of a posterior density, I use Bayesian as opposed to frequentist language. This distinction is unimportant for the subsequent discussion, as the critiques I make of conventional growth regressions concern their interpretability, an issue that is equally salient under Bayesian and frequentist paradigms. Bayesian language is more appropriate in my discussion, however, because Bayesian approaches can be integrated much more naturally into decision-theoretic analyses than can frequentist approaches.

2. Interpreting Growth Regressions

The previous section illustrates why the conventional use of growth regressions for policy analysis has no logical justification. These regressions, nevertheless, do contain information about the growth process and its relationship to particular policy variables. In this section, I explore reasons why the regressions themselves are difficult to interpret in policy contexts.

The use of growth regressions to inform policy analyses is based on interpretations of these regressions as structural relationships. Put differently, these analyses presuppose that the observed correlations on which these regressions are computed can be interpreted as something more. Whether interpretations of the type found in this literature are justifiable is not entirely clear, for two main reasons: openendedness of the theories and parameter heterogeneity.

2.1 Openendedness and the Structure of Growth Theories

A first problem in specifying empirical growth models concerns the identification of the growth determinants to be included in a statistical model. This problem arises in any statistical analysis, but the danger is especially problematic in growth contexts. As originally argued in

Durlauf (2000), modern growth theories are fundamentally openended: one growth theory typically has no bearing on the empirical relevance of another. Modern growth economics has put forward an enormous range of alternative explanations for cross-country growth differences. Hence, one paper focuses on the effects of inequality on growth (Persson and Tabellini, 1994), another on the role of social capital (Knack and Keefer, 1997), another on geography, (Sala-i-Martin, 1997), and so on. What is critical in assessing individual empirical exercises is that these alternative explanations are both not mutually exclusive and often perfectly compatible. There is nothing in the logic of a theory linking social capital to growth that is inconsistent with a theory linking trade openness to growth, even though there may be interrelationships between the two theories.

How large is the set of growth theories that have been taken to data? Durlauf and Quah (1999) survey the empirical literature and note that as of 1998, at least as many ex ante plausible regressors have been used to proxy for growth theories as there are countries in the standard growth dataset. My own reading of the literature suggests that the number of potential variables has grown substantially since then.[2]

Openendedness has several critical implications for the interpretation of growth regressions. First, since the mutual compatibility of alternative growth theories in no way implies that they are uncorrelated (when their empirical analogues are compared across countries), the danger of omitted variable bias in a given cross-country regression is immense. Furthermore, the large number of growth variables means that one cannot simply run a regression with all theories, but rather must employ an empirical strategy for variable selection.

A number of studies make an effort to engage in variable selection in growth contexts and thereby deal with the dangers of misspecification. Levine and Renelt (1992) employ Edward Leamer's celebrated extreme bounds analysis to determine which variables can be robustly related to growth. This amounts to running a large set of regressions, each of which contains some subset of the potential regressors used for growth theories, and seeing how the sign of a given regressor changes according to what other regressors are included. When this sign is stable across alternative regressions, the regressor is considered to have a robust relationship. Sala-i-Martin (1997) employs a related procedure, but he interprets a regressor as robust if it is statistically significant in

2. I also believe that our 1999 survey seriously underestimates the number of growth theories that had been empirically employed up to that time.

95 percent of the regressions in which it is included. Each of these is an important paper. Neither can be said to provide a satisfactory resolution of the problem of variable selection, however, because neither approach has a fully satisfactory decision-theoretic foundation. Extreme bounds analysis implies that a policy variable is unimportant if it is not constant for a large number of regressions, although that sort of instability might well occur even if there is a relationship between the variable and growth. Furthermore, Levine and Renelt (1992) treat all regressions as equally informative, whereas standard metrics such as goodness of fit suggest they may not be. Similar criticisms may be made of Sala-i-Martin (1997). Brock and Durlauf (2001) provide some ways to think about decision-theoretic approaches to variable selection and discuss approaches that appear in the econometrics literature. For my purposes, however, the key point is that the proposed solutions to variable selection do not reflect the attention to decision-theoretic foundations needed to make the procedures wholly compelling. What I propose below incorporates the important insights of these techniques, but in a way that is more compatible with policy analysis.

Second, openendedness implies that it is extremely difficult to use instrumental variables in growth contexts. In regression 1, suppose one is worried that the policy variable, p_i, is endogenous. How can one construct an instrument for it? To be valid, the instrument must be predetermined with respect to p_i; this is the basis on which instruments are typically used in the growth literature. Validity also requires that a second condition be fulfilled: namely, that the instrument is uncorrelated with ε_i. And what is ε_i? This is the unobserved variable that captures all growth determinants that have not been modeled in the regression. Hence, to argue that the instrument is valid, one has to argue that it is uncorrelated with all theories not embodied by the regression, a condition that seems virtually impossible to satisfy.

Theory openendedness makes clear how prior information is an inevitable part of the interpretation of growth regressions and thus of their use in policy analysis. To interpret a particular regression of the form of equation 1 as revealing economic structure, it is necessary to believe something about the errors. As noted above, these errors embody growth determinants that have been neglected by the regression. The analyst must be able to interpret the parameter estimates despite the presence of these omitted variables. One's understanding of these omitted variables, however, reflects one's knowledge of the histories and societies of the various countries in the dataset. Such prior information often comes from qualitative and descriptive sources. The fact that these sources are not quantitative does not allow the analyst to ignore them.

2.2 Heterogeneity

A second issue in interpreting growth regressions concerns heterogeneity in countries. Put in its simplest form, the use of a regression such as equation 1 for policy analysis presupposes the belief that the growth process for different countries can be well approximated as a country-invariant relationship. Again, invariance of parameters across observations is an assumption that is certainly not unique to growth contexts, yet it seems particularly difficult to defend such an assumption in growth contexts. Consider the claim that a measure of the tariff level affects growth. Does one interpret the tariff coefficient in equation 1 as saying that the effects of a change in tariffs for the United States is the same as for Belgium and for Singapore? Does one believe that the growth implications of a unit change in human capital are the same for the United States as for countries in sub-Saharan Africa? Presumably not, but this is precisely what is asserted when one uses regressions such as equation 1 to uncover growth determinants.

Concerns about parameter heterogeneity are of more than theoretical interest. Studies such as Canova (1999), Desdoigts (1999), Durlauf and Johnson (1995), Durlauf, Kourtellos, and Minkin (2001), and Kourtellos (2000) all provide evidence of parameter heterogeneity. Taken as a whole, the evidence clearly suggests that the standard approach to assuming country-invariant parameters as the null modeling assumption in growth regressions is inconsistent with the data. This practice is still quite general, however, and most exceptions to this generalization amount to nothing more than ad hoc additions of cross products of growth variables with thresholds (for example, a variable that is zero for countries below some measure of income, 1 otherwise.) It is thus no exaggeration to say that parameter heterogeneity has yet to become a primary component of growth models.

From the perspective of evaluating growth policies, the implications of parameter heterogeneity are clear. Policy advice is not given in terms of average effects in the world. One would not say, "Since the average effect of tariffs on growth for all countries is negative, country *i* should lower tariffs." Yet this is essentially what occurs when one neglects heterogeneity in the growth process and uses the coefficient estimates in equation 1 as the basis for advising a particular country.

Large deviations between the growth effect of a variable as estimated in a regression such as equation 1 and the effect for a particular country can easily occur when parameters are heterogeneous; there is no guarantee that the signs are even the same. Hence, neglected parameter heterogeneity can lead to bad policy advice.

3. Bayesian Model Averaging and Growth Regressions

This section describes a new approach to the analysis of growth regressions that has the potential for making inferences on growth regressions more credible. This technique is known as Bayesian model averaging (BMA). It has been developed by Adrian Raftery and a series of coauthors (Raftery, Madigan, and Hoeting, 1997; Hoeting, and others, 1999). Wasserman (2000) provides a very clear introduction to model averaging. Much of the motivation for the work can be traced to the issues of model uncertainty analyzed by Leamer (1978), a book whose importance to econometric practice has yet to be fully appreciated. Applications of BMA to growth regressions may be found in Brock and Durlauf (2001), Doppelhofer, Miller, and Sala-i-Martin (2000), and Fernandez, Ley, and Steel (2001b). While these papers differ in many details, each is motivated by similar concerns.

3.1 Basic Ideas

The basic idea of Bayesian model averaging is the following. Suppose that one is concerned with a parameter, in my case δ, that is an element of a model. Unlike conventional practice, however, suppose that one does not know the true model of which the parameter is an element. Instead, one has a set of models M, with a typical element M_m, which for the sake of exposition contains the true model. (If an element of the model set does not contain the parameter δ, it is interpreted as meaning $\delta = 0$).

Conventional econometric practice amounts to computing $\mu(\delta \mid D, M_m)$, that is, one evaluates the probability density of the parameter δ given the available data D and the assumption that the data are generated by a particular model M_m.[3] In contrast, Bayesian model averaging advocates computing the conditional probability of the parameter given only the data, that is, $\mu(\delta \mid D)$. This computation basi-

3. I sometimes refer to conditional probabilities as posterior probabilities, in recognition of their dependence on the available data.

cally eliminates the dependence of $\mu(\delta \mid D, M_m)$ on M_m by integrating out this additional conditioning variable. Since the number of models is discrete, this amounts to computing

$$\mu\left(\delta \mid D\right) = \sum_m \mu\left(\delta \mid D, M_m\right) \mu\left(M_m \mid D\right). \tag{5}$$

Using Bayes rule, this expression may be rewritten as

$$\mu\left(\delta \mid D\right) = \sum_m \mu\left(\delta \mid D, M_m\right) \mu\left(D \mid M_m\right) \mu\left(M_m\right), \tag{6}$$

which provides some insight into the difference between the BMA approach and conventional practice. Rather than condition on a single M_m in computing the posterior density, the BMA approach takes the posterior density $\mu(\delta \mid \mathrm{D}, M_m)$ for each model and computes a particular weighted average. The weights assigned to each model consist of two components: $\mu(M_m)$, which is the prior probability assigned to a given model, and $\mu(\mathrm{D} \mid M_m)$, which is the posterior probability of the data given a particular model. The latter term is nothing more than the likelihood function.

One can compute the posterior mean and variance of the parameter δ using these formulas. As originally shown in Leamer (1978), these are

$$E\left(\delta \mid D\right) = \sum_m \mu\left(M_m \mid D\right) E\left(\delta \mid D, M_m\right) \text{ and} \tag{7}$$

$$\begin{aligned} \operatorname{var}\left(\delta \mid D\right) &= E\left(\delta^2 \mid D\right) - \left[E\left(\delta \mid D\right)\right]^2 \\ &= \sum_m \mu\left(M_m \mid D\right)\left\{\operatorname{var}\left(\delta \mid M_m, D\right) + \left[E\left(\delta \mid D, M_m\right)\right]^2\right\} - \left[E\left(\delta \mid D\right)\right]^2 \\ &= \sum_m \mu\left(M_m \mid D\right) \operatorname{var}\left(\delta \mid M_m, D\right) \\ &\quad + \sum_m \mu\left(M_m \mid D\right) \left[E\left(\delta \mid D, M_m\right) - E\left(\delta \mid D\right)\right]^2, \end{aligned} \tag{8}$$

respectively.

These formulas illustrate how model uncertainty affects a given parameter estimate. First, the posterior mean of the parameter is a weighted average of the posterior means across each model. Second, the posterior variance is the sum of two terms. The first term is a weighted average of the variances for each model. The second term reflects the variance across models of the expected value for δ; these differences reflect the fact that the models are themselves different. This second variance term captures how model uncertainty increases the variance associated with a parameter estimate relative to conventional calculations.[4]

3.2 Regression

From the perspective of a regression, model uncertainty is a function of what regressors to include. Both theory openendedness and country heterogeneity may be interpreted in this context. To see this, suppose that we have a set of R possible alternative determinants of growth. Theory openendedness means that the researcher does not have a basis for excluding one of the potential theories because another one matters. From the perspective of R, a regression that includes any subset of its elements constitutes a possible growth model. Hence, if there are K different regressors in R, then 2^{K-1} different possible models exist.

One can also interpret a range of possible forms of country heterogeneity in terms of variable inclusion in the same way I have interpreted theory uncertainty. Suppose that the countries in a growth cross section can be grouped into two distinct classes, such that countries within a class obey the same linear growth model. Let A_1 and A_2 denote the collections of country indices corresponding to these classes. The assumption of two classes means that there are two growth models for the data.

$$g_i = X_i\beta + Z_i\gamma + p_i\delta + \varepsilon_i \qquad \text{if } i \in A_1 \text{ and} \tag{9}$$

$$g_i = X_i\beta' + Z_i\gamma' + p_i\delta' + \varepsilon_i \qquad \text{if } i \in A_2 \,. \tag{10}$$

Equation 10 can be rewritten, however, as

$$\begin{aligned} g_i = {} & X_i\beta + Z_i\gamma + p_i\delta + X_i\left(\beta' - \beta\right) \\ & + Z_i\left(\gamma' - \gamma\right) + p_i\left(\delta' - \delta\right) + \varepsilon_i \qquad \text{if } i \in A_2 \,. \end{aligned} \tag{11}$$

4. See Draper (1995) for additional discussion.

Therefore, one can combine the data from both classes of countries into a single regression

$$g_i = X_i\beta + Z_i\gamma + p_i\delta + X_i\xi_{i,A_2}\left(\beta' - \beta\right) + Z_i\xi_{i,A_2}\left(\gamma' - \gamma\right) + p_i\xi_{i,A_2}\left(\delta' - \delta\right) + \varepsilon_i \qquad \text{if } i \in A_1 \cup A_2\,, \tag{12}$$

where ξ_{i,A_2} if $i \in \mathrm{A}_2$, 0 otherwise. As this regression indicates, the presence of multiple classes of countries may be captured by introducing additional regressors, $X_i\xi_{i,A_2}$, $Z_i\xi_{i,A_2}$, and $p_i\xi_{i,A_2}$. It is straightforward to generalize this argument to multiple classes.

This approach is not completely general, in that it requires some prior judgments about what possible groups of countries will be considered. If one allows each country to have its own parameters, then one will not have enough degrees of freedom to estimate the model. I am currently unaware of any way to generalize BMA procedures to allow for endogenous determination of groups of countries with similar parameters. Such techniques could be developed, however. For example, regression tree methods of the type employed by Durlauf and Johnson (1995) to allow the data to reveal groups of similar countries could perhaps be incorporated into a BMA framework. This is a fruitful area for future research.

An alternative to this approach to parameter heterogeneity is to model the parameters of a growth regression as functions of country-specific characteristics. This would allow each country to be associated with a unique set of regression coefficients. See Durlauf, Kourtellos, and Minkin (2001) for an example of this approach. Both the approach here and the methods in Durlauf, Kourtellos, and Minkin (2001) can address issues of nonlinearities in the growth process; the differences between the approaches concerns how one approximates an unknown nonlinearity. The approach here has some advantage when one thinks that threshold effects are present, as suggested by models such as Azariadis and Drazen (1990); Galor (1996) provides additional discussion of issues related to nonlinearities in theory and empirical practice.

3.3 Implementation

To implement the BMA procedure, it is necessary to characterize $\mu(\mathrm{D} \mid M_m)$ and $\mu(M_m)$. The former essentially requires the specification of two things: the prior distribution on the coefficients and the probability density for the residuals within a given model. I do this as follows. For a given regression, let S_i denote the regressor associated with country i. A growth regression will therefore have the form

$$g_i = S_i \zeta + \varepsilon_i \qquad i = 1, \ldots, I\ . \tag{13}$$

To compute the posterior distribution of ζ, I assume, first, that I have no informative prior information on the coefficients. In more standard language, I impose a noninformative prior on the coefficients, that is,

$$\mu(\zeta) \propto c\ . \tag{14}$$

Second, I assume that the errors are i.i.d. normal with a known variance. Under this assumption, one can show that the posterior density of the regression coefficients is

$$\mu(\zeta | D) \sim N\left[\hat{\zeta}, (S'S)^{-1}\sigma_\varepsilon^2\right], \tag{15}$$

where $\hat{\zeta}$ is the OLS estimate of the parameters in equation 13.[5] Notice that $(S'S)^{-1}\sigma_\varepsilon^2$ is the OLS variance estimate for the parameters when the error variance is known. What is very useful about this formula is that it means that the parameters of the posterior density of ζ have OLS interpretations. The assumption that the error variance is known is not serious; the formula will still be valid asymptotically if σ_ε^2 is replaced with its OLS estimate.

The choice of $\mu(M_m)$ is more problematic, in that it corresponds to the prior information a researcher has about which model is true. At first glance, it might seem that if one does not have such information, one should assign equal prior weight to each element of M. This is not entirely satisfactory, however. Assigning equal probabilities to each model is equivalent to assuming that the prior probability of including a given regressor is 0.5 and is independent of the presence or absence of any other regressor. This is clearly untenable given the economics of growth. Presumably, the fact that inequality affects growth says something about whether political institutions affect growth. This observation is consistent with the problem of theory openendedness discussed earlier: mutual compatibility does not entail independence.

As yet, there has been no satisfactory proposal to deal with this problem. For the purposes of this paper, I employ the equal prior model

5. Compare the approach in Box and Tiao (1973, p. 115).

probability assumption. I do so, however, to allow for a simple interpretation of my results, not because it is intrinsically appealing. The development of better priors is an important outstanding research question. The approach I follow is in the spirit of the benchmark approach to choosing priors, which emphasizes the idea that priors should facilitate comparisons across studies. In this regard, Fernandez, Ley, and Steel (2001a) develop a number of priors for model averaging contexts that have desirable properties. Another approach is to use prior economic reasoning to structure priors. As argued in Brock and Durlauf (2001), the problem of interdependences in variables is analogous to violations of the assumption in discrete choice theory of the independence of irrelevant alternatives. This problem led to the development of models such as the nested logit; I conjecture that a similar tree structure may exist to organize growth regressors. Yet another possibility is the use of panel data as a training sample to form priors for the analysis of the rest of the sample. While this has yet to be done in the cases of variable selection, work such as that by Berger and Peracchi (2001, 2002) shows that this is a promising approach in other contexts.

4. Empirical Example

In this section, I describe a small BMA exercise in exploring the role of three different policy variables in growth. The exercise does not attempt to explore a large class of alternative theories, as would be ideal in analyses of this type and as is done in the important papers by Doppelhofer, Miller and Sala-i-Martin (2000) and Fernandez, Ley, and Steel (2001b). Rather, my intent is to illustrate how attention to model uncertainty can affect one's views of a regression.

My analysis focuses on a particular growth regression studied in an influential paper by Easterly and Levine (1997). I use their baseline regression, which is conducted on panel data constructed of ten-year moving averages for the decades 1960 to 1990.[6] Working with a baseline growth regression suggested by that paper, I consider various model averaging generalizations. Specifically, I focus on three policy variables that have received attention in the growth literature: a measure of the size of government deficits (SURP), a measure of human capital (SCHOOLING), and a measure of democracy (DEMOCRACY). One could plausibly argue that these are not control

6. Data definitions are provided in the appendix A below. See Easterly and Levine (1997) for additional discussion of the data.

variables with respect to any policymaker and should themselves be modeled as endogenous outcomes influenced by a policymaker, but this does not mitigate against the value of the exercise. (See the appendix B for estimation details.)

Six different regressions are run for each of these variables. First, I report an OLS growth regression that includes only the policy variable of interest. The regressor set referred to as ALL corresponds to the list of regressors in the first column of table 1. Second, I report a Bayesian model averaging exercise taken over all variables in the original model. Third, I report an ordinary least squares regression that allows for the coefficients on the Latin American countries to differ from the rest of the sample. The term LATINCA in the table refers to regressors that are set equal to zero for countries outside of Latin America. Fourth, I report the BMA analog to this regression. In the third and fourth cases, the regression coefficients I report are the ones that apply to the Latin American countries. Finally, I report OLS growth regressions and BMA analogues using only Latin American countries in columns 5 and 6. Columns 3 and 5, in principle, should be identical; differences here are second-order and reflect computational differences.

From the perspective of inferences about policy variables, the results of this exercise are mixed, in the sense that the conclusions one would draw from the BMA exercises are not systematically different from those that would be drawn from the OLS exercise. Nevertheless, there are some noteworthy differences. Perhaps the biggest difference concerns the SURP variable (see table 1). If one compares the estimates in columns 1 and 4 for this variable, one sees that the point estimate declines by about 30 percent and the standard error increases by about 30 percent when one engages in a BMA exercise that allows for both theory uncertainty and country heterogeneity. The exercise thus seems to undermine the evidence that this policy variable can be used to affect growth. Interestingly, the reason why the evidence is weakened is not simply that this analysis allows the Latin American countries to have different parameters than the rest of the world. As column 3 indicates, an application of BMA that only allows for theory uncertainty gives very similar results.

The impact of schooling on growth also exhibits some sensitivity to accounting for model uncertainty. Interestingly, this sensitivity is not uniform across alternative formulations. The posterior mean and standard deviation of the schooling parameter are quite similar when one compares columns 1 and 4, but they exhibit variations elsewhere. In particu-

Table 1. Government Deficit: Ordinary Least Squares versus Bayesian Model Averaging[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Intercept term	—	—	—	—	–0.9084	–0.0333
	—	—	—	—	(0.3869)	(0.2305)
Dummy for sub-Saharan Africa	–0.0150	–0.0157	–0.0148	–0.0155	—	—
	(0.0044)	(0.0044)	(0.0045)	(0.0044)	—	—
Dummy for Latin America and the Caribbean	–0.0180	–0.0187	–0.8014	–0.0124	—	—
	(0.0037)	(0.0038)	(0.4425)	(0.0098)	—	—
Dummy for 1960s	–0.1428	0.0003	–0.1070	–0.0001	—	—
	(0.0831)	(0.0027)	(0.0863)	(0.0008)	—	—
Dummy for 1970s	–0.1388	0.0008	–0.1035	0.0008	0.0034	—
	(0.0829)	(0.0032)	(0.0866)	(0.0028)	(0.0060)	—
Dummy for 1980s	–0.1539	–0.0134	–0.1259	–0.0141	–0.0190	–0.0261
	(0.0828)	(0.0040)	(0.0867)	(0.0034)	(0.0068)	(0.0054)
Log of initial income	0.0559	0.0193	0.2446	0.0184	0.2446	0.0162
	(0.0215)	(0.0023)	(0.1108)	(0.0026)	(0.0987)	(0.0594)
Log of initial income squared	–0.0041	–0.0017	–0.0160	–0.0017	–0.0160	–0.0011
	(0.0014)	(0.0003)	(0.0071)	(0.0003)	(0.0063)	(0.0038)
Assassinations	–12.771	–0.6515	–22.1548	–0.8421	–22.1548	–4.8753
	(9.6661)	(3.4941)	(11.4928)	(3.9877)	(10.2465)	(9.1183)
Financial depth	0.0164	0.0114	0.0329	0.0113	0.0329	–0.0003
	(0.0059)	(0.0085)	(0.0260)	(0.0086)	(0.0231)	(0.0060)
Black market premium	–0.0204	–0.0226	–0.0133	–0.0221	–0.0133	–0.0090
	(0.0044)	(0.0045)	(0.0086)	(0.0047)	(0.0077)	(0.0099)
Ethnic diversity (ELF60)	–0.0189	–0.0208	–0.0019	–0.0201	–0.0019	–0.0016
	(0.0054)	(0.0055)	(0.0121)	(0.0064)	(0.0108)	(0.0057)
Fiscal surplus/GDP (SURP)	0.102	0.0775	0.1207	0.0792	0.1208	0.0458
	(0.0305)	(0.0417)	(0.0666)	(0.0401)	(0.0593)	(0.0573)

Source: Author's calculations, based on data from Easterly and Levine (1997).
a. The estimated regressions are as follows: (1) ordinary least squares (OLS) estimates for model ALL; (2) Bayesian model averaging (BMA) estimates for model ALL; (3) OLS estimates for model ALL + ALL*I(LATINCA), for which composite coefficient estimates and standard errors are reported and in which AFRICA, LATINCA, and DUM60 are dropped from the LATINCA-specific set of regressors; (4) BMA estimates for model ALL + ALL*I(LATINCA), for which composite coefficient estimates and standard errors are reported and in which AFRICA, LATINCA, and DUM60 are dropped from the LATINCA-specific set of regressors; (5) OLS on LATINCA subsample; and (6) BMA on LATINCA subsample. Standard errors are in parentheses.

lar, when BMA is applied to the Latin American countries in isolation (column 6), the posterior expected value of the schooling coefficient is less than half as large as the OLS estimate, with a much larger standard error as well. I am not sure how to interpret this finding.

Table 3 examines democracy and growth. This table fails to pick up any particularly interesting differences in the various democracy esti-

Table 2. Schooling: Ordinary Least Squares versus Bayesian Model Averaging[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Intercept term	—	—	—	—	–0.7425	–0.0991
	—	—	—	—	(0.3837)	(0.3260)
Dummy for	–0.0144	–0.0160	–0.0146	–0.0159	—	—
sub-Saharan Africa	(0.0043)	(0.0043)	(0.0044)	(0.0043)	—	—
Dummy for Latin America	–0.0187	–0.0203	–0.6480	–0.0169	—	—
and the Caribbean	(0.0035)	(0.0036)	(0.4088)	(0.0136)	—	—
Dummy for 1960s	–0.1480	–0.00005	–0.0944	—	—	—
	(0.0813)	(0.00072)	(0.0863)	—	—	—
Dummy for 1970s	–0.1472	0.00004	–0.0892	0.0016	0.0052	0.0004
	(0.0814)	(0.00070)	(0.0865)	(0.0041)	(0.0059)	(0.0022)
Dummy for 1980s	–0.1630	–0.0152	–0.1146	–0.0155	–0.0201	–0.0259
	(0.0814)	(0.0027)	(0.0866)	(0.0035)	(0.0069)	(0.0059)
Log of initial income	0.0565	0.0190	0.1991	0.0184	0.1991	0.0316
	(0.0207)	(0.0022)	(0.1019)	(0.0029)	(0.0978)	(0.0837)
Log of initial income	–0.0044	–0.0019	0.0131	–0.0019	–0.0131	–0.0021
squared	(0.0013)	(0.0003)	(0.0064)	(0.0003)	(0.0062)	(0.0053)
Assassinations	–14.5187	–1.2223	–17.6708	–1.849	–17.6707	–5.8233
	(9.1125)	(4.6371)	(11.2981)	(5.7521)	(10.8444)	(9.9402)
Financial depth	0.0135	0.0072	0.0024	0.0073	0.0024	–0.0008
	(0.0055)	(0.0077)	(0.0196)	(0.0081)	(0.0188)	(0.0055)
Black market premium	–0.0230	–0.0242	–0.0191	–0.0240	–0.0192	–0.0129
	(0.0039)	(0.0039)	(0.0076)	(0.0039)	(0.0073)	(0.0096)
Ethnic diversity (ELF60)	–0.0160	–0.0194	–0.0079	–0.0191	–0.0079	–0.0010
	(0.0055)	(0.0055)	(0.0112)	(0.0057)	(0.0108)	(0.0045)
Log of SCHOOLING	0.0120	0.0107	0.0107	0.0114	0.0107	0.0018
	(0.0037)	(0.0047)	(0.0104)	(0.0048)	(0.0100)	(0.0053)

Source: Author's calculations, based on data from Easterly and Levine (1997).

a. The estimated regressions are as follows: (1) ordinary least squares (OLS) estimates for model ALL; (2) Bayesian model averaging (BMA) estimates for model ALL; (3) OLS estimates for model ALL + ALL*I(LATINCA), for which composite coefficient estimates and standard errors are reported and in which AFRICA, LATINCA, and DUM60 are dropped from the LATINCA-specific set of regressors; (4) BMA estimates for model ALL + ALL*I(LATINCA), for which composite coefficient estimates and standard errors are reported and in which AFRICA, LATINCA, and DUM60 are dropped from the LATINCA-specific set of regressors; (5) OLS on LATINCA subsample; and (6) BMA on LATINCA subsample. Standard errors are in parentheses.

mates, in that the posterior expectation in each case is quite small when compared with the variance. The consistency of this finding across the estimated alternatives, however, strengthens arguments that democracy levels do not seem to add much to empirical models of growth.[7]

7. Compare Barro (1996).

Table 3. Democracy: Ordinary Least Squares versus Bayesian Model Averaging[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Intercept term	—	—	—	—	–0.7667	0.0083
	—	—	—	—	(0.4894)	(0.1529)
Dummy for sub-Saharan Africa	–0.0168	–0.0161	–0.0160	–0.0162	—	—
	(0.0047)	(0.0073)	(0.0049)	(0.0061)	—	—
Dummy for Latin America and the Caribbean	–0.0150	–0.0138	–0.6866	–0.0027	—	—
	(0.0045)	(0.0070)	(0.5295)	(0.0063)	—	—
Dummy for 1970s	–0.0949	0.0464	–0.0801	0.0467	—	—
	(0.0890)	(0.0155)	(0.0928)	(0.0146)	—	—
Dummy for 1980s	–0.1111	0.0293	–0.1052	0.0262	–0.0252	–0.0276
	(0.0890)	(0.0167)	(0.0930)	(0.0170)	(0.0062)	(0.0063)
Log of initial income	0.0423	–0.0001	0.2045	–0.0006	0.2045	0.0059
	(0.0231)	(0.0006)	(0.1304)	(0.0013)	(0.1224)	(0.0389)
Log of initial income squared	–0.0032	–0.0001	–0.0131	–0.0002	–0.0131	–0.0004
	(0.0015)	(0.0002)	(0.0082)	(0.0002)	(0.0077)	(0.0025)
Assassinations	–19.2393	–4.0676	–18.5783	–3.1335	–18.5783	–6.2317
	(10.3025)	(9.2535)	(12.4481)	(8.2420)	(11.6849)	(10.5951)
Financial depth	0.0172	0.0103	0.00780	0.0006	0.0079	–0.0019
	(0.0068)	(0.0115)	(0.0233)	(0.0187)	(0.0219)	(0.0087)
Black market premium	–0.0207	–0.0205	–0.0197	–0.0201	–0.0197	–0.0137
	(0.0044)	(0.0046)	(0.0087)	(0.0047)	(0.0081)	(0.0100)
Ethnic diversity (ELF60)	–0.0136	–0.0080	–0.0143	–0.0085	–0.0143	–0.0054
	(0.0059)	(0.0085)	(0.0148)	(0.0097)	(0.0140)	(0.0112)
DEMOCRACY	–0.0008	–0.000003	0.0005	—	0.0006	0.00003
	(0.0009)	(0.000190)	(0.0018)	—	(0.0016)	(0.00037)

Source: Author's calculations, based on data from Easterly and Levine (1997).
a. The estimated regressions are as follows: (1) ordinary least squares (OLS) estimates for model ALL; (2) Bayesian model averaging (BMA) estimates for model ALL; (3) OLS estimates for model ALL + ALL*I(LATINCA), for which composite coefficient estimates and standard errors are reported and in which AFRICA, LATINCA, and (LATINCA*DUM70) are dropped from LATINCA-specific set of regressors; (4) BMA estimates for model ALL + ALL*I(LATINCA), for which composite coefficient estimates and standard errors are reported and in which AFRICA, LATINCA, and (LATINCA*DUM70) are dropped from LATINCA-specific set of regressors; the democracy variable is included in set of regressors, but never picked up by BMA procedure. (5) OLS on LATINCA subsample; and (6) BMA on LATINCA subsample. Standard errors are in parentheses. No democracy data are available for the 1960s period, so DUM60 was dropped.

Finally, the tables generally reveal substantial differences for parameter estimates for Latin America versus the world as a whole. This strongly suggests that in using growth regressions to inform policy in Latin America, one must be very cautious in drawing generalizations from standard empirical exercises and applying them to Latin America. This finding is not unique; Brock and Durlauf (2001) draw similar conclusions with respect to countries in sub-Saharan Africa.

5. CONCLUSIONS

The objective of this paper was to argue that the conventional use of empirical studies of growth to inform policy suffers from a number of problems, which may be defined on two levels. First, the use of statistical significance levels to determine which policy instruments affect growth and which do not is an unsatisfactory basis for integrating empirical work and policy evaluation. Policy evaluation is better thought of as a comparison of posterior distributions of growth rates for a given country under alternative policy scenarios. This comparison can only be made relative to the payoff function of the policymaker. Statistical significance levels correspond to this comparison only for very special cases. Second, in assessing posterior distributions of growth rates, conventional growth regressions suffer from a number of limitations. These regressions typically do not allow for the fact that an empirical researcher does not know the true growth model. Model uncertainty, in this context, occurs because the modeler does not know what growth determinants must be included in a model or what forms of country-level heterogeneity need to be accounted for in the model. I follow Brock and Durlauf (2001), Doppelhofer, Miller, and Sala-i-Martin (2000), and Fernandez, Ley, and Steel (2001b) in advocating the use of Bayesian model averaging methods to allow for the explicit incorporation of model uncertainty in empirical work. A small empirical exercise illustrates how the use of growth regressions to draw policy implications for Latin American countries is affected by allowing for model uncertainty.

To repeat, this paper should not be regarded as advocating nihilism when it comes to econometric analyses of growth. Rather, it should be read as advocating caution. Within the discourse of academic economics, far too much emphasis is placed on zero-one assessments of whether a given theory is true. What is needed is a more nuanced approach to empirical work that gives adequate scope to the limits on inferences that can be made from observational data. Regressions have a role to play in policy evaluations, even for phenomena as important as growth. This role is distorted when a researcher ignores available historical and cultural information about a given country when conducting statistical work. Put differently, it is troubling how such deep qualitative studies as Greenfield (2001) and Landes (1998) have had little integration into the quantitative studies of growth that currently dominate the field.

The issues of the integration of econometrics with policy analysis and the appropriate incorporation of model uncertainty into empirical studies are by no means unique to the study of economic growth.

However, given the breadth of the phenomenon under study, as well as the complexities of the units whose behavior is to be evaluated (after all, we are dealing with the growth rates of entire economies), the study of growth at a country-wide level seems particularly susceptible to these problems. While there is no magic solution to the question of how to integrate different sources and types of information into a coherent policy exercise, such issues cannot be ignored. Ultimately, what is needed is a full recognition of the difficulties and limits facing any judgments that must be made in using data to inform growth policies.

Appendix A

The data cover 160 countries and include the following variables.

Code	*Description*
GYP	Growth rate of real per capita GDP. Source: *World Bank National Accounts* (various years).
AFRICA	Dummy variable for sub-Saharan African countries (according to World Bank definition). Source: *World Bank National Accounts* for AGO, BDI, BEN, BWA, CAF, CIV, CMR, COG, COM, CPV, DJI, ETH, GAB, GHA, GIN, GMB, GNB, GNQ, HVO, KEN, LBR, LSO, MDG, MLI, MOZ, MRT, MUS, MWI, NAM, NER, NGA, RWA, SDN, SEN, SLE, SOM, STP, SWZ, SYC, TCD, TGO, TZA, UGA, ZAF, ZAR, ZMB, ZWE (various years).
ASSASS	Number of assassinations per thousand population, decade average. Source: Banks (1994).
BLCK	Log of 1 plus black market premium, decade average. Source: World Bank (1991, with updates); *Pick's Currency Yearbook* (various years).
DUM60	Dummy variable for 1960s.
DUM70	Dummy variable for 1970s.
DUM80	Dummy variable for 1980s.
ELF60	Index of ethnolinguistic fractionalization, 1960. Measures the probability that two randomly selected people from a given country will not belong to the same ethnolinguistic group. Source: Easterly and Levine (1997); *Atlas Narodov Mira* (1964).
LATINCA	Dummy variable for Latin America and the Caribbean. Source: Easterly and Levine (1997).
LLY	Measure of financial depth, based on the ratio of the financial system's liquid liabilities to GDP, decade average. Liquid liabilities consist of currency held outside the banking system plus demand and interest bearing liabilities of banks and nonbank financial intermediaries. Source: King and Levine (1993).
LRGDP	Initial income, measured as the log of real per capita GDP at the start of each decade (1960, 1970, 1980). Source: Summers and Heston (1988).
LRGDPSQ	Log of initial real per capita GDP squared. Source: Summers and Heston (1988).
DEMOC	Measure of democracy (Gastil's political rights variable) Source: Gastil (1990, 1988).
LSCHOOL	Log of 1 plus average years of school attainment, quinquennial values (1960–1965, 1970–1975, and 1980–1985). Source: Barro and Lee (1993).
SURP	Ratio of central government fiscal surplus to GDP, both in local currency at current prices, decade average. Source: IMF's *International Financial Statistics* (various years, line 80) and *Government Finance Statistics* (various years, line L80).

Appendix B

All model averaging calculations were done using the program *bicreg*, which is an SPLUS program written by Adrian Raftery.[8] The key feature of the program is the way it deals with the large number of regressions involved in a BMA exercise. This program, following standard procedures in the model averaging literature, uses a search algorithm that explores only a subset of the model space; the design of the algorithm ensures that the search proceeds along directions such that it is likely to cover models that are relatively strongly supported by the data. I follow the procedure suggested by Madigan and Raftery (1995); see Raftery, Madigan, and Hoeting (1997) and Hoeting and others (1999) for additional discussion and a full description of the search algorithm. The latter paper provides a nice intuitive description of the ideas that underlie the algorithm:

> First, when the algorithm compares two nested models and decisively rejects the simpler model, then all submodels of the simpler model are rejected. The second idea, "Occam's window," concerns the interpretation of the ratio of posterior model probabilities $Pr(M_0/D)/Pr(M_1/D)$. Here M_0 is "smaller" than M_1.... If there is evidence for M_0 then M_1 is rejected, but rejecting M_0 requires strong evidence for the larger model M_1 (Hoeting and others, 1999, p. 385).

The algorithm I employ to implement the model averaging procedure uses an approximation, following Raftery (1995), based on the idea that for a large enough number of observations, the posterior coefficient distribution will be close to the maximum likelihood estimator, such that one can use the maximum likelihood estimates to avoid the need to specify a particular prior. Raftery (1995) and Tierney and Kadane (1986) contain technical details. While some evidence exists that this approximation works well in practice, more research is needed on the specification of priors for model averaging. Fernandez, Ley, and Steel (2001a) make an important contribution in this respect.

8. Available at www.research.att.com/~volinsky/bma.html.

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The Effects of Business Cycles on Growth

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This paper explores the links between business cycles and long-run growth. Although it is clear from a theoretical point of view that both of these phenomena are driven by the same macroeconomic variables, the interaction between economic fluctuations and growth has been largely ignored in the academic literature. The main reason for this lack of attention is the surprising stability of long-term growth rates and their apparent independence from business cycle conditions, at least among industrial economies. Business cycles in these countries can be characterized as alternating series of recessions followed by recoveries that bring gross domestic product (GDP) levels to trend; this suggests that one can study growth and business cycles independently. To illustrate this point, figure 1 displays real GDP per capita for the U.S. economy during the period 1870–1999. A simple log-linear trend represents a highly accurate description of the long-term patterns of per capita output in the United States.[1] This pattern is very similar for other industrial countries such as France, Germany, and Great Britain, although the slope of the trend shows stronger indications of breaks, especially after the Second World War.

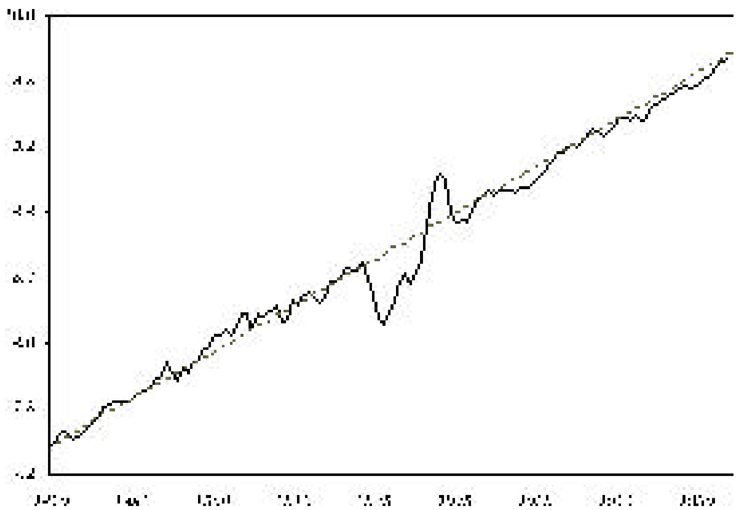
The lack of a widely accepted, empirically valid growth model has resulted in the use of two distinctive approaches to studying the relation between growth and business cycles. From an empirical viewpoint, the (augmented) Solow model seems to fit the cross-country data quite well, as

I would like to thank Norman Loayza, Ilian Mihov, and Luis Servén for useful comments and suggestions.

1. As Jones (1995a, 1995b) has pointed out, an extrapolation of a log-linear trend for the pre-1914 period produces extremely accurate point estimates of current GDP levels.

Economic Growth: Sources, Trends, and Cycles, edited by Norman Loayza and Raimundo Soto, Santiago, Chile.

Figure 1. U.S. Real per Capita GDP (in logs)



shown in Mankiw, Romer, and Weil (1992) and Barro and Sala-i-Martin (1992, 1995). However, early attempts to empirically validate endogenous growth models have not been very successful, as argued in Easterly and others (1993) and Jones (1995b). As a result, no clear framework has been established for analyzing the impact of business cycles on growth.

Despite such arguments, a growing literature establishes interesting theoretical links and empirical regularities relating growth and business cycles. Recent analysis of cross-country growth performances reveals less support for Solow-type growth models.[2] At the same time, since the work of Nelson and Plosser (1982), it is commonly accepted that business cycles are much more persistent than what is suggested in figure 1. Moreover, the GDP profile of countries other than the United States is at odds with steady-state models of economic growth, as suggested by Easterly and Levine (2001). Direct evidence has also been presented on the effects of business cycles on variables related to long-term growth. Productivity is affected by the business cycle and seems to react to events that are supposed to be only cyclical.[3] Growth-related variables, such as investment or research and

2. Bernanke and Gürkaynak (2002); Easterly and Levine (this volume).
3. See, for example, Shea (1999).

development (R&D) expenditures, are procyclical. Finally, features of the business cycle, such as the volatility or persistence of economic fluctuations, are correlated with long-term growth rates.[4] These empirical regularities are very difficult, or even impossible, to reconcile with models in which technological progress and long-term growth are exogenous.

This paper presents an overview of the theoretical arguments, together with a summary of the evidence of the effects of business cycles on growth in a large cross section of countries.[5] The analysis is undertaken on two levels. The first part of the paper looks at the connections between certain characteristics of the business cycle and long-term growth rates and establishes a set of empirical regularities. These regularities are well captured by a simple endogenous growth model in which long-term growth dynamics are central to business cycles. Although this theoretical framework uncovers interesting connections between long-term growth and features of the business cycle such as persistence, it does not produce unambiguous predictions about whether the volatility of economic fluctuations has negative effects on long-term growth rates.

The second part of the paper directly studies the possibility that business cycles have a significant effect on long-term growth rates by looking at asymmetric business cycles as well as considering the general effects of uncertainty. Overall, the evidence presented suggests that business cycles and long-term growth rates are determined jointly by the same economic model. There is evidence that characteristics of the business cycle are not independent of the growth process, and the volatility associated with the business cycle is negatively related to long-term growth rates.

The paper is organized as follows; Section 1 studies the relation between the persistence of business cycles and long-term growth. Section 2 explores the links between volatility and growth, and Section 3 concludes.

1. Trends, Persistence, and Growth

The stability of growth rates for the U.S. economy has been used as an argument for keeping the analysis of trends separate from the analysis of economic fluctuations. However, this apparent stability of U.S

4. See Fatás (2000a, 2000b) for evidence on the effects of business cycles on R&D expenditures and the link between persistence and growth.

5. My sample of ninety-eight countries is identical to the one used by Bernanke and Gürkaynak (2002), and it excludes formerly planned economies. See the appendix for a detailed description of the data.

growth rates is at odds with the econometric analysis of its time series properties, which shows that the log-linear trend is far from being an accurate representation of its long-term properties. This stylized fact was brought up by Nelson and Plosser (1982), who question the traditional method of measuring business cycles as temporary deviations of output from a deterministic log-linear trend. Their paper triggered a debate on the persistence of output fluctuations and the existence of a unit root in GDP. Although some of this debate is still open, one fact is no longer questioned: output does not show a strong tendency to return to trend after being hit by a shock. Consequently, growth and business cycles cannot be separated analytically, which raises the need for models in which the stochastic properties of the trend are somehow related to the business cycle itself.

This evidence was initially used to promote the real business cycle theory, in which the persistence of business cycles is interpreted as a sign of the nature of the disturbances that causes business cycles (technological events). While this approach incorporates growth and fluctuations into a single model, however, there is still a sense in which growth is left out of the analysis, given that long-term growth rates are determined by the exogenous growth rate of technological progress in a Solow-type model.[6]

An alternative explanation to the high persistence of business cycle fluctuations comes from models that consider growth dynamics to be central to the properties of the business cycle. Within the framework of endogenous growth models, King, Plosser, and Rebelo (1988) and Stadler (1990) notice that many types of disturbances other than permanent shifts in the production function can produce persistent fluctuations. The intuition is simple: any temporary disturbance that has an effect on the amount of resources allocated to growth can produce permanent effects on the level of output. In other words, if investment in growth-enhancing projects is diminished during recessions and the recovery is not strong enough to catch up with lost time, then output will not return to its trend. Recessions can thus have costs that go well beyond the added volatility to the economy.

The task of distinguishing these two explanations empirically is a difficult one. Two approaches have been followed. One is to compare the relative ability of both types of models to match features of the business cycle. This is the approach taken by Jones, Manuelli, and Siu (2000). Their conclusions are in some cases supportive of endogenous growth

6. See, for example, Kydland and Prescott (1982); King and others (1991).

models, but they encounter many difficulties discriminating between the two types of models. An alternative methodology is to look for empirical connections between the degree of persistence of business cycles and long-term growth rates. This is only interesting if there are significant differences in persistence across countries. Cogley (1990) studies the variability of the low-frequency component of output in a sample of nine countries; he shows that there are significant differences among them, with the United States having the most stable low-frequency component of the sample. If this degree of persistence is related to the long-term growth rates of these countries, then it would establish a direct connection between long-term growth rates and a feature of economic fluctuations intrinsically linked to the question of whether business cycles have long-term consequences beyond uncertainty and short-term volatility.

A reduced-form version of a model that displays endogenous growth can be used to illustrate the link between persistence and growth.[7] Assume that the economy is characterized by a production function of the type

$$Y_t = A_t L_t^{\alpha} K_t \,, \tag{1}$$

where Y is output, L is labor, A is a technological parameter, and K is the economy's stock of knowledge; for simplicity, the stock of knowledge is assumed to affect all firms equally, and no firm is large enough to internalize the effects of its actions on this stock. Knowledge is accumulated by the process of learning by doing and takes the following functional form:

$$\frac{K_t}{K_{t-1}} = \left(\frac{Y_{t-1}}{K_{t-1}}\right)^{\gamma}, \tag{2}$$

where γ represents the degree of learning in the economy.[8]

7. See Fatás (2000b) for a complete optimizing model that leads to dynamics identical to those of this reduced form model.

8. This production function, together with the learning process, implies very strong scale effects. These scale effects are not necessary for any of the intuitions developed with this simple model, and a model without scale effects can display similar dynamics. I use such a simplistic production function and learning process to make the resolution of the model as simple as possible and to provide the clearest possible presentation of the intuition. See Fatás (2000b) for a detailed discussion of these arguments.

The growth rate of output at any point in time is equal to

$$\Delta y_t = a_t - (1-\gamma)a_{t-1} + \alpha\left[l_t - (1-\gamma)l_{t-1}\right], \tag{3}$$

where lowercase letters denote natural logarithms. I assume that a_t is a stationary process and that the labor supply function is such that labor is also stationary. Let a^* and l^* be the steady-state values of labor and productivity. In the absence of any cyclical disturbance, the economy will grow at a rate equal to

$$\Delta y_t = \gamma a^* + \alpha\gamma l^* . \tag{4}$$

I now introduce cyclical shocks by postulating a stochastic process for the technology parameter a_t. Assume that it follows an AR(1) process such that

$$a_t = \rho a_{t-1} + \mu_t . \tag{5}$$

Under the assumption that labor supply is inelastic, output growth can be expressed as a function of μ.

$$\Delta y_t = \left[1-(1-\gamma)L\right]C(L)\mu_t , \tag{6}$$

where L is the lag operator and $C(L)$ is the Wold representation of the AR(1) process for a_t, such that

$$C(L) = 1 + \rho L + \rho^2 L^2 + \rho^3 L^3 + \ldots \tag{7}$$

From equation 6, it is clear that cyclical fluctuations have long-lasting effects on output despite their transitory nature, because of the effects on the accumulation of knowledge. One way to look at these long-lasting effects is to measure the change in the long-term forecasts of output when there is a shock to a_t. The solution is simply the sum of the coefficients from equation 6 for Δy_t, above.

$$\Delta y_t = D(L)\mu_t , \tag{8}$$

where $D(L) = d_0 + d_1L + d_2L^2 + d_3L^3 + \ldots$ is a lag polynomial. Then, the coefficients d_j measure the impact of a shock μ_t on the growth rate of output in period $t + j$. Adding up these coefficients yields the long-run impact of a given shock on the level of output. In general, the equation,

$$P^J = \sum_{j=0}^{j=J} d_j, \tag{9}$$

represents the impact of a shock μ_t on the level of output at $t + J$. The infinite sum of all d_j coefficients measures the permanent impact of a given shock on the output level, let P be this sum, such that

$$P = \lim_{J \to \infty} P^J = D(1). \tag{10}$$

In the model, the sum of these coefficients is equal to

$$P = 1 + \left[\rho - (1 - \gamma)\right] + \left[\rho^2 - \rho(1 - \gamma)\right] + \left[\rho^3 - \rho^2 (1 - \gamma)\right] + \dots, \tag{11}$$

which can be simplified to

$$P = \frac{\gamma}{1 - \rho}, \tag{12}$$

This expression is intuitive: the long-term effects of business cycles are an increasing function of the persistence of the shocks themselves and the parameter γ, which represents the speed at which knowledge accumulates through learning by doing. What is important for my argument is that long-term persistence becomes a measure of the long-term costs of recessions, and the origin of these costs are the effects that recessions have on the accumulation of knowledge (the driving force behind long-term growth). In this stylized model, output always returns to its log-linear trend in the absence of long-term growth ($\gamma = 0$).

The above model produces a simple, intuitive explanation suggesting that business cycles have permanent effects on output through the dynamics of the growth process. During recessions, the growth process slows down. Recoveries bring the growth rate back to normal, but the level remains below the log-linear trend followed before the recession. Countries with larger growth rates have more to lose during recessions than countries with lower rates, and they therefore display larger permanent effects of business cycles. As a result, fast-growing countries display more volatile trends.[9]

The relationship described above can be used to discriminate among different theories on growth and business cycles. For example, in a model in which growth stems from exogenous technological progress (assume that A grows exogenously at some rate), this measure of persistence (P) would simply be a function of the parameter ρ. The typical formulation of a real business cycle has $\gamma = 0$ and $\rho = 1$, together with exogenous technological progress for the technological parameter A. Under these circumstances, persistence would be independent of growth and $P = 1$.

Is there any empirical evidence that persistence and growth rates are correlated? The answer is yes. Using a sample of about a hundred countries from the Summers-Heston dataset, I calculate the degree of persistence of annual fluctuations to determine whether this degree of persistence is correlated to the countries' long-term growth rates. Persistence is calculated using two different methods. First, I estimate an AR(1) process for GDP growth and approximate P by inverting the lag polynomial associated with the AR(1) process. Second, I use Cochrane's variance ratio, which has often been used to estimate the persistence of time series.[10] This measure is equal to

$$V^{J} = \left(\frac{1}{J}\right)\frac{\operatorname{var}\left(y_t - y_{t-J}\right)}{\operatorname{var}\left(y_t - y_{t-1}\right)} = 1 + 2\sum_{j=1}^{J-1}\left(\frac{1-j}{J}\right)\rho_j \ , \tag{13}$$

where ρ_j is the j^{th} autocorrelation of the growth rate of output. Taking the limit of this expression as J tends to infinity, I obtain a measure of long-run persistence,

$$V = \lim\nolimits_{J\to\infty} V^{J} \ . \tag{14}$$

9. A set of papers postulate that recessions can have the opposite effect (that is, be beneficial for growth). Caballero and Hammour (1994), Galí and Hammour (1991), and Hall (1991) all present models in which recessions lead to permanent improvements in productivity because research activities offer a higher return than production activities during such periods or because recessions lead to the destruction of the least productive firms.

10. See Cochrane (1988) for a description of this series.

Table 1. Persistence and Growth[a]

Explanatory variable	*P*		V^5	
Sample	All	OECD	All	OECD
β	0.066	0.383	0.090	0.611
	(0.029)	(0.137)	(0.043)	(0.102)
Summary statistics				
R^2	0.09	0.53	0.07	0.62

a. $\text{Persistence}_i = \alpha + \beta\ \text{Avg.Growth}_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

Both *V* and *P* take the value 0 for a trend-stationary series and the value 1 for a random walk. For any other series,

$$V = |P|^2 \frac{\text{var}(\mu)}{\text{var}(\Delta y)}. \tag{15}$$

For the model above, this expression is equal to

$$V = \frac{\gamma^2(1-\rho^2)}{(1-\rho)^2\left[\gamma^2 + 2(1-\rho)(1-\gamma)\right]}.$$

This expression is always increasing in γ as long as $\gamma < 2$, a condition that is required for output growth to be a stationary series. In other words, fast-growing countries display a larger degree of persistence as measured by either of the two indicators (*P* or *V*).

Table 1 presents the results of regressing the degree of persistence of annual fluctuations on the long-term growth rate of output for both the full sample (ninety-eight countries) and the restricted sample of member countries of the Organization for Economic Cooperation and Development (OECD).[11] This procedure is carried out for the two proposed measures of persistence and using per capita GDP as measures of economic activity. In the case of the variance ratio, I choose a window of five years (that is, including correlations of GDP growth with its first four lags).

In all cases, the coefficient is positive and significant. In the case of the OECD economies, the fit of the regression and the size of the coeffi-

11. See the appendix for a detailed description of the countries included.

cient are larger than in the overall sample.[12] These differences can partially be attributed to the different nature of the business cycle across countries. OECD economies generally exhibit well-defined business cycles, so the measure of persistence is appropriate for them. Some of the other countries, however, experience less regular, less uniform booms and recessions; a symmetric measure of persistence like the one used in table 1 can be much noisier in these cases than among the OECD countries. This reasoning explains the larger standard errors in the full sample. The fact that the coefficient is low has no straightforward explanation. A formal test could not reject the hypothesis that they are equal, and the two coefficients become closer in size if one corrects for outliers. However, whether these effects are of greater economic importance for OECD countries remains an open question.[13]

The results of table 1 show strong support for the idea that growth and business cycles are not independent phenomena. Persistence, which serves as a measure of the long-term effects of business cycles, is positively correlated to growth. Explaining the estimates of table 1 one requires a theory in which growth and fluctuations are jointly determined.

One has to be careful in interpreting the results of table 1 in terms of the effects of volatility on growth. The results suggest that growth dynamics play a role in shaping business cycles, but the argument could be entirely symmetric. The discussion on recessions (negative shocks) also applies to booms (positive shocks). Thus while fast-growing countries feel the effects of recessions more than slow-growing counties, they also benefit more from positive shocks. In that sense, the correlation between persistence and growth, although encouraging, does not provide a direct link between the volatility of fluctuations and average growth. Given enough symmetry, more fluctuations lead to more volatile trends, but the average growth rate remains constant. The next section explores theories and empirical evidence that go beyond this first relationship between growth and business cycles. By introducing asymmetries and by taking into consideration the direct role that volatility and uncertainty can play in determining growth rates, the analysis establishes a link between volatility and average growth rates.

12. These results are also confirmed when using quarterly data; see Fatás (2000b).

13. If the regressions from Table 1 are estimated by a robust minimum absolute deviation technique to check for the possibility that outliers, the estimates for the full sample and the OECD sample are closer. It is also interesting to point out that with this estimation technique, the significance of the coefficient increases for both samples confirming that outliers are not driving our main result.

2. Business Cycles, Uncertainty, and Growth

Do business cycles affect long-term performance? Is volatility bad for growth? The evidence presented thus far cannot answer these questions. In models of the type above, an increase in uncertainty—that is, an increase in the volatility of the disturbance μ—has no effect on long-term growth rates. Average growth is not affected by business cycles.

There are two ways of modifying the analysis so that volatility and uncertainty become relevant for long-term growth. The first is very mechanical and consists of thinking about fluctuations as being asymmetric. What if more fluctuations meant deeper recessions relative to unchanged expansions? Rodrik (1991), for example, considers the case of policy reform and the uncertainty introduced by the possibility that reform is reversed. In his model, additional uncertainty not only increases risk, but also lowers the average return to investment, because it is assumed that no reform leads to larger distortions.[14] Another example is the analysis of political uncertainty. Political uncertainty is usually measured by variables such as the number of revolutions and military coups or the number of political assassinations. An increase in both of these variables does not simply represent more volatility around a constant mean, but rather indicates more volatility and a lower mean. Introducing this type of asymmetric fluctuation into an endogenous growth model can lead to a straightforward connection between fluctuations and growth. For example, introducing asymmetric fluctuations in the disturbance μ in the model from the previous section establishes a direct relationship between average technology and its volatility and, therefore, the average growth rate of output. More volatile economies would display a lower mean for the technology parameter, A, than would less volatile economies, and they would grow at a lower rate as a result. Another possible source of asymmetry is the accumulation process. What if the negative effects of recessions on learning by doing are stronger than the positive effects of booms? This is the spirit of the model developed by Martin and Rogers (1997). In this case, there is also a negative relationship between volatility and growth.

The second way to link business cycles and growth is to introduce risk aversion or irreversibilities to investment. In this case, even if disturbances and business cycles are held symmetric, uncertainty can

14. Hausmann and Gavin (1996) make a similar argument to explain the poor growth performance of Latin American countries.

also directly affect growth.[15] For example, Feeney (1999) argues that risk sharing (through trade) and the associated decrease in uncertainty and volatility can have positive effects on growth. An endogenous growth model can also introduce general equilibrium effects of uncertainty on growth through consumer's behavior and the labor supply, as in Jones, Manuelli, and Stachetti (1999) or de Hek and Roy (2001).

In the sample of countries considered here, what are the main sources of uncertainty and volatility that make business cycles so different across countries? One possibility involves differences in economic policies. Talvi and Végh (2000) and Fatás and Mihov (2002) present evidence of differences in fiscal policy behavior across countries and examine how these differences are associated with different political institutions or economic structures. A second candidate is terms-of-trade shocks and the economy's degree of openness, as argued by Rodrik (1998). A third possibility is that the development of financial markets is strongly correlated with the shape of business cycles. Well-functioning financial markets can provide the tools for smoothing business cycles. In the absence of these tools, countries are more likely to suffer excessive volatility (see, for example, Caballero, 2000).

Several papers analyze the relationship between volatility and growth from an empirical standpoint. The first group of papers looks directly at the relationship between volatility and growth without focusing on a specific channel through which the effects take place. This group includes Ramey and Ramey (1995), Kormendi and Meguire (1985), and Martin and Rogers (2000). A second strand of the literature explores specific sources of uncertainty and how this uncertainty has affected long-term growth. For example, Alesina and others (1996) study the effects of political instability on growth, while Judson and Orphanides (1999) analyze the effects of the volatility of inflation on growth. Most of these papers present evidence in favor of the hypothesis that volatility, uncertainty, or political instability hurts growth. I now review some of this evidence, presenting additional tests of the robustness of the relationship between volatility and growth and also investigating some of the specific channels through which the relationship takes place.

I start by measuring the volatility of the business cycle by the standard deviation of per capita GDP growth rates. Table 2 displays the results of a regression of average growth rates (1950–1998) on business cycle volatility for all the countries in the sample. The coefficient is

15. Bernanke (1983); Bertola and Caballero (1994).

Table 2. Business Cycle Volatility and Growth[a]

Explanatory variable	*(1)*	*(2)*
Volatility	–0.241	–0.179
	(0.075)	(0.090)
Per capita GDP in 1960 (log)		0.365
		(0.182)
Summary statistics		
R^2	0.13	0.15

a. $\text{Growth}_i = \alpha + \beta\,\text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

positive and significant. Conditioning the correlation to the logarithm of 1960 per capita GDP does not alter the size of the coefficient, although its significance falls.[16] In terms of the size of the coefficient, a one standard deviation increase in volatility (about 2.3 percent) leads to a decrease in the growth rate of per capita GDP of about 0.4 percent, a relatively large effect.

2.1 Volatility versus Uncertainty

Table 2 measures business cycle volatility as the standard deviation of per capita GDP growth rates. This measure includes variations in GDP that can be forecast by economic agents. If what really matters for growth is uncertainty, then the residuals of a forecasting equation for output growth might provide a key indicator. For each of the countries in the sample, I regress output growth on its own lagged value, as well as on a linear and a quadratic trend. Introducing these trends serves to remove low-frequency movements in output that log-linear detrending cannot address.[17] The results are practically identical, both in terms of the size of the coefficient and the fit of the regression (see table 3). Because of the similarity of the results, the rest of the paper uses the standard deviation of per capita output growth rates to measure volatility.

16. Although the data starts for some countries in 1950, we always choose 1960 as the 'initial' year in order to keep consistency across countries. Using 1950 for those countries for which data is available does not change any of the results presented in the paper.

17. These low frequency movements could bias some of our results because they could be measured as volatility of output growth when they are simply changes in average growth rates over time.

Table 3. Uncertainty and Growth[a]

Explanatory variable	*(1)*	*(2)*
Uncertainty	–0.247	–0.187
	(0.077)	(0.093)
Per capita GDP in 1960 (log)		0.36
		(0.181)
Summary statistics		
R^2	0.13	0.15

a. Growth$_i$ = $\alpha + \beta$ Uncertainty$_i$ + ♎ $X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

2.2 Volatility versus Bad Policies

The biggest concern with the negative correlation between growth and business cycles found in tables 2 and 3 is the possibility that a third variable (or group of variables) is correlated with both of them and is ultimately responsible for this correlation. The first candidate is so-called bad economic policy. Governments with policies that are unfriendly to growth can introduce additional sources of volatility in the economy. It might also be the case that bad economic policies are generally more volatile policies, leading to more pronounced business cycles. If so, more volatile policies might be correlated with lower growth, while the true cause of lower growth is the low average quality of the policies.[18]

Empirically assessing whether volatility is acting as a proxy for bad policies in the regressions of tables 1 and 2 requires identifying variables that can serve as direct measures of policies that hurt growth and are correlated with the volatility of the business cycle. For example, the degree of openness is known to be correlated with long-term growth, and it is also related to the general degree of uncertainty faced by an economy.[19] Government size, which is a relevant variable in many growth models, is also related to the volatility of business cycles. Finally, inflation or inflation variability are key variables in business cycles and have been shown to have an effect on growth.

Table 4 presents the results of introducing these four variables into the analysis. Once again, the size of the coefficient is practically

18. As discussed before, in the analysis of policy reform in developing countries in Rodrik (1991), a higher probability of failure of reform is associated both to worse economic policy (higher distortions) and more uncertainty.

19. See Rodrik (1998).

Table 4. Business Cycle Volatility versus Bad Policies[a]

Explanatory variable	*(1)*
Volatility	–0.187
	(0.083)
Per capita GDP in 1960 (log)	0.394
	(0.190)
Trade openness	0.019
	(0.007)
Inflation	0.004
	(0.003)
Inflation Volatility	–0.002
	(0.001)
Government size	–0.014
	(0.017)
Summary statistics	
R^2	0.29

a. $\text{Growth}_i = \alpha + \beta\ \text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

unchanged from the previous table. Although this is only a partial list of variables capturing policy effects, I conclude that in the regressions, business cycle volatility is not capturing differences in economic policies, at least not in those related to inflation, openness, or government size.

2.3 Specific Sources of Business Cycle Volatility

The previous tables measured volatility by the standard deviation of output growth. What are the main variables that determine this volatility? Do all of them have the same effect? Answering these questions can be useful for two reasons. First, it can help discriminate among different theories by providing a more precise measure of the cause of the volatility that affects long-term growth rates. Second, it can be used in the main regression to avoid biases associated with endogeneity or omitted variables. The idea is to introduce variables that are clearly related to economic policy and the business cycle but that, in principle, should not be directly related to long-term growth rates. I look at variables that are normally considered to be neutral in the long run, starting with a set of variables that are associated with monetary policy. These include average inflation, the volatility of detrended money balances, and a measure of the exchange rate arrangement of

Table 5. Business Cycle Volatility and Economic Policy[a]

Explanatory variable	*(1)*
Exchange rate flexibility	–0.901
	(0.401)
Volatility in monetary policy	0.132
	(0.053)
Volatility in fiscal policy	0.172
	(0.223)
Inflation	0.002
	(0.001)
Summary statistics	
R^2	0.21

a. $\text{Volatility}_i = \alpha + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

each country.[20] I also include a measure of the volatility of fiscal policy: the residual of a forecasting regression of the budget deficit that includes output growth as well as a linear and a quadratic trend. My empirical strategy is first to see whether these variables are correlated with the measure of business cycle volatility and then to use this correlation to refine the estimates of the effects of volatility on growth.

A regression of output volatility on these four variables produces coefficients of the sign that would be expected (see table 5). Countries with fixed exchange rates, a higher inflation rate, more uncertain monetary policy, and more volatile fiscal policy have a more pronounced business cycle.

The information contained in table 5 can be used to reproduce the estimates of tables 2, 3, and 4, using these four variables as instruments of the volatility of the business cycle. Results are presented in table 6. The effect of volatility on growth is still significant, and the coefficient is larger in magnitude compared with the results of the ordinary least squares (OLS) regressions.

I do not claim that these variables are, under all theories, exogenous to economic growth or unrelated to all possible omitted variables that directly influence economic growth.[21] Rather, the results of table 6 confirm the negative relationship between growth and business cycles

20. Including the volatility of inflation rates does not add much to the analysis as it is highly correlated with the average inflation rate.

21. For example, and as argued before, inflation rates or the volatility of monetary and fiscal policy can be related to overall 'bad economic policy' that leads to lower economic growth.

Table 6. Growth and Business Cycle Volatility, with Economic Policy Variables[a]

Explanatory variable	*(1)*	*(2)*
Volatility	–0.483 (0.163)	–0.453 (0.189)
Per capita GDP in 1960 (log)		–0.073 (0.243)

a. $\text{Growth}_i = \alpha + \beta\ \text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses

when the volatility of economic fluctuations is measured using a set of variables that originate in monetary and fiscal policies generally believed to be neutral to economic growth beyond their impact on economic fluctuations.

2.4 Cross-Country Variation

The effects of volatility on growth should differ among countries. The development of financial markets, the degree of openness, and the level of development can condition the negative effects of uncertainty on investment and growth. This section explores this issue by incorporating interaction terms between the volatility of output and per capita GDP, together with a measure of financial development (the average ratio of M3 to GDP). Table 7 shows the results of introducing these two interaction terms in the main regression.

In both cases, the interaction terms are significant, suggesting that the effects are larger for poor countries and countries with relatively less developed financial markets. This is true regardless of whether in the regression we condition for initial per capita GDP. Moreover, both the fit of the regression and the significance of the coefficient on volatility improve considerably. Of the two interaction terms introduced, the one with per capita GDP achieves a higher significance when both variables are introduced in the regression (see columns 3 and 6). From an economic viewpoint, both interaction variables are large in size. For example, large differences are found on analyzing the individual regressions (such as columns 1 and 2) and measuring the effect of volatility on output for the countries with the highest and lowest levels of development or financial deepening. Using the estimates of column 5, the (net) coefficient on volatility for the country with the average level of financial development is about –0.25, which is practically identical to the

Table 7. Growth and Business Cycle Volatility: Cross-country Variation[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Volatility	–1.583	–0.418	–1.329	–3.311	–0.411	–3.100
	(0.278)	(0.072)	(0.298)	(0.436)	(0.099)	(0.514)
Volatility* per capita GDP	0.190		0.146	0.399		0.363
	(0.040)		(0.047)	(0.055)		(0.066)
Volatility* financial development		0.005	0.002		0.005	0.002
		(0.002)	(0.001)		(0.002)	(0.001)
Per capita GDP in 1960 (log)				–1.511	0.009	–1.488
				(0.280)	(0.179)	(0.321)
Summary statistics						
R^2	0.37	0.21	0.32	0.53	0.20	0.50

a. $\text{Growth}_i = \alpha + \beta\,\text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

coefficient estimated in table 2 (with no interaction terms). The same calculation for the country with the lowest level of financial development produces a larger coefficient (in absolute value) of about –0.361. The coefficient turns positive for the country with the highest level of development, at about 0.10. In other words, for high levels of development (measured by per capita GDP or financial deepening), the relationship between growth and business cycles turns positive instead of negative.

I can only speculate about the reason for this effect. One possibility is that business cycles differ in nature significantly depending on the level of development. Another possibility is that fluctuations and uncertainty only result in lower growth when financial markets are not fully developed and cannot provide risk-sharing mechanisms to protect agents against uncertainty. Theories that predict a positive correlation between growth and volatility probably fit rich countries better than poor countries. These theories suggest that countries choose from a set of technologies characterized by different combinations of risk and returns (growth). Countries that opt for riskier technologies will display both more pronounced business cycles and faster growth. This process, however, requires very well developed financial markets that can channel funds to those risky projects.

2.5 Effects of Business Cycles on Investment

In looking for a mechanism that explains the observed correlation between growth rates and business cycle volatility, the obvious candidate is investment. Uncertainty can adversely affect investment, and

Table 8. Investment and Business Cycle Volatility[a]

Explanatory variable	*(1)*	*(2)*	*(3)*
Volatility	–1.106	–0.244	–8.42
	(0.363)	(0.361)	(3.226)
Per capita GDP in 1960 (log)		5.227	0.33
		(0.861)	(1.778)
Volatility* per capita GDP			1.043
			(0.418)
Summary statistics			
R^2	0.11	0.33	0.43

a. $\text{Investment}_i = \alpha + \beta\, \text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

investment is one of the most robust variables for explaining long-term growth rates. Ramey and Ramey (1995) find that the link between investment and business cycle volatility is less robust than that between growth and business cycles. Aizenman and Marion (1999), however, find that the link between investment and volatility is stronger if one includes only private investment. Table 8 replicates these regressions for the dataset; it indicates that business cycle volatility is negatively correlated with average investment rates (see column 1, which reports the results of a regression run with only volatility on the right-hand side). A 1 percent increase in volatility reduces the average investment rate by about 0.5 percentage points. A quick, back-of-the-envelope calculation suggests that this drop in investment can justify lower growth rates of about 0.07 percent. This is about one-third of the effect estimated when average growth rates are regressed on volatility. According to these numbers, therefore, at most one-third of the effect of volatility on output growth can be attributed to its effect on lower investment.

Not only is the estimate of the effects of volatility on investment small, but it is not robust to the introduction of the initial level of GDP, as shown in column 2. This result can be overturned by allowing for the effect of volatility on growth rates to depend on the level of per capita GDP. In this case, the coefficient remains significant (see column 3). This last result suggests that taking into account the possibility that the relationship between volatility and growth is a function of the level of development greatly improves the fit of these regressions. Simple calculations using the range of values of the interaction term suggest that the coefficient of volatility on growth is about –3 for the poorest countries in the sample and about 1 for the richest countries.

Table 9. Growth and Business Cycle Volatility: Robustness Tests[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*
Volatility	–0.145	–0.142	–0.110	–0.081
	(0.103)	(0.059)	(0.096)	(0.071)
Per capita GDP	0.016	–0.437	–0.102	–0.753
	(0.227)	(0.207)	(0.213)	(0.271)
Secondary education in 1960	0.069			0.028
	(0.036)			(0.019)
Investment		0.153		0.143
		(0.024)		(0.025)
Population Growth			–0.679	–0.413
			(0.229)	(0.204)
Summary statistics				
R^2	0.15	0.53	0.21	0.54

a. $\text{Growth}_i = \alpha + \beta\ \text{Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

It thus seems that although business cycle volatility has negative effects on investment, investment cannot be the only channel through which uncertainty and volatility affect growth. Even in the best scenario, this channel can only account for about one-third of the total effect. This interpretation seems to corroborate the results of Easterly and Levine (2001), who argue that factor accumulation cannot explain most of the cross-country variation on growth rates.

2.6 Robustness of the Correlation to Other Growth-Related Variables

All the previous tables indicate that volatility matters for growth. More volatile economies tend to display lower long-term growth rates. In this section, I run a series of regressions to see whether this relationship between volatility and growth is robust to the introduction of a series of variables that have been shown to be relevant for growth. Most of the variables introduced are supposed to be independent of the volatility of business cycles, and there is no prior indication of the direction in which they might affect the results. This exercise follows the methodology of Levine and Renelt (1992) in testing the robustness of different sets of variables explaining cross-country differences in growth rates.

The set of variables added to the main regression is that identified by Levine and Renelt (1992). I include a measure of initial human capital (secondary education), the average investment rate, and the

Table 10. Volatility and Growth: Interaction between Business Cycles and Level of Development[a]

Explanatory variable	*(1)*	*(2)*	*(3)*
Volatility	–2.772 (0.282)	–1.7 (0.645)	–0.27 (0.091)
Per capita GDP in 1960 (log)	–2.229 (0.235)	–1.856 (0.422)	–0.953 (0.220)
Secondary education in 1960	0.037 (0.015)	0.04 (0.018)	0.026 (0.017)
Investment	0.083 (0.013)	0.143 (0.021)	0.12 (0.024)
Population Growth	–0.624 (0.153)	–0.562 (0.205)	–0.465 (0.465)
Volatility * Per capita GDP	0.34 (0.036)		
Volatility * Per capita GDP in 1960		0.212 (0.082)	
Volatility *M3/GDP			0.004 (0.001)
Summary statistics			
R^2	0.77	0.58	0.57

a. $\text{Growth}_i = \alpha + \beta \text{ Volatility}_i + \delta X_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses.

growth rate of the population. Table 9 presents the results of including one variable at a time, as well as all variables together. All regressions also include the 1960 level of per capita GDP. The four columns reveal that the relationship between volatility and growth becomes weaker as these controls are added. The coefficient is still always negative, but its size goes down by almost half and its significance falls below standard levels.[22]

These results cast doubt on the robustness of the relationship between volatility and growth, but they offer no hint on the economic mechanism that lies behind the estimates. It is unclear why a variable such as average population growth would be related to business cycle volatility in a way that breaks down the relationship between volatility and growth.

To examine these robustness tests more carefully, I again allow an interaction term between volatility and the level of development. Table 10 summarizes the results of a regression identical to that in table 9, but with a new variable that captures the interaction between

22. Similar results are obtained if one uses uncertainty, measured by the residual of a forecasting regression for output growth, instead of volatility.

business cycles and the level of development. Three variables represent possible sources of interaction with volatility: average (log) per capita GDP (column 1), initial (log) per capita GDP (column 2), and the average ratio of M3 to GDP (column 3).

All three columns produce consistent and interesting results. First, all the variables are significant and have the correct sign. Second, and most important, the introduction of an interaction term drastically increases the significance of the estimate of volatility on growth. This estimate appears much more robust than in table 9. The interaction term is positive in all cases, which confirms my previous estimates and suggests that the negative effects of business cycles on growth are much larger for poor countries. My main result is thus robust to the introduction of growth-related variables as long as I allow for differences across poor and rich countries in the effects of volatility on growth.

Table 10 can also be used to provide a reading on the significance of these interaction terms in relation to the ability of poor economies to converge to the levels of development of rich countries. The table suggests that the speed of convergence is a function of the volatility of business cycles. For countries with very volatile business cycles, lower per capita GDP does not ensure convergence toward richer economies. Taken in conjunction with theories postulating that poor economies are more likely to be subject to political and economic uncertainty, this finding points to the possibility that countries will fall into growth traps. Uncertain environments in poor countries prevent growth from taking off, and this lack of growth creates the conditions for uncertainty and economic volatility.

2.7 The Importance of Asymmetries in the Business Cycle

The analysis thus far indicates that economic fluctuations are negatively related to growth, but the question remains whether other features of the business cycle can influence the relationship between the two variables. The obvious candidate is the asymmetry of business cycles. In fact, the paper has frequently referred to the possibility that asymmetric business cycles are responsible for the observed link between volatility and growth. A proper characterization of business cycle asymmetries in a sample of ninety-eight countries is beyond the scope of this paper, but I want to see whether simple statistics that capture the asymmetric nature of shocks can modify or explain the main results.

Table 11. Growth and Business Cycles Asymmetries[a]

Explanatory variable	*(1)*	*(2)*
Business cycles asymmetry[b]	0.334	0.188
	(0.242)	(0.198)
Volatility		–0.229
		(0.071)
Summary statistics		
R^2	0.02	0.13

a. $\text{Growth}_i = \alpha + \beta\ \text{Skewness}_i + \text{Volatility}_i + \eta_i$. Sample: 1950–1998. Robust standard errors in parentheses
b. Measured as the skewness of per capita GDP growth rates.

I calculated the skewness of per capita GDP growth rates for each country in the sample and then used this measure of asymmetry as an explanatory variable in the basic growth regression. Table 11 shows the results of regressing average growth rates on skewness and on skewness and volatility. The coefficient on skewness has the right sign, indicating that average growth is lower when business cycles are skewed toward large negative shocks.[23] The coefficient is not significant, however, and both the coefficient and the significance drop even further when the measure of volatility is introduced into the regression. I therefore conclude that business cycles that are skewed to the left (that is, when countries suffer large, infrequent negative shocks) are more harmful to growth than symmetric fluctuations. However, the effect is weak and the coefficient is not significant, especially after introducing the volatility of business cycles into the regression.

Although the results of table 11 seem to question the economic importance of asymmetries in the link between business cycle and growth, it is important to take into account the difficulties of consistently characterizing asymmetries for the sample of countries under study. The type of asymmetries captured in the theoretical framework of Rodrik (1991), for example, is poorly captured by an indicator such as the skewness of the distribution.[24]

23. See Hausmann and Gavin (1996) for similar arguments in the case of Latin America.

24. One possible solution to this measurement problem is to look at a specific source of economic fluctuations (such as oil shocks) and characterize asymmetries by looking at the response to both positive and negative shocks to that variable. Even so, there is a question on whether those shocks have the same impact in economies at different stages of development.

3. Conclusions

This paper studies the link between business cycles and long-term growth rates. Business cycles and growth are generally analyzed separately under the assumption that business cycles can be characterized by transitory dynamics that have no effect on long-term trends. The stability of growth rates over the last hundred years in the United States and other industrial economies, combined with the good fit that Solow-type growth models produce in cross-country studies, has been used as a strong empirical argument for keeping economic fluctuations out of growth models and restricting the study of business cycles to deviations around the steady state.

The empirical evidence presented here has uncovered interesting interactions between cycles and growth that are significant both economically and statistically. My argument is based on two related pieces of evidence. First, business cycles cannot be considered temporary deviations from a trend. This observation, which is largely studied in the literature that looks at the trend-cycle decomposition, is instrumental for understanding the effects of volatility on growth. Under the interpretation presented in this paper, the documented persistence of business cycles is a measure of the effects of business cycles on growth. The fact that there is a strong positive correlation between persistence of short-term fluctuations and long-term growth rates contradicts business cycle models based on small deviations from a steady-state solution in a Solow-type growth model. This paper shows that a simple endogenous growth model in which business cycles affect growth can easily replicate this correlation.

Second, in models featuring asymmetric business cycles, an increase in volatility can lead to a decrease in long-term growth rates. Even without asymmetries, uncertainty related to business cycle volatility can lead to lower growth. The data support this proposition. Countries with more volatile fluctuations display lower long-term growth rates. A series of robustness tests designed to correct for possible omitted variables bias or problems of endogeneity reveals that the relationship is robust. Additional evidence points to a nonlinear relationship between growth and business cycles, which is well captured by an interaction term between volatility and the level of development. The effect of business cycles on growth is much larger for poor countries. This finding holds true if the level of development is measured by the degree of financial deepening. A plausible interpretation of this effect is that the development of financial markets reduces the costs associated with volatility and uncertainty because it opens possibilities for risk sharing among individuals.

Although the results clearly support models that integrate business cycles and long-term growth, the process of extracting policy recommendations from them is inherently difficult. The lack of an accepted theoretical framework limits the ability to produce structural tests of well-specified theories. So far, endogenous growth models have had only limited success explaining cross-country growth patterns. The results of this paper encourage further theoretical development of endogenous growth models with business cycles. They also suggest that making explicit the effects of economic fluctuations on growth could improve the models' ability to explain features of the business cycle.

Appendix

List of Countries

Algeria	Ecuador	Malawi	Singapore
Angola	Egypt	Malaysia	Somalia
Argentina	El Salvador	Mali	South Africa
Australia	Ethiopia	Mauritania	Spain
Austria	Finland	Mauritius	Sri Lanka
Bangladesh	France	Mexico	Sudan
Belgium	Germany	Morocco	Sweden
Benin	Ghana	Mozambique	Switzerland
Bolivia	Greece	Nepal	Syria
Botswana	Guatemala	Netherlands	Tanzania
Brazil	Haiti	New Zealand	Thailand
Burkina Faso	Honduras	Nicaragua	Togo
Burma	Hong Kong	Niger	Trinidad and Tobago
Burundi	India	Nigeria	Tunisia
Cameroon	Indonesia	Norway	Turkey
Canada	Ireland	Pakistan	Uganda
Central African Rep.	Israel	Panama	United Kingdom
Colombia	Italy	Papua New Guinea	United States
Congo	Jamaica	Paraguay	Uruguay
Costa Rica	Japan	Peru	Venezuela
Cote d'Ivoire	Jordan	Philippines	Zaire
Chad	Kenya	Portugal	Zambia
Chile	Korea, Republic of	Rwanda	Zimbabwe
Denmark	Liberia	Senegal	
Dominican Republic	Madagascar	Sierra Leone	

Source of variables:
GDP, population, and investment rates are from the Summers-Heston Penn World Tables, version 6.0 (available at www.princeton.edu/~gurkaynk/growthdata.html).
Inflation, money supply (M3), openness, government size, and budget deficit are from the World Bank, *World Development Indicators, 2001*.
Exchange rate arrangements are from the International Monetary Fund, "Annual Report on Exchange Arrangements and Exchange Restrictions," several years. Original coefficients (from 1 to 10) have been transformed to a scale of 1 to 3, where 1 represents fixed, 2 intermediate, and 3 flexible exchange rates. Fixed exchange rates correspond to the original values of 1 to 5, intermediate to the values of 6 to 8, and flexible to the values 9 and 10.

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TRENDS, CYCLES, AND CONVERGENCE

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Determining turning points in the business cycle is a difficult problem. Making sensible predictions concerning the growth path of an economy in the medium or long term is even harder. This paper explores what can be achieved by analysing and modeling time series observations on gross domestic product (GDP) and other macroeconomic time series.

Separating out trends and cycles is fundamental to a good deal of economic analysis. It is often done by applying filters in a rather arbitrary fashion. Thus the low-pass filter introduced by Hodrick and Prescott (1997) is frequently used to remove trends in situations in which it can create serious distortions (see Harvey and Jaeger, 1993; Cogley and Nason, 1995). The band-pass filter, recently introduced by Baxter and King (1999), can also result in distortions (see Murray, 2002).

Trends and cycles are best constructed using unobserved component, or structural, time series models. The parameters in such models are typically estimated by maximum likelihood, after which optimal estimates of the components are obtained by smoothing algorithms. The calculations are most easily performed by putting the model in state-space form.

The paper begins by discussing the basic ideas of structural time series models and reviewing the link with the Hodrick-Prescott (HP)

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filter. An extended class of cyclical models is then introduced. Harvey and Trimbur (2002) argue that these models enable the extraction of smoother cycles and that they lead to a more satisfactory decomposition into trend and cycle at the end of the series. The extraction of these generalised cycles is closely linked to the application of Butterworth band-pass filters. These filters are widely used in engineering but have only recently been introduced into economic statistics (see Gomez, 2001). The analysis of such filters reveals that a model yielding the equivalent of an ideal band-pass filter can be obtained as a limiting case. Fitting models with the generalised cyclical component to U.S. macroeconomic series illustrates the point about their yielding clearer and smoother cycles than are normally obtained.

Structural models can also be extended so as to include more than one cycle. A model with two cycles produces a plausible trend for quarterly Chilean GDP data.

Multivariate models are discussed in section 2. A related series with a more pronounced cycle, such as investment, may help in extracting a better cycle from GDP. Multivariate models can also be set up so as to handle economies that have converged and so have a stable relationship. These are called balanced growth models. However, the more relevant question for developing economies, such as Chile, is whether convergence is actually taking place. Section 3 examines ways of assessing and modeling convergence between two economies. A dynamic error-correction model is proposed and then extended so as to incorporate a mechanism that allows convergence to take place smoothly. Unobserved component and autoregressive versions of these models are fitted to per capita data on GDP in the United States and Japan.

Section 4 brings together the material from the earlier sections to set out bivariate models for the levels of two converging economies. The preferred models combine unobserved components with an error-correction mechanism and allow a decomposition into trend, cycle, and convergence components. This provides insight into what has happened in the past, enables the current state of an economy to be more accurately assessed, and gives a procedure for the prediction of future observations. The properties of these models are explored, and they are fitted to the Japanese and U.S. series. Finally, the scope for using these models for making medium-term predictions for Chile is assessed.

1. Time Series Models for Trends and Cycles

1.1 Structural Time Series Models

The local linear trend model for a set of observations, y_t, $t = 1, \ldots, T$, consists of stochastic trend and irregular components, that is,

$$y_t = \mu_t + \varepsilon_t, \qquad t = 1, \ldots, T. \tag{1}$$

The trend, μ_t, receives shocks to both its level and slope, so

$$\begin{aligned} \mu_t &= \mu_{t-1} + \beta_{t-1} + \eta_t, & \eta_t &\sim NID\left(0, \sigma_\eta^2\right), \\ \beta_t &= \beta_{t-1} + \zeta_t, & \zeta_t &\sim NID\left(0, \sigma_\zeta^2\right), \end{aligned} \tag{2}$$

where the irregular, level, and slope disturbances, ε_t, η_t, and ζ_t, respectively, are mutually independent and the notation NID$(0, \sigma^2)$ denotes normally and independently distributed with mean zero and variance σ^2. If both variances σ_η^2 and σ_ζ^2 are zero, the trend is deterministic. When only σ_ζ^2 is zero, the slope is fixed and the trend reduces to a random walk with drift

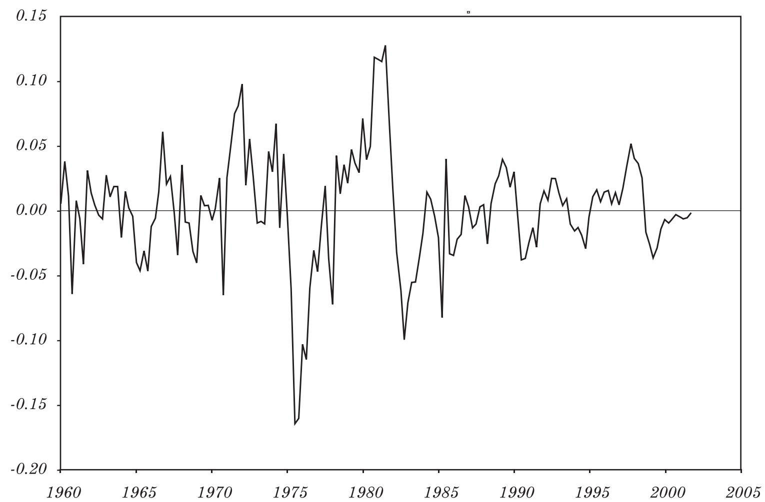
$$\mu_t = \mu_{t-1} + \beta + \eta_t. \tag{3}$$

Allowing σ_ζ^2 to be positive, but setting σ_η^2 to zero gives an integrated random walk (IRW) trend, which when estimated tends to be relatively smooth. This model is equivalent to a cubic spine and is often referred to as the smooth trend model.

The statistical treatment of unobserved component models is based on the state-space form (SSF). Once a model has been put in SSF, the Kalman filter yields estimators of the components based on current and past observations. Signal extraction refers to the estimation of components based on all the information in the sample. Signal extraction is based on smoothing recursions which run backward from the last observation. Predictions are made by extending the Kalman filter forward. Root-mean-square errors (RMSEs) can be computed for all estimators and prediction intervals constructed.

The unknown variance parameters are estimated by constructing a likelihood function from the one-step-ahead prediction errors, or innovations, produced by the Kalman filter. The likelihood function is maximized by an iterative procedure. The calculations can be done with

Figure 1. HP Filter for Chilean GDP, Using Seasonally Adjusted Data



the STAMP package of Koopman and others (2000). Once estimated, the fit of the model can be checked using standard time series diagnostics such as tests for residual serial correlation.

HP filtering can be carried out by applying a signal extraction algorithm to a special case of the smooth trend model in which the signal-noise ratio, $q = \sigma_\zeta^2 / \sigma_\varepsilon^2$, is set to 1/1600 for quarterly data. Figure 1 shows the cycle obtained from HP detrending of quarterly, seasonally adjusted data on GDP for Chile.[1] The result is a rather noisy series from which no clear message emerges, particularly toward the end. The HP filter applied to U.S. GDP is more satisfactory in that the business cycle emerges clearly, but again it is not clear what is happening at the end of the series; the HP cycle is very similar to the one shown later in figure 2.

Estimating the parameters of a smooth trend model for GDP will not usually result in an HP cycle, as there is nothing in the model to distinguish long-term from short-term movements. Short-term movements may be captured by including a serially correlated stationary

1. Seasonal adjustment was carried out using the basic X-12-ARIMA option in PcGive.

component, ψ_t, in the model. Thus,

(4)

An autoregressive process is often used for ψ_t, as in Kitagawa and Gersch (1996). Another possibility is the stochastic cycle

$$\begin{bmatrix} \psi_t \\ \psi_t^* \end{bmatrix} = \rho \begin{bmatrix} \cos\lambda_c & \sin\lambda_c \\ -\sin\lambda_c & \cos\lambda_c \end{bmatrix} \begin{bmatrix} \psi_{t-1} \\ \psi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix}, \quad t = 1, \ldots, T, \tag{5}$$

where λ_c is frequency in radians and κ_t and κ_t* are two mutually independent white noise disturbances with zero means and common variance σ_κ^2. Given the initial conditions that the vector $(\psi_t, \psi_t^*)'$ has zero mean and covariance matrix **I,** it can be shown that for the process ψ_t is stationary and indeterministic with zero mean, variance , and autocorrelation function

(6)

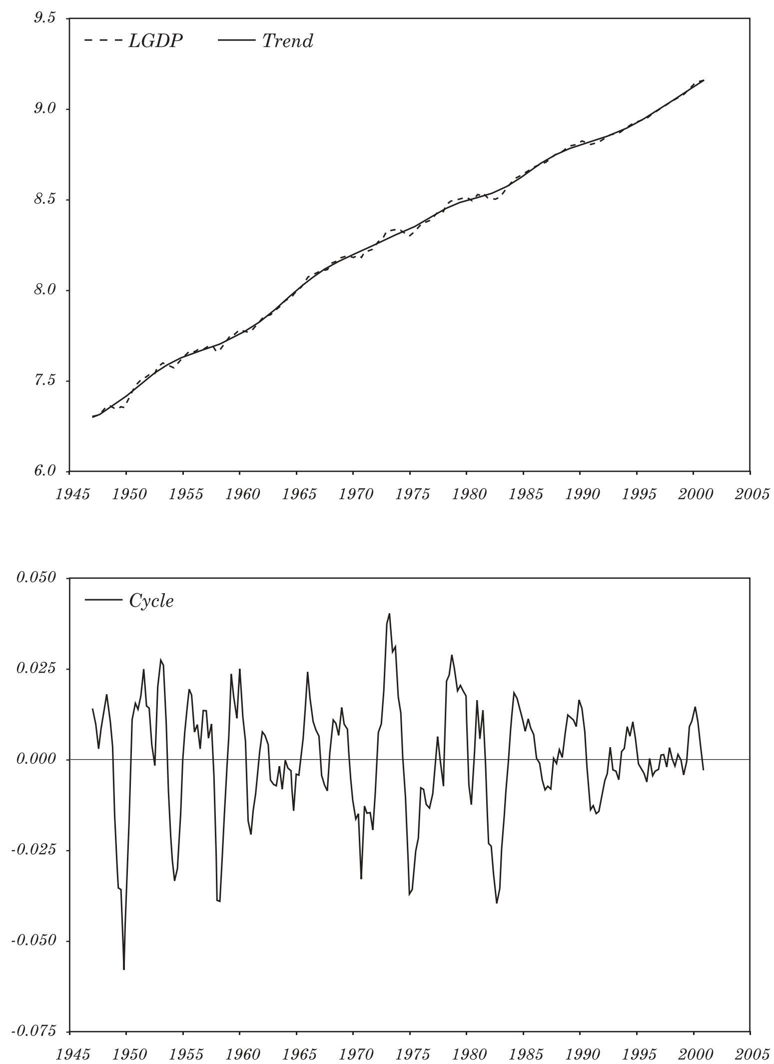
For $0 < \lambda_c < \pi$, the spectrum of ψ_t displays a peak, centered around λ_c, which becomes sharper as ρ moves closer to one. The period corresponding to λ_c is $2\pi / \lambda_c$. In the limiting cases when $\lambda_c = 0$ or π, ψ_t collapses to first-order autoregressive processes with coefficients ρ and minus ρ, respectively. More generally the reduced form is an ARMA(2,1) process in which the autoregressive part has complex roots. The complex root restriction can be very helpful in fitting a model, particularly if there is reason to include more than one cycle.

Harvey and Jaeger (1993) show that extracting a cycle from U.S. GDP using a smooth trend plus cycle model gives a very similar result to the HP filter. This correspondence continues to hold with the series shown in figure 2, which is from 1947:1 to 2001:3. The problem at the end of the series is apparent. The challenge is to devise models that are capable of giving a clearer breakdown into trend and cycle.

1.2 Extracting Smoother Cycles

The cycle extracted for U.S. GDP in figure 2 comes from a model in which the irregular variance is estimated to be zero. Thus, as with the HP filter, the cycle is the same as the detrended series. A clearer indication of the business cycle might be obtained by a model that manages

Figure 2. Trend and Cycle in U.S. GDP from a Structural Time Series Model



to force some of the stationary part of the series into the irregular component. The same idea is inherent in the notion of a band-pass filter centred on the business cycle frequencies (see Baxter and King, 1999).

The smoothness of a trend depends on the shape of the weighting function—the kernel—for extracting it and the signal-noise ratio. In the local linear trend model of equation 1, the weighting pattern for a random walk plus drift is a double exponential. For the integrated random walk trend the kernel decays more slowly; some examples can be found in Harvey and Trimbur (2002). Furthermore, if the IRW trend model is fitted, the signal-noise ratio is usually smaller than it is for a random walk with drift: the result is a wider bandwidth and a smoother trend. A similar device may be employed for the cycle. Thus the double, or second-order, stochastic cycle is

$$\begin{bmatrix}\psi_t\\ \psi_t^*\end{bmatrix} = \rho\begin{bmatrix}\cos\lambda_c & \sin\lambda_c\\ -\sin\lambda_c & \cos\lambda_c\end{bmatrix}\begin{bmatrix}\psi_{t-1}\\ \psi_{t-1}^*\end{bmatrix} + \begin{bmatrix}\psi_{\beta,t-1}\\ \psi_{\beta,t-1}^*\end{bmatrix},$$
$$\begin{bmatrix}\psi_{\beta,t}\\ \psi_{\beta,t}^*\end{bmatrix} = \rho\begin{bmatrix}\cos\lambda_c & \sin\lambda_c\\ -\sin\lambda_c & \cos\lambda_c\end{bmatrix}\begin{bmatrix}\psi_{\beta,t-1}\\ \psi_{\beta,t-1}^*\end{bmatrix} + \begin{bmatrix}\kappa_t\\ \kappa_t^*\end{bmatrix}, \tag{7}$$

where κ_t and κ_t* are as in the first-order cycle, equation 5, and ρ and λ_c satisfy the same conditions.

General classes of higher-order trends and cycles may be defined. A higher-order trend will give a nonlinear forecast function and so may not be attractive. On the other hand, higher-order cycles may have a degree of merit. Harvey and Trimbur (2002) define the n^{th}-order stochastic cycle, for positive integer n, as

$$\begin{bmatrix}\psi_{1,t}\\ \psi_{1,t}^*\end{bmatrix} = \rho\begin{bmatrix}\cos\lambda_c & \sin\lambda_c\\ -\sin\lambda_c & \cos\lambda_c\end{bmatrix}\begin{bmatrix}\psi_{1,t-1}\\ \psi_{1,t-1}^*\end{bmatrix} + \begin{bmatrix}\kappa_t\\ 0\end{bmatrix},$$
$$\begin{bmatrix}\psi_{i,t}\\ \psi_{i,t}^*\end{bmatrix} = \rho\begin{bmatrix}\cos\lambda_c & \sin\lambda_c\\ -\sin\lambda_c & \cos\lambda_c\end{bmatrix}\begin{bmatrix}\psi_{i,t-1}\\ \psi_{i,t-1}^*\end{bmatrix} + \begin{bmatrix}\psi_{i-1,t}\\ 0\end{bmatrix}, \quad i = 2,\ldots,n. \tag{8}$$

The fact that there is neither κ_t* nor $\psi_{i-1,t}^*$ is a matter of convenience in working out frequency domain properties. It enables one to write

$$\psi_{i,t} = C(L)\psi_{i-1,t}, \qquad i = 2,\ldots,n,$$

with $\psi_{1,t} = C(L)\kappa_t$, where

Repeated substitution yields

(9)

The power spectrum, for $\rho < 1$, is given directly from the spectral generating function as

$$f_\psi(\lambda;\rho,\lambda_c,n) = \left|C\left(e^{-i\lambda}\right)\right|^n \sigma_\kappa^2/2\pi$$

$$= \frac{\sigma_\kappa^2}{2\pi}\left[\frac{1+\rho^2\cos^2\lambda_c - 2\rho\cos\lambda_c\cos\lambda}{1+\rho^4+4\rho^2\cos^2\lambda_c - 4\left(\rho+\rho^3\right)\cos\lambda_c\cos\lambda + 2\rho^2\cos 2\lambda}\right]^n . \tag{10}$$

As n increases, the shape of the spectrum becomes such that there is relatively less power at high frequencies.

If the cycle is embedded in white noise, that is,

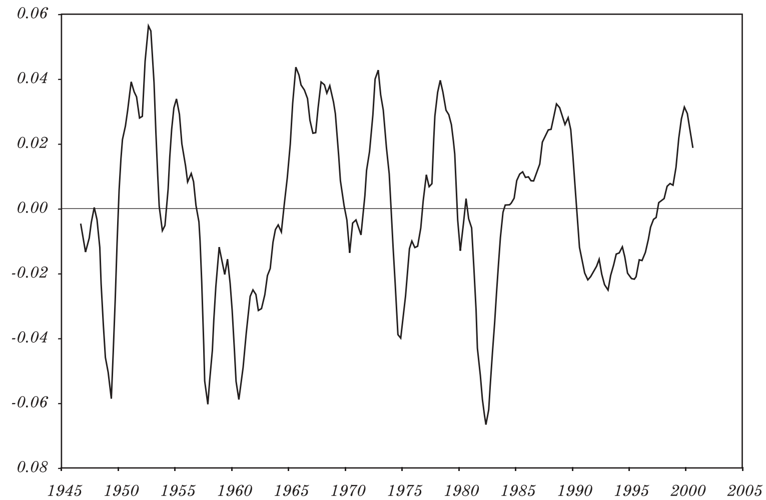
(11)

the gain function for extracting the cycle is found to be

(12)

where $q_\kappa = \sigma_\kappa^2/\sigma_\varepsilon^2$. The higher is n, the more a block of frequencies around λ_c is passed by the filter. When a model of the form of equation 11 is fitted, the irregular component tends to become bigger as n increases, the signal-noise ratio, q_κ, becomes smaller, and the estimated cycle tends to become smoother. Similar conclusions hold if the model contains a trend, as in equation 4.

Figure 3. Second-Order Cycle for U.S. GDP

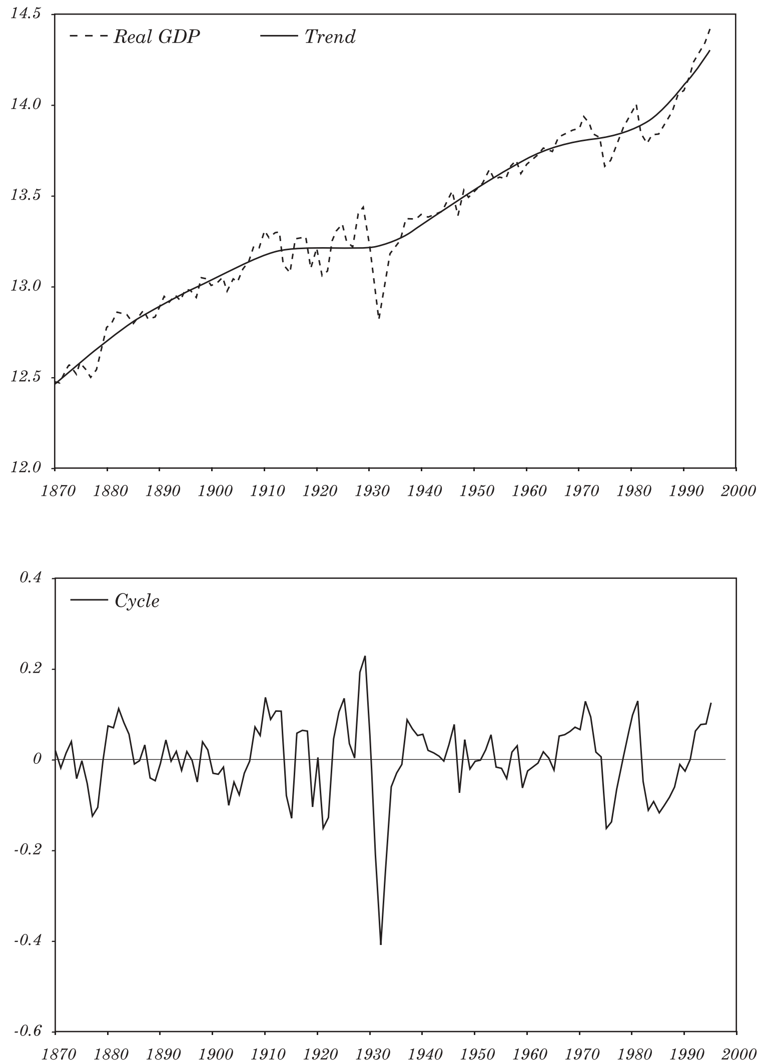


Gomez (2001) shows that the signal extraction filter for the cycle is a member of the Butterworth class if $\rho = 1$. More generally, Harvey and Trimbur (2002) refer to a filter obtained with $0 < \rho < 1$ as a generalised Butterworth band-pass filter of order n.

With ρ equal to one, the gain becomes more rectangular as n increases, and an ideal band-pass filter is obtained as a limiting case. Baxter and King (1999) argue for the desirability of ideal band-pass filters; they suggest how the filters may be approximated in the time domain by truncating weights beyond a certain lag and then modifying them so they sum to zero. A model containing a higher-order cycle can also approximate an ideal band-pass filter, but without sacrificing observations at the beginning and end of the series. The model suggests, however, that this may be unappealing, one reason being that the cycle is nonstationary. Business cycles are normally thought of as being stationary, so the additional flexibility resulting from the inclusion of the damping factor is an important generalisation.

Fitting a fully specified model consisting of trend, cycle, and irregular components, together with any other necessary components such as a seasonal, yields a filter that is optimal for extracting a cycle with clearly defined properties and that is consistent with the data. Root-mean-square errors of extracted components are also available, though the basic formulae do not make allowance for the parameters

Figure 4. Trend Fitted to Annual Chilean GDP, 1870–1995



having been estimated. The calculations may be programmed in Ox using the SsfPack set of subroutines documented in Koopman, Shephard, and Doornik (1999). Figure 3 shows the cycle extracted from U.S. GDP when $n = 2$. This cycle is smoother than the one shown in figure 2, and even more importantly, it gives a much clearer indication of the state of the economy at the end of the series. It appears that the United States is at the top of a boom, and there is a strong indication of a turning point.

1.3 Several Cycles: The Case of Chile

Fitting the trend plus cycle model to the logarithms of annual data on Chilean GDP from 1870 to 1995 (in 1995 pesos) gives the trend shown in figure 4. The period of the cycle is $P = 12.05$, with $\rho = 0.75$ and the signal-noise ratio, q_ζ, equal to 0.0056. Fitting the same model to the quarterly data set, 1960:1 to 2001:4, in real 1986 Chilean pesos, is less successful.[2] The recessions in the 1970s and 1980s are very pronounced, and because they so dominate the sample period, they become incorporated into the trend, leaving only very short-term movements in the cycle. Estimating a model with two cyclical components solves the problem, however. The first cycle, which picks up the major recessions, has a period of 10.66 years with $\rho = 0.97$, while the second has a period of just under three years and $\rho = 0.92$. If one uses the monthly series from January 1982 to July 2001, only the short-term cycle can be extracted. As can be seen from figure 1, the HP filter (applied to seasonally adjusted data) is unsatisfactory, as it yields a confusing mixture of short- and long-term cycles together with the noise from the irregular. The Baxter-King filter would be of little help, since it normally focuses on frequencies between six and thirty-two quarters.

Figure 5 shows the five components into which the series is decomposed. Of particular note is the fact that the economy is near the trough of the longer-term cycle. Figure 6 shows forecasts of the series, with one RMSE on either side, together with extrapolations of the two cycles. However, the forecasts for the two cycles should be interpreted with caution. While they pick up identifiable movements in the past and thereby allow a more satisfactory trend to be extracted, there is no reason to suppose that they will be a permanent feature of the Chilean economy; this applies particularly to the longer cycle.

2. The last two quarters are estimates.

The series has a seasonal component, which shows marked changes over the period; the graph of individual seasons is particularly informative. These changes are apparently due to the fact that the figures in the first part of the series are unofficial estimates. It is interesting to ponder on the effect of trying to tackle such movements with a non-model-based seasonal adjustment procedure such as the U.S. Census Bureau's X-12.

2. Multivariate Models and Balanced Growth

More precise information on the target series can sometimes be obtained by bringing in information in a related series. This is done by constructing a bivariate model. For example, because the cycle in investment is quite marked, it may help give a better estimate of the cycle in GDP. Several auxiliary series may be used in a multivariate systems, but the principle remains the same. The ideas of cointegration, common trends, and balanced growth are directly relevant to the potential gains in efficiency.

2.1 Bivariate Structural Time Series Models

The bivariate local level model is

$$y_{1t} = \mu_{1t} + \varepsilon_{1t}, \quad \mu$$
$$y_{it} = \mu_{it} + \psi_{it} + \varepsilon_{it},$$
$$y_{2t} = \mu_{2t} + \varepsilon_{2t}, \quad \mu_2$$

(13)

The covariance matrix of (η_{1t}, η_{2t}) may be written

$$\Sigma_\eta = \begin{bmatrix} \sigma_{1\eta}^2 & \rho_\eta \sigma_{1\eta}\sigma_{2\eta} \\ \rho_\eta \sigma_{1\eta}\sigma_{2\eta} & \sigma_{2\eta}^2 \end{bmatrix},$$

where ρ_η is the correlation. More generally,

(14)

where μ_{it} is a local linear trend and ψ_{it} is a cycle, as defined earlier.

The similar cycle model, introduced by Harvey and Koopman (1997), allows the disturbances driving the cycles to be correlated across the series. The damping factor and the frequency, ρ and λ_c, are the same in all series, however, so the cycles in the different series have similar properties; in particular, their movements are centred around the same

Figure 5. Decomposition of Chilean Real GDP into Trend, Two Cycles, Seasonal and Irregular

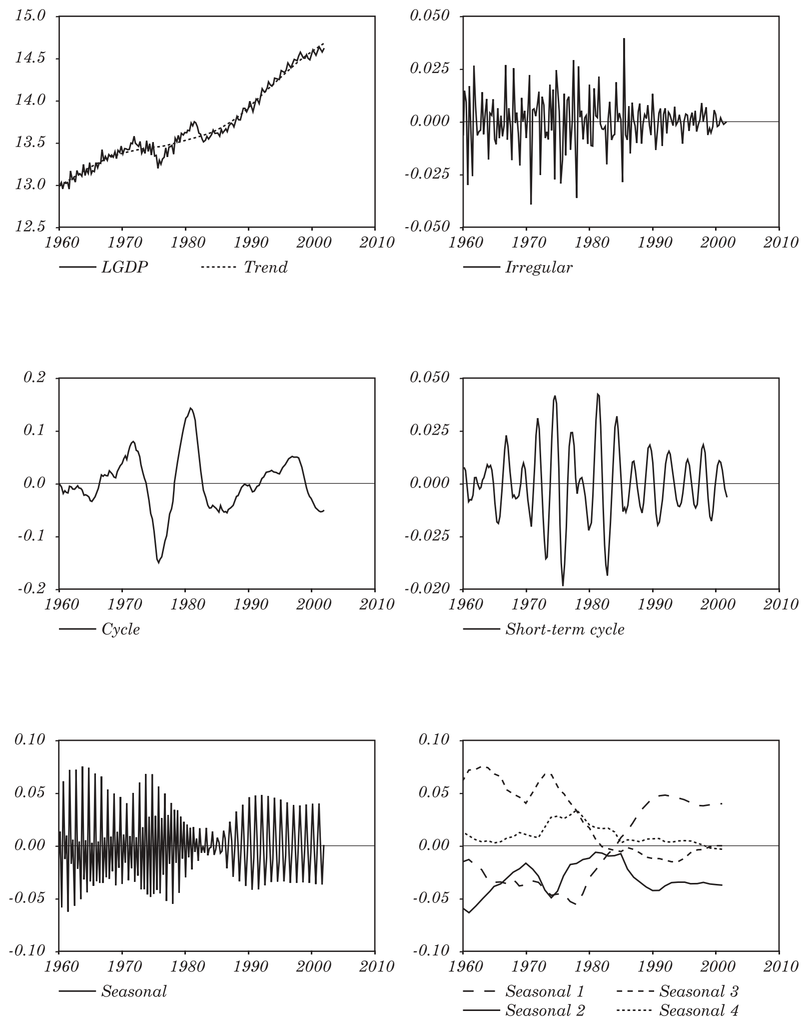
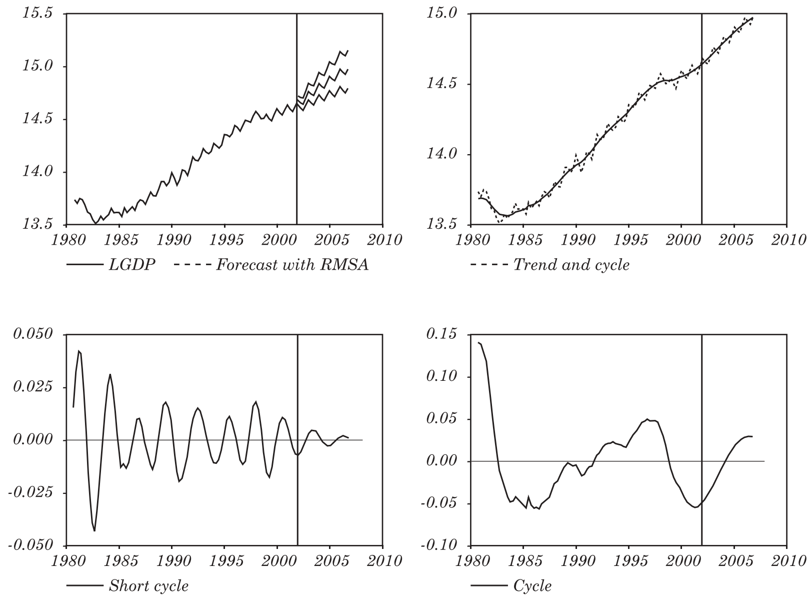


Figure 6. Forecasts for Chilean Real GDP



period. This seems eminently reasonable if the cyclical movements all arise from a similar source, such as an underlying business cycle. Furthermore, the restriction means that it is often easier to separate out trend and cycle movements when several series are jointly estimated.

2.2 Stability and Balanced Growth

In the balanced growth model, the same trend, μ_t, appears in the two series. Thus the bivariate local level model becomes

$$\begin{aligned} y_{1t} &= \mu_t + \alpha + \varepsilon_{1t}, \qquad t = 1,\ldots,T. \\ y_{2t} &= \mu_t + \varepsilon_{2t}, \end{aligned} \tag{15}$$

In terms of equation 13, $\rho_\eta = 1$ and $\sigma_{1\eta} = \sigma_{2\eta}$. A corresponding property holds for the slope disturbance in the local linear trend.

The series have a stable relationship over time in that they are evolving in such a way that their difference, $y_{1t} - y_{2t}$, is stationary. In other words, the series are cointegrated with a known cointegrating vector. A stability test of the null hypothesis of a stable relationship can be carried out using a stationarity test, such as the one proposed by Nyblom and Mäkeläinen (1983). Under the null hypothesis, the limiting distribution of the test statistic is Cramér-von Mises. The test can be modified so as to include a nonparametric correction for serial correlation, as in Kwiatkowski and others (1992). Parametric adjustments can also be made. If there are no constant terms in equation 15, that is, $\alpha = 0$, then the series contain an identical common trend. The test statistic is constructed without the mean subtracted, and its asymptotic distribution under the null comes from a different member of the Cramér-von Mises family.

The common trend restriction is a strong one, but it can lead to considerable gains in the efficiency with which components in the target series are estimated. An analysis can be found in Harvey and Chung (2000) in connection with the estimation of the underlying change in the level of unemployment. The paper also demonstrates how state-space methods can be used to combine information produced at different sampling intervals. Thus, in the case of the United Kingdom, quarterly survey data are combined with monthly claimant count figures to produce a better estimate of the underlying change in unemployment.

2.3 Japan and the United States

Models with smooth trends were fitted to the logarithms of quarterly, seasonally adjusted data on real GDP per capita in the United States and Japan over the period 1961:1 to 2000:1. The data were obtained from the Organization for Economic Cooperation and Development (OECD) *Main Economic Indicators* and the population series were constructed as quarterly moving averages of annual figures spread over all four quarters. The series are in 1990 U.S. dollars; the choice of conversion date, of course, affects the gap between the series, but it is otherwise irrelevant.

Fitting a univariate model to Japan does not yield a satisfactory cycle.[3] By contrast, it becomes much more like the United States cycle in the similar cycle bivariate model. Table 1 shows the estimates of the parameters, obtained using STAMP, together with the standard error (SE) for each equation and the Box-Ljung statistic, $Q(P)$, based on the first P residual autocorrelations. The correlations between the slope, cycle, and irregular disturbances were –0.143, 0.274, and 1, respectively. The period of 27.07 quarters corresponds to 6.77 years.

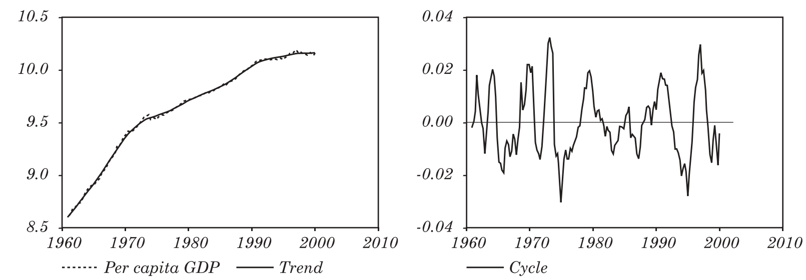
3. The cycle is almost nonstationary, with $\rho = 0.998$, while the period is only 2.97 years.

Table 1. Bivariate Model for Japan and the United States

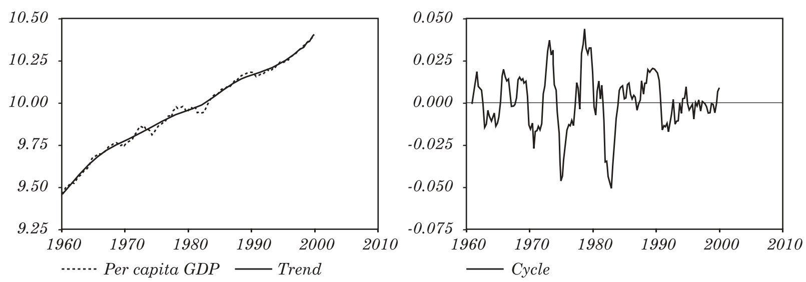
Component/Fit	*Hyperparameter*	*Japan*	*United States*
Trend	$\sigma_\zeta(x10^{-3})$	1.638	0.907
Cycle	$\sigma_\kappa(x10^{-3})$	7.177	7.642
	$\sigma_\psi(x10^{-3})$	17.22	18.34
	ρ	0.91	0.91
	Period $(2\pi/\lambda_c)$	27.07	27.07
Irregular	$\sigma_\varepsilon(x10^{-3})$	4.380	0.174
Equation standard error	$SE(x10^{-3})$	11.144	9.058
Box-Ljung statistic	$Q(11)$	11.766	14.719

Figure 7. Trends and Cycles from a Bivariate Structural Time Series Model

Japan



US



The extracted cycles are shown in figure 7. Their presence means that the trends are quite smooth. The forecasts will clearly diverge, however, as there is virtually no growth in Japan at the end of the series. This issue is taken up in section 4, when a convergence model is fitted.

3. Models of Converging Economies

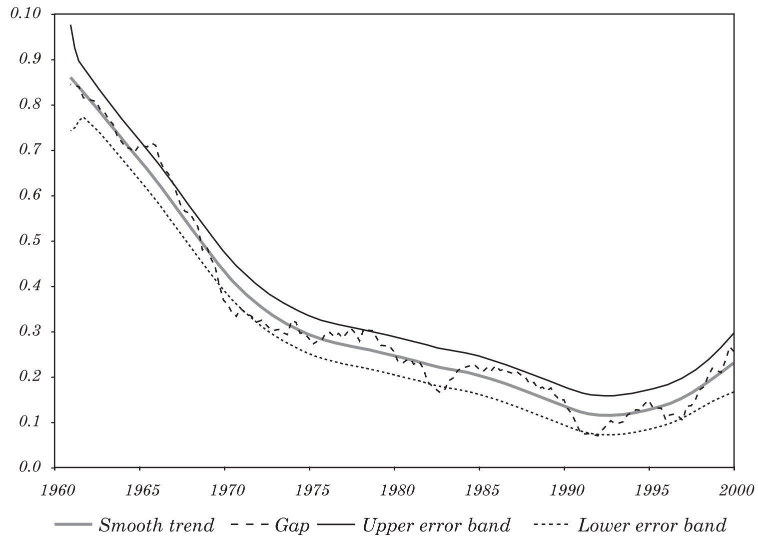
Two countries have converged if the difference between them is stable. If initial conditions are unimportant, stability implies that the difference between the series, y_t, is stationary for virtually the whole period. If the mean of y_t is zero, the countries are in a state of absolute convergence. If the mean, α, is not zero, they exhibit *conditional or relative convergence.* This is a possibility if one entertains the existence of increasing costs of convergence and possible barriers to absolute convergence (see, for example, Bernard and Durlauf, 1996). The limiting growth paths for the regions are then parallel, differing by α.

Suppose now that one wishes to model the process of convergence. If two economies are converging, the model for y_t will have the property that forecasts converge to α. The models set up below are able to satisfy this condition, and they become stationary for economies that have converged.

3.1 Stylized Facts

It is possible to consider stylized facts without positing a particular mechanism for convergence. The difference, y_t, is assumed to be made up of a stochastic trend or level, μ_t, together with other components such as cycle and irregular, as in equation 4. The smoothed estimates of the trend describe the time path reflecting the long-run difference between the two economies. Simply plotting this time path may be very informative. For example, figure 8 shows the difference in the trend of per capita GDP between the United States and Japan obtained by fitting a smooth trend, that is, with σ^2_η set to zero, plus cycle model using the STAMP package of Koopman and others (2000). Additional tests can be carried out to determine whether the gap between the two economies has narrowed significantly or whether the gap is zero, that is, $\mu_T = 0$, indicating that absolute convergence has taken place. The result can be seen from the graph, which shows a confidence interval of two RMSEs. The level in the trend at the end of the sample is 0.230 with an RMSE of 0.032 giving a t value of 7.10. Although Japan came close to catching up with the United States in the early 1990s, the movement since then has been in the opposite direction.

Figure 8. US-Japan Gap Modeled by a Smooth Trend



3.2 Error-Correction Mechanism

The use of nonstationary components to model convergence is apparently contradictory, since once convergence has taken place the series are stationary. I now show how an error-correction mechanism (ECM) can be used to capture convergence dynamics instead of approximating the process by a stochastic trend.

The simplest model is

$$y_t = \alpha + \mu_t, \tag{16}$$

with a fixed initial value, μ_0. This is not constructed as a model of a stable contrast, but rather as a model of transitional dynamics in a situation in which the initial value is some way from zero. If $\phi < 1$, the gap tends to narrow over time. It makes little sense to have ϕ negative, so I assume that $\phi > 0$. Of course, when the initial conditions have worked themselves out, the series becomes stationary. The equivalent error-correction (EC) representation for μ_t is

$$\Delta y_t = (\phi - 1)(y_{t-1} - \alpha) + \eta_t = \delta + (\phi - 1) y_{t-1} + \eta_t, \qquad t = 2, \ldots, T, \tag{17}$$

where $\delta = \alpha(1 - \phi)$. This can be interpreted as saying that for data in logarithms, the expected growth rate in the current period is a negative fraction of the gap between the two economies after allowing for the permanent difference, α. For example, with $\phi = 0.98$ and a ratio of 1.65 in income per capita, which corresponds to a gap in logarithms of 0.5, the difference in growth rates is 1 percent. Some idea of what different values of ϕ imply about the closing of the gap can be obtained by noting that the τ-step-ahead forecast from an AR(1) model is ϕ^τ times the current value. Thus ϕ^τ is the fraction of the gap expected to remain after τ time periods.

Written in the EC form (equation 17), the model accords with the notion of convergence in the cross-sectional literature, as expounded by Barro and Sala-i-Martin (1992) and others, except that there the growth rate is taken to be a linear function of the initial value, giving a model that is internally inconsistent over time (see Evans and Karras, 1996, p. 253).

The ECM may be generalised to allow for richer dynamics. Within an autoregressive framework, equation 17 may be augmented with lagged values of differenced observations. Fitting such a model to the U.S.-Japan series without the constant gives

$$\Delta \hat{y}_t = -0.0086 y_{t-1} + 0.127\Delta y_{t-1} + 0.083\Delta y_{t-2} + 0.136\Delta y_{t-3} + 0.128\Delta y_{t-4}.$$

The equation standard error, denoted SE (here equal to $\tilde{\sigma}_\eta$), is 0.0126, and $Q(11)$, the Box-Ljung statistic based on eleven residual autocorrelations, is 7.29. Under the null hypothesis of correct specification, the asymptotic distribution of this statistic is χ^2_6. With a constant added to the right-hand side

$$\begin{aligned}\Delta y_t = \underset{(0.0019)}{0.0029} &\underset{(0.0056)}{-0.0156} y_{t-1} + \underset{(0.081)}{0.118}\Delta y_{t-1} + \underset{(0.083)}{0.076}\Delta y_{t-2} \\ &+ \underset{(0.083)}{0.133}\Delta y_{t-3} + \underset{(0.083)}{0.127}\Delta y_{t-4},\end{aligned}$$

with SE = 0.0125 and $Q(11) = 6.84$. The estimate of ϕ has fallen from 0.991 to 0.984. The t statistic of the constant is –1.54, and the implied value of α is 0.187. None of the lagged differences is statistically significant at the 5 percent level. With no lags, the estimate of ϕ was 0.979, and the implied value of α was 0.143. However, there was evidence of residual serial correlation with $Q(11) = 25.14$.

3.3 Unobserved Components and Smooth Convergence

The unobserved components (UC) approach is to add cycle and irregular components to the error-correction mechanism. This avoids confounding the transitional dynamics of convergence with short-term steady-state dynamics. Thus

$$y_t = \alpha + \mu_t + \psi_t + \varepsilon_t, \qquad \mu_t = \phi\mu_{t-1} + \eta_t, \qquad t = 1,\ldots,T. \tag{18}$$

Estimation is effected by using the state-space form with a diffuse prior for μ_t (as though it were nonstationary). Although α is regarded as a fixed parameter, it can also be estimated by including it in the state vector with a diffuse prior. Care must be taken since α is not identified when ϕ is unity. A likelihood ratio (LR) test of the null hypothesis that $\alpha = 0$ can be carried out, but to ensure comparability of likelihood, the one for the unrestricted model must be calculated by treating α as fixed.

Smoother transitional dynamics can be achieved by specifying μ_t in equation 18 as

$$\begin{aligned} \mu_t &= \phi\mu_{t-1} + \beta_{t-1}, \qquad t = 1, \ldots, T. \\ \beta_t &= \phi\beta_{t-1} + \zeta_t, \end{aligned} \tag{19}$$

$$\Delta\mu_t = (\phi-1)\mu_{t-1} + \beta_{t-1}$$
$$\Delta\mu_t = -(1-\phi)^2\mu_{t-1} + $$
$$\Delta\beta_t = (\phi-1)\beta_{t-1} + \zeta_t,$$

If the model is written with what might be termed a second-order ECM, that is,

(20)

then a convergence mechanism is clearly operating on both the gap in the level and the gap in the growth rate. Alternatively, this second-order ECM can be expressed as

showing that the underlying change depends not only on the gap, but also on the change in the previous time period. This means that changes take place more smoothly. Note that the model is a special case of the second-order cycle of equation 7, obtained by setting $\lambda_c = 0$.

Table 2. Univariate Model for Difference between the United States and Japan

Component/Fit	*Hyperparameter*	*Absolute*	*Relative*	*Trend*
Convergence	$\sigma_\zeta (\text{x}10^{-3})$	1.933	1.286	1.244
	ϕ	0.963	0.943	1 (fixed)
Cycle	$\sigma_\kappa (\text{x}10^{-3})$	11.33	11.51	11.25
	ρ_c	0.94	0.96	0.95
	Period $(2\pi/\lambda_c)$	50.51	50.14	50.91
Irregular	$\sigma_\varepsilon (\text{x}10^{-3})$	0.014	0.071	1.54
Gap	α	0 (fixed)	0.180	—
Equation standard error	$SE(\text{x}10^{-3})$	12.7	12.4	12.8
Box-Ljung statistic	$Q(11)$	11.54	1.85	9.37

The model is equivalent to an AR(2) process with both roots equal to ϕ. Obviously, the condition for stationarity is $|\phi| < 1$. With a value of ϕ close to one, μ_t will behave in a similar way to the smooth trend shown in figure 8. On the other hand, the first-order ECM behaves rather like a random walk specification and tracks the observations closely, leaving little scope for the addition of short-term nontransitional components. An important feature of the second-order model is that if the convergence process stalls sufficiently, the forecast function indicates that the gap can be expected to widen in the short run.

Estimating the first-order UC model of equation 18 resulted in relatively small values for the cycle and irregular variances. The same thing happened when a random walk trend was fitted in the preliminary model, instead of a smooth trend. The dominance of the transitional component over the cycle and irregular means that the model is not too far from a simple ECM, as in equation 17. The convergence parameter, ϕ, is 0.984 for absolute convergence and 0.977 when α is estimated. The estimate of α is 0.134, but the LR statistic is 3.33, which is not significant against a χ^2_1 distribution.

The second-order convergence model (equation 20) fared much better insofar as it was able to separate out a cyclical component. The results are shown in table 2. The smoothed path of μ_t is very similar to that shown in figure 8. The parameters obtained when the smooth trend was fitted to give figure 8 are shown in the last column. The estimate of α, 0.180, now has a statistically significant LR statistic of 6.46.

I argued in section 2 that the higher-order cycles of equation 8 may be more clearly defined in that they cut out more high frequencies.

Such cycles could also be used in equation 18, although they may be more effective in the bivariate models described in the next section.

4. Bivariate Models for the Levels of Converging Economies

The previous section devised a mechanism for capturing convergence between two economies. This section explores how this mechanism can be incorporated into a bivariate model for the levels of converging economies. The aim is to extract trend and convergence components and to make forecasts that take convergence to a common trend into account. The extension to multivariate modeling is not covered, but a discussion can be found in Harvey and Carvalho (2002).

4.1 Bivariate Error-Correction Mechanism

A bivariate model for two converging economies can be set up as

$$\begin{aligned} \Delta y_{1t} &= \phi_1 \left(y_{2,t-1} - y_{1,t-1} \right) \\ \Delta y_{2t} &= \phi_2 \left(y_{1,t-1} - y_{2,t-1} \right) \end{aligned} \qquad (21)$$

where y_{it} denotes, for example, per capita output for economy i at time t. Absolute convergence and no growth is initially assumed for simplicity. The growth rate of the first economy thus depends on the gap between its level and that of the second economy and vice versa.

The model corresponds to the first-order vector autoregression

$$\begin{aligned} y_{1t} &= (1-\phi_1) y_{1,t-1} + \phi_1 y_{2,t-1} \\ y_{2t} &= \phi_2 y_{1,t-1} + (1-\phi_2) y_{2,t-1} \end{aligned} \qquad (22)$$

The roots of the transition matrix,

$$\Phi = \begin{bmatrix} 1-\phi_1 & \phi_1 \\ \phi_2 & 1-\phi_2 \end{bmatrix}$$

are one and $\phi_1 + \phi_2 - 1$. The condition for the second root to lie inside the unit circle is $0 < \phi_1 + \phi_2 < 2$. This being the case, the long-run forecasts converge to the same value, that is,

(23)

where $\bar{\phi} = \phi_2 / (\phi_1 + \phi_2)$.

The model of equation 22 can be transformed to

$$y_{1t} - y_{2t} = \phi(y_{1,t-1} - y_{2,t-1}) + \eta_{1t} - \eta_{2t},$$
$$\bar{y}_{\phi t} = \bar{y}_{\phi,t-1} + \bar{\eta}_{\phi t},$$

where $\phi = 1 - (\phi_1 + \phi_2)$ and

$$\bar{y}_{\phi t} = \bar{\phi} y_{1t} + (1 - \bar{\phi}) y_{2t}. \tag{24}$$

The disturbance $\bar{\eta}_{\phi t}$ is defined similarly. The first equation corresponds to the univariate convergence equation 17, since it is an ECM for the difference $y_{1t} - y_{2t}$. In the second equation, the weighted sum follows a random walk and, as is clear from equation 23, this is the growth path to which the two economies are converging.

Parameterising the model in terms of $\bar{\phi}$ and ϕ has some attractions. The stability condition is $|\phi| < 1$, though it makes little sense to have ϕ negative. It seems desirable (though not essential for stability) to have $0 < \bar{\phi} < 1$. This condition implies that ϕ_1 and ϕ_2 are both greater than or equal to zero. Note that if $\phi = 1$, then $\bar{\phi}$ is not identified.

Benchmark Model

Setting $\phi_2 = 0$ (or $\phi_1 = 0$) implies that country one (two) converges to country two (one), the benchmark country. Provided ϕ_1 is positive, $\phi_2 = 0$ does not imply a second unit root, so a test of this hypothesis can be based on standard distribution theory. Note that $y_{1t-1} - y_{2t-1}$ is stationary (the variables are cointegrated) in equation 21.

Trend and Constant

The model may be extended so as to include a common deterministic trend and a constant, α, to allow for relative convergence. Thus

$$y_{2t} = \beta t + \mu_{2t}, \tag{25}$$

where

$$\Delta\mu_{1t} = \phi_1\left(\mu_{2,t-1} - \mu_{1,t-1}\right) + \eta_{1t},$$
$$\Delta\mu_{2t} = \phi_2\left(\mu_{1,t-1} - \mu_{2,t-1}\right) + \eta_{2t}. \tag{26}$$

The gap, $y_{2t} - y_{1t}$, is as in equation 16, except that the sign of α is different (this is more convenient for what follows). Substituting for μ_{1t} and μ_{2t} gives

(27)

Note that the weighted average of equation 24 is a random walk with a drift of β and that the gap, $y_{2t} - y_{1t}$, is as in equation 17.

4.2 Autoregressive Models

The dynamics in equation 27 may be extended by adding lagged differences to the right-hand side of the equations and re-arranging to give

$$\Delta y_{1t} = \beta - \phi_1\alpha + \phi_1\left(y_2\right.$$
$$\Delta y_{1t} = \delta_1 - \phi_1\left(y_{1,t-1} -\right.$$
$$\Delta y_{2t} = \beta + \phi_2\alpha + \phi_2\left(y_1\right.$$
$$\Delta y_{2t} = \delta_2 - \phi_2\left(y_{1,t-1} -\right.$$

where $\delta_i = \beta\left[1 - \sum_{j=1}^{p}\left(\phi^{\dagger}_{i1j} + \phi^{\dagger}_{i2j}\right)\right] + (-1)^i\phi_i\alpha, i = 1,2$. The parameters α and β can be identified from the estimated constants once estimates of ϕ_1 and ϕ_2 have been obtained. The model belongs to the vector error-correction mechanism (VECM) class. The cointegrating vector is known, and ML estimation can be carried out by ordinary least squares (OLS) since the regressors are the same in each equation. If α is set to zero, then the restriction that the slopes are the same would need to be enforced.

In the benchmark model, ϕ_i is set to zero in one equation, such that β is identified from that equation. Using the estimate of β, an estimate of the parameter α can be extracted from the estimated constant in the other equation. There should, in theory, be gains from seemingly unrelated regressions estimation, although in practice it seems to make little difference here.

A bivariate model was estimated for the United States and Japan with $p = 4$. For Japan, $\tilde{\phi}_1 = 0.0184$ while for the United States, $\tilde{\phi}_2 = -0.0046$. The model is stable, but the negative sign for $\tilde{\phi}_2$ suggests that it should be set to zero, as in a benchmark model. Indeed the t statistic is only 0.937; this is asymptotically standard normal provided ϕ_1 is positive. The benchmark model gave an estimate of ϕ_1 equal to 0.0176, corresponding to $\phi = 0.9824$. From the estimates of the constants, α and β are estimated as 0.140 and 0.0062, respectively. The estimate of β corresponds to an annual growth rate of 2.6 percent. Recall that the univariate estimate of α from modeling the difference as an autoregression was 0.143.

4.3 Unobserved Components

Embedding the ECM within a UC model by adding a cycle and an irregular to equation 25 gives

$$\begin{aligned} y_{1t} &= \alpha + \beta t + \mu_{1t} + \psi_{1t} + \varepsilon_{1t}, \\ y_{2t} &= \beta t + \mu_{2t} + \psi_{2t} + \varepsilon_{2t}. \end{aligned} \tag{28}$$

If ψ_{1t} and ψ_{2t} are modeled as similar cycles, subtracting y_{1t} from y_{2t} in equation 28 gives a univariate model of the form of equation 18.

The vector $(\mu_{1t}, \mu_{2t})'$ may be initialized with a diffuse prior in the SSF. The parameters α and β may also be included in the state and initialized with a diffuse prior, though to compare likelihoods they should be treated as fixed. Note that if $\phi_1 = \phi_2 = 0$, then there is no convergence. The pure trend model of section 2 is then obtained, provided α is set to zero. A balanced growth model is obtained, however, if η_{1t} and η_{2t} are perfectly correlated with the same variance.

A smooth stochastic trend can replace the random walk with common drift. This is most natural if a second-order model for the convergence dynamics, generalising equation 20, is adopted. This yields

$$\begin{aligned} y_{1t} &= \alpha + \mu_{1t} + \psi_{1t} + \varepsilon_{1t}, \\ y_{2t} &= \mu_{2t} + \psi_{2t} + \varepsilon_{2t}. \end{aligned} \tag{29}$$

$$\begin{aligned} \mu_{1t} &= (1 - \phi_1)\mu_{1,t-1} + \phi_1 \mu_{2,t-1} + \beta_{1,t-1}, \\ \beta_{1t} &= (1 - \phi_1)\beta_{1,t-1} + \phi_1 \beta_{2,t-1} + \zeta_{1,t}, \\ \mu_{2t} &= (1 - \phi_2)\mu_{2,t-1} + \phi_2 \mu_{1,t-1} + \beta_{2,t-1}, \\ \beta_{2t} &= (1 - \phi_2)\beta_{2,t-1} + \phi_2 \beta_{1,t-1} + \zeta\beta_{2,t}. \end{aligned} \tag{30}$$

Again, if $\phi_1 = \phi_2 = 0$, then there is no convergence, but a balanced growth model is obtained if ζ_{1T} and $_{2T}$ are perfectly correlated with the same variance.

If the second economy is taken to be a benchmark, then $\phi_2 = 0$ in the last two equations of 30. In this case, μ_{2t} is a smooth trend and the gap is . The implied model for $y_{1t} - y_{2t}$ is as in equation 18, with μ_t replaced by .

4.4 UC Model for Japan and the United States

The smooth stochastic trends model fitted in subsection 2.3 gives an indication of the kind of results which might be expected from a convergence model and can provide starting values for some of the parameters. As already noted, the model is a limiting case which results when $\phi_1 = \phi_2 = 0$ and $\alpha = 0$.

The results of fitting the bivariate convergence model (equations 29 and 30) can be found in Harvey and Carvalho (2002). The model was estimated with the United States taken as the benchmark, with α set to zero and α unrestricted. When the more general model with no restrictions on ϕ_1 and ϕ_2 was estimated, it collapsed to the benchmark model. This is consistent with what was found when the bivariate autoregressive model was fitted.

$\zeta^{\dagger}$ $\mu^{\dagger}_{1t} = \mu_{1t} - \mu_{2t}$

The main features are as follows:

—The cycle parameters are similar to those obtained with the bivariate pure trend model reported in table 1, and the fitted cycles seem to provide a more satisfactory decomposition than was obtained for the univariate model for the difference.

—The estimate of α is only slightly smaller than the one obtained in the univariate gap model. Again there is clear evidence of relative convergence.

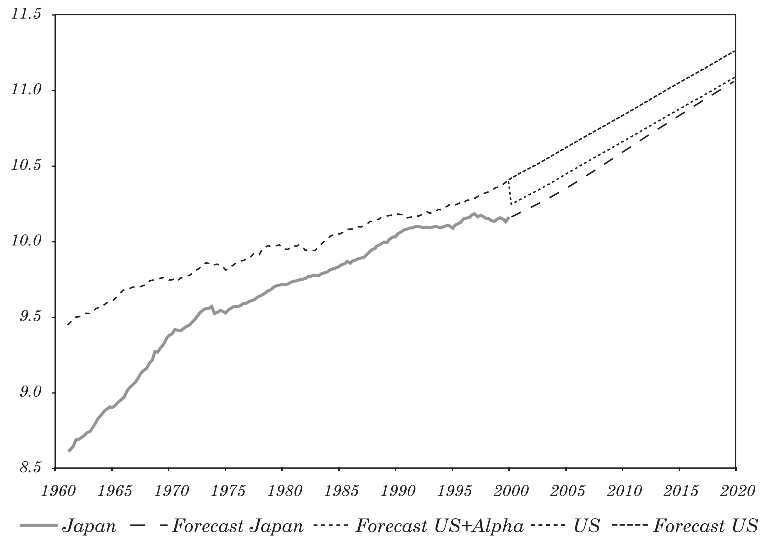
—The estimated convergence component, , assigned to Japan is very similar to the smoothed gap shown in figure 8.

—Figure 9 shows the forecasts for the two countries. It can be seen that they converge to the same growth path, μ_t, but at a constant distance, α, apart. The estimated value of α is –0.174, implying that the level of Japanese per capita GDP is about 16 percent below that of the United States.

4.5 Chile and the United States

The difference between Chilean and U.S. GDP is characterized by an enormous swing in favour of the United States during the 1960s and 1970s, followed by an equally strong movement in favour of Chile.

Figure 9. Forecasts for Bivariate Model with Relative Convergence



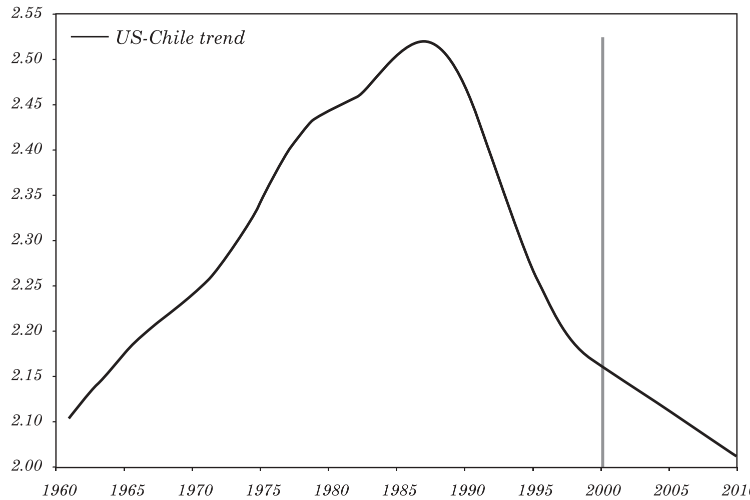
This makes modeling any kind of convergence process extremely difficult. The difficulty is compounded by the fact that the cyclical processes in the two countries have little in common. In the case of Chile, the structural time series model for quarterly per capita GDP is virtually the same as the one fitted to GDP in section 2. Extracting a trend and then subtracting from the United States trend yields the pattern shown in figure 10. Both series are in 1986 U.S. dollars. The forecasts are simply extrapolations made using the smooth trend model.[4]

5. Conclusion

This article has described an extension to the class of structural time series models which allows more clearly defined cycles to be extracted from economic time series. This was illustrated with U.S. GDP. The attraction of this model-based approach is that the filters implicitly defined by the model are consistent with each other and with the

4. Fitting a smooth trend model results in only the slope disturbance being nonzero. This is not surprising since the series is constructed from two estimated smooth trends.

Figure 10. Difference in Underlying Levels of U.S. and Chilean Real Per Capita GDP, in Logarithms



data. Furthermore, they automatically adapt to the ends of the sample, and root-mean-square errors can be calculated, if desired. The models can also be used to gain insight into the more ad hoc filters used in business cycle analysis, indicating when it might be appropriate to use them and when they can lead to serious distortions of the kind that can arise for the HP filter and band-pass filters. The preferred model for Chilean GDP has two cycles, both of which have a direct and meaningful interpretation in terms of economic activity. This decomposition could not have been achieved by an ad hoc filter.

Bivariate structural time series models allow the information on another series to be taken into account in order to extract better information from a target series. Joint modeling of different countries may also be useful. For example, a bivariate model of Japanese and U.S. GDP appears to give a more informative decomposition of Japanese GDP. The model used can be extended to include a convergence mechanism. This yields more coherent forecasts for the levels of GDP in the two countries.

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Industrial Policies and Growth: Lessons from International Experience

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For a period of roughly thirty-five years, Japan, the Republic of Korea, and Taiwan pursued industrial policies aimed at altering the sectoral structure of production toward sectors believed to offer greater prospects for accelerated growth than a typical process of industrial evolution would generate. All developing countries, excluding perhaps Hong Kong, have employed and continue to use industrial policy, broadly defined. Credit directed at specific sectors at below market interest rates for long term and working capital, sectorally differentiated profit taxes, subsidized electricity rates, research and development subsidies, control of the entry and exit of firms, and highly differentiated tariffs and nontariff barriers are all forms of industrial policy. Several Asian countries, particularly Japan, Korea, and Taiwan, are exemplars of these efforts. Given their performance over this period, it is tempting to conclude that industrial policy played a decisive role in their success.

In analyzing the impact of industrial policy, it is important to distinguish between the initiation of industrialization and its continuance once a higher level of growth was achieved. The recovery in Japan between 1945 and 1955 or 1960 was probably accelerated by government efforts to restore prewar levels of capacity and productivity in sectors such as mining, cotton spinning, and steel. In some ways this was the relatively easy part of postwar Japanese growth, as

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the knowledge base on which the prewar structure was based had not been destroyed. Capital accumulation, the direction of foreign exchange to acquire critical equipment and technology licenses, and investment coordination almost surely served a positive role, though it is hard to prove given lacunae in data for this period. Yet when one considers the Japanese or foreign image of Japan Inc. popular in the 1980s, the issue is not the contribution of industrial policy to the immediate postwar recovery, but the role of government in fostering the entry of firms into new (for Japan) sectors and whether such policies were the source of rapid growth in living standards in the period from 1960 to 1990.

Similarly, the Korean and Taiwanese governments probably played a significant role in the initiation of industrial development from roughly 1960 to 1970. This was by no means a trivial achievement, and there have been many efforts to understand the government's role in this process. By the early 1970s, however, both Korea and Taiwan had achieved considerable growth in per capita income based largely on labor-intensive industries and, as in the case of Japan, there was an effort to move into capital- and technology-intensive sectors.

A country considering the imitation of the policies that led to the initiation of industrialization in all three countries and trying to derive lessons from the three countries should worry about the replicability of their experiences. A large number of conditions have to be present including significant government competence and an overriding interest by the government in economic success measured in growth in per capita income rather than in enriching specific groups at the expense of the society. Many developing countries looking to Asia for insights are interested not in the economies' ability to export wigs, baseball gloves, or shirts, which were important products in the initial growth of manufacturing, but in their later transition into more complex sectors. Much of the evidence of this paper considers the success of the three Asian countries in their endeavor to succeed in more complex industries in the period after higher growth was initiated.

Two questions immediately arise. First, during the period of successful growth—say, 1960 to 1990 for Japan and 1965 through the late 1990s for Korea and Taiwan—was industrial policy the primary source of growth, or was it a mild accelerant, improving the growth rate slightly given the high growth of capital, education, and gains in total factor productivity (TFP) realized through borrowing technology from abroad? Second, are any of the problems encountered in Japan since 1990 and in Korea since 1997 partly the legacy of one aspect or another of industrial policy?

An alternative view of the role of industrial policy in explaining these Asian success stories is that they resulted largely from getting macroeconomic policies correct: responsible government monetary and fiscal policy, low inflation, and maintenance of the correct real exchange rate were key to their success, as was the considerable investment in the education system. Growth was propelled largely by physical and human capital accumulation, and the growth rate of TFP—while not spectacular—was high by developing country standards.

The disagreement between those who believe in the efficacy of industrial policy and those who maintain that economic fundamentals were critical is, at one level, unbridgeable, as it would require an agreement on the counterfactual evolution of sectors and productivity in each. Nevertheless, the considerable body of evidence available that attempts to empirically assess the impact of industrial policy brackets most of the plausible counterfactual scenarios. The neoclassical interpretation that success was due to getting the fundamentals right may be correct, but it must deal with the abundant evidence that Japan, Korea, and Taiwan were indeed interventionist (World Bank, 1993; Pack and Westphal, 1986; Wade, 1990; Komiya, Okuno, and Suzumura, 1984). The issue is whether the documented use of industrial policies can be shown to have been a quantitatively significant contributor to welfare. If growth rates, conditional on physical and human capital accumulation and normal TFP growth rates, would have been 9.7 but were increased to 10 percent as a result of industrial policy, then industrial policies may have played a positive but not overwhelming role. Did such an increase occur and at what contemporary cost, including lost consumer surplus, future costs, and the weakening of the financial system that had a negative effect in the late 1990s in Korea and throughout the 1990s in Japan?

Some would argue that the above view is too partial in that it does not consider factor accumulation rates, which were themselves positively affected by industrial policy. The 35 percent national saving rates and the passion for education reflected profit and wage opportunities that were generated by industrial policy or the lower risk attached to a given prospective rate of return. We briefly discuss this issue later in the paper.

1. The Case for Industrial Policy

For selective government intervention or industrial policy to be welfare improving, policymakers must identify market failures that would provide the scope for welfare-enhancing interventions; design and implement the appropriate interventions; and correct or terminate the applied policy as changing circumstances warrant.[1] Economists have identified numerous circumstances in which market failures could provide scope for welfare-enhancing industrial policies, including the following.

—Real external economies, such as the diffusion of knowledge, that one set of firms obtains without incurring its own costs. One mechanism by which this occurs is the movement of individuals among firms, but knowledge spillovers may also occur from informal exchanges in both professional and social contexts. In the case of traded goods, real externalities improve welfare only if they allow goods to be produced at less than the imported cost, insurance, and freight (c.i.f.) price.[2]

—External economies that arise as the size of a competitive industry increases, permitting a falling long-run supply curve. Such gains in productivity in a competitive sector in which individual firms exhibit constant or increasing costs are attributable to economies of scope in the use of specialized equipment and greater specialization of individual skills. Accelerating the growth of the sector may generate an earlier move toward lower long-run costs as a result of learning-by-doing. Where large-scale economies exist, firms will incur lower unit costs if capacity is established at higher levels of output. If they perceive only a domestic market, they will construct a larger plant only if potential purchasers also establish large plants that generate extensive demand. The market failure is that at a given point in time, current prices may not convey the information about prospective expansion that is relevant to attaining a lower cost of production through larger plant size. (Scitovsky, 1954; Chenery, 1959). This motivates the argument for coordinating planned investment given by Murphy, Shleifer, and Vishny (1989), who formalize Rosenstein-Rodan's (1943) idea of the big push. Multiple equilibria result from pecuniary externalities generated by imperfect competition with large fixed costs. They argue that industrial policy that "encourages industrialization in many sectors simultaneously can substantially boost income and welfare even when investment in any one sector appears impossible" (p. 1024). Such arguments critically depend on the

1. We use the terms welfare enhancing and growth accelerating interchangeably in this discussion. Most of the theoretical models are explicitly static; hence the normative results are expressed in terms of welfare enhancement, not growth acceleration. While it is possible that industrial policies could generate a one-step increase in welfare that would not lead to an acceleration in the secular growth rate, we believe that focusing solely on explicitly dynamic models would be too limiting in this context.

2. This is not, however, sufficient to justify intervention. A socially successful intervention depends on whether the present discounted value (PDV) of future producer surplus exceeds the PDV of the social cost of subsidies.

nontradability of some of the inputs or difficulties in exporting the resulting output (Pack and Westphal, 1986). Growth of the size of the economy will eventually preclude the need for policies to obtain the productivity gains from either economies of scope or scale.

—Externalities conferred on other firms in an industry by the first entrant. These include the demonstration that the sector is physically and economically feasible (Pack and Westphal, 1986; Rob, 1991) and the diffusion of information on technology and marketing conditions.[3]

—The incomplete appropriability of the results of research and development (R&D) and the possibility that its private risk exceeds social risk.

—Externalities that arise from the interaction of suppliers and buyers on product design or production methods, leading to a better or cheaper good than is available internationally. In this case, the source of the externality is the nontradability of some types of inputs or knowledge—otherwise the improved method or product could be obtained from international suppliers.

In all of these cases, industrial policies can directly enhance welfare by improving the competitiveness of domestic industry, leading to both higher national (and world) output. Industrial policies can also enhance welfare or promote growth through the capture of rents or through terms-of-trade effects associated with international trade.[4] In these cases, national industrial policies have a zero-sum element at the global level and could thus be thought of as containing a strategic or predatory element. Similarly, the trade endogenous growth literature that links the cross-national pattern of international trade specialization to differential cross-national growth rates provides numerous theoretical

3. Okuno-Fujiwara (1988) provides a formal example of this in the form of a model of the interdependence of two industries. One industry, which produces an intermediate product, is assumed to be oligopolistic as a result of underlying scale economies and to engage in Cournot competition. The other industry, which produces a final product from an intermediate product, is perfectly competitive. This situation may result in multiple equilibria, with one equilibrium Pareto-superior to the others. Industrial policy has a positive role in the form of preplay communication to generate a superior coordinated equilibrium. For the intervention to convey some purely national welfare enhancement, there has to be some nontraded aspect of the externality. Otherwise, foreigners have access to the same low-cost inputs, and the pattern of production in the downstream industry is indeterminate without additional assumptions.

4. Early formalizations of arguments along these lines are contained in Spencer and Brander (1983) and Itoh and Kiyono (1987). Helpman and Krugman (1989) provides a synthesis of the subsequent literature on strategic trade policy. Kang (2000a, 2000b) shows that the degree of intellectual property rights protection can have a strategic effect similar to export subsidization in the earlier literature.

possibilities for growth-enhancing industrial policies at the national level (Grossman and Helpman, 1991).[5]

This discussion has established the theoretical possibility for welfare- or growth-enhancing industrial policies. Comprehensively mapping the advisable policy interventions to the specific market failures or strategic opportunities identified in the literature is beyond the scope of the paper. Nevertheless, we would like to point out a few general caveats for the successful implementation of industrial policies. First, the appropriate policy response may be very case specific. For example, in the well-known Brander-Spencer model, the optimal intervention changes from an export subsidy to an export tax if Bertrand rather than Cournot competition is assumed.[6] In the case of the international trade models, pursuing domestic and international goals may require multiple policy tools if the good in question is not purely importable or exportable.

Second, with the exception of some policies that might be accomplished purely through informational efforts or coordination effects, industrial policies require scarce resources. It is not sufficient, for example, to show that in a partial equilibrium sense, a particular production or export subsidy might be potentially growth enhancing if the necessary resources are mobilized at the expense of even more worthy sectors (Dixit and Grossman, 1986). This suggests a more general informational problem: even if policymakers identify the possibility of a growth-accelerating intervention and design an appropriate policy package, they still have to calibrate the appropriate magnitude of, say, a tax or subsidy, because after all, it is as possible to intervene too much as too little.

Third, in the case of globally zero-sum strategic policies, policymakers must consider the possibility of retaliation. As a general proposition, one would expect that the possibility of retaliation would reduce the likelihood of growth-accelerating industrial policies.[7] A basic lesson from the

5.The normative results of these models to a large extent turn on conventional differences in factor usage across industries, and they therefore do not appear to yield robust policy inferences. Empirical work has focused on modeling international spillovers arising from research and development activities (for example, Coe and Helpman, 1995; Coe, Helpman, and Hoffmaister, 1996) rather than on the implications of industrial policies themselves.

6. Similarly, the presence of increasing returns to scale decreases the likelihood that the optimal policy is a subsidy, since a subsidy may encourage the entry of additional firms into the market and reduce efficiency by reducing plant size or output. See Helpman and Krugman (1989) for more such examples.

7. As demonstrated by Johnson (1953–1954), however, the possibility of retaliation does not eliminate the possibility that the introduction of a tariff by a large country would necessarily be welfare reducing, even allowing for retaliation.

strategic trade literature is that the possibility of retaliation further complicates the problem of identifying optimal policies.[8]

Finally, in the cases discussed thus far, intervention may be effective if the government itself does not suffer from deficiencies leading to government failure. One of the notable lacunae of the industrial policies literature is the general absence of discussion of political economy factors, in particular the possibility of rent-seeking behavior by self-interested firms and policymakers and the concomitant degradation of policy. One of the important aspects of Asian industrial policies was the relative lack of corruption, perhaps reflecting the high status of civil service jobs and their relatively high rate of remuneration.[9] We touch on these conditions again in the discussion of the specific cases below.

2. Industrial Policy in Japan

The roots of contemporary industrial policies in Japan go back to the Meiji Restoration of the mid-nineteenth century, when state-led development was carried out under the slogans *Shokusan-Kogyo* (industrialization) and *Fukoku-Kyohei* (a wealthy nation and a strong army.) Ironically, the unequal treaties concluded between Japan and Western powers, which greatly circumscribed Japan's ability to protect its domestic industries through tariffs, encouraged Japanese policymakers to develop other tools such as targeted subsidized lending through state-controlled banks to achieve the same effect. Intellectually, the Japanese took their cues not from Great Britain, but from Prussia (a curious precursor of the Axis alliance of World War II), and they followed Friedrich List, the proponent of infant industry promotion, rather than Alfred Marshall, the father of neoclassical economics.[10]

Japan developed a dual economy, exporting labor-intensive products such as tea, textiles, and apparel while at the same time developing considerable heavy industry, much of it organized by family-dominated

8. For example, in the Brander-Spencer model with retaliation, the previously optimal export subsidy policy is welfare reducing, and the optimal policy is a coordinated export tax by both national governments.

9. See World Bank (1993, chap. 4); Campos and Root (1996).

10. Neoclassical economics remained weak in Japan, and until quite recently the bulk of Japanese academic economists were Marxist in orientation. This is relevant to the extent that there was a general coincidence between the neomercantilist orientation of many of the so-called modern economists and the viewpoint of the Japanese Marxists, who regarded industrial policies as the manifestation of state monopoly capitalism—arguably a progressive development from their perspective.

conglomerates (*zaibatsu*) and oriented toward military production. Japan defeated first China (1895) (annexing Taiwan) and then Russia (1905) (eventually annexing Korea) and established itself as a formidable military power, as recognized by Great Britain in the Anglo-Japanese Alliance of 1902.

State dominance of the economy, which had waned in the early twentieth century as the private sector expanded, revived with the political radicalization of the late 1920s, the Great Depression, and the onset of World War II in the Pacific. Many of the institutional features often considered uniquely Japanese have their origins in the wartime economy (Okazaki, 1993; Noguchi, 1995). The devastation of World War II left Japan's per capita income in 1950 at less than three-fourths its prewar level. However, the contemporaneous level of per capita income was surely a misleading indicator of Japan's underlying technological capacity. Japan, after all, had produced aircraft carriers and fighter airplanes in the 1930s, and as shown in table 1, the human capital embodied in Japan's labor force was quite high relative to per capita income.

In the aftermath of the war, the Japanese government, in cooperation with U.S. occupation authorities, implemented an economic reconstruction plan characterized by a considerable amount of direct state resource allocation, multiple exchange rates, extensive quantitative controls on imports, foreign exchange, inward foreign investment, and royalties for technology licensing.[11]

After the withdrawal of U.S. occupation forces in 1950, Japan continued to implement sectoral industrial policies through tax policy, off-budget finance, direct subsidy, subsidized credit, research and development policy, and controls on international trade, investment, and technology importation, as well as tolerance of cartels and other kinds of anti-competitive behavior on the part of domestic firms. Capital channeling required repression of the financial system and discouragement of direct finance. In addition to these formal policy tools, government officials also sought to exercise influence through informal administrative guidance (*gyosei shido*), coercing recalcitrant firms if necessary. These efforts were largely oriented toward rebuilding heavy industries that had been destroyed during the war, such as steel and transportation equipment.

11. For histories of early postwar economic policies, see Shinohara (1982); Morishima (1982); Johnson (1982); Calder (1993). The classic work on Japanese industrial policies is Komiya, Okuno, and Suzumura (1984). Okazaki (2001) provides a highly informative description of the institutions through which postwar Japanese industrial policies was carried out. See also Johnson (1984); Patrick (1986).

Table 1. Human Capital and per Capita Income in Selected Asian and Latin American Countries, Mid-1950s

Country	*Year*	*Human capital index*[a]	*Per capita income*[b]	*Ratio of human capital index to per capita income*
Japan	1955	1673	519	3.2
Korea	1955	494	217	2.3
Philippines	1956	738	277	2.7
Malaysia	1957	334	351	1.0
Argentina	1955	760	1059	0.7
Mexico	1955	352	637	0.6

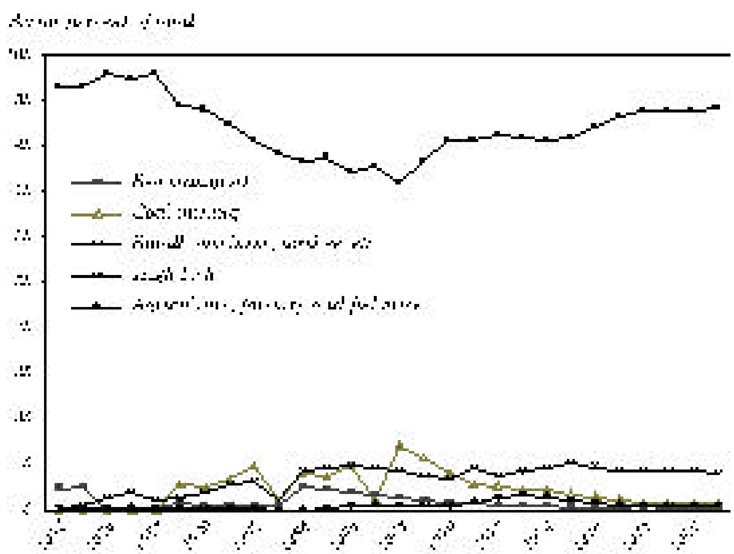
a. Human capital index is educational expenditure embodied in the labor force. Values for Japan and Mexico are interpolated from observations for 1950 and 1960; value for Argentina interpolated from observations from 1947 and 1960.
b. Per capita income is the purchasing-power-adjusted figure in international dollars from the Penn World Tables.

The conventional wisdom among economists is that direct subsidies played little role in fostering changes in Japan's industrial composition. As shown in figure 1, the declining sectors of agriculture, forestry, fishing, and coal mining typically account for 90 percent or more of direct on-budget subsidies in the period after 1955, and one study by the Japanese government found that only one sector, food processing, received direct subsidies exceeding 0.1 percent of gross domestic product (GDP) originating in that sector (Saxonhouse, 1983).

Another strand of policies pursued by the Japanese government comprises indirect subsidies through the tax system and off-budget finance. The primary source of subsidized capital is the Fiscal Investment and Loan Program (FILP), under the control of the Ministry of Finance Trust Bureau. The FILP is an off-budget program around half the size of the general account budget; it has been a powerful policy tool, giving bureaucrats a second or shadow budget with which to address priorities not met in the general accounts budget.

Funds for the FILP come mainly from the postal savings system. In addition to financing the activities of public corporations, the program finances private sector investments through public financial institutions such as the Japan Development Bank, the Export-Import Bank, and the Housing Loan Corporation. In the early postwar period, nearly one-quarter of FILP finance went toward strengthening industry, but the share dropped steadily through the 1950s, 1960s, and 1970s. By 1980, less than 3 percent of FILP funds went to industry, while housing, regional development, and other activities received half of the money (Ogura and Yoshino, 1988, table 3).

Figure 1. Sectoral Composition of On-budget Subsidies



Source: Ogura and Yoshino (1988, table 1).

One source of indirect subsidies is the public financial institutions, which offer loans at rates below the prevailing market interest rate. A second source of implicit capital subsidy is the accelerated depreciation allowed under the tax system.[12] Although some countries allow instantaneous depreciation of new investment (the only method that does not distort profitability of new investment), most require depreciation to be taken over the life of the asset. Insofar as legal asset life and the structure of assets differ among sectors, there may be implicit differentiation among them in the present discounted value of depreciation allowances. In addition, an export-based special depreciation system existed in Japan from 1961–1972.

An indication of the quantitative significance of the implicit capital subsidies is given in table 2, which reports the ratio of the implicit

12. This discussion follows that of Ogura and Yoshino (1988). Special deprecation schemes existed in Japan throughout the postwar period. The most important of these had the effect of subsidizing certain classes of investment goods.

Table 2. Japan: Ratio of Capital Subsidy to Investment
Percent

	1968			*1976*			*1984*		
Industry	*Loan*	*Tax*	*Total*	*Loan*	*Tax*	*Total*	*Loan*	*Tax*	*Total*
Mining	9.38	1.36	10.74	13.28	1.48	14.76	3.83	1.29	5.12
Food processing	0.65	0.49	1.14	1.24	0.81	2.05	0.51	0.46	0.97
Textiles	0.66	1.60	2.26	2.59	0.88	3.47	0.22	0.51	0.73
Pulp and paper	0.01	0.26	0.27	0.03	0.66	0.69	0.03	0.42	0.45
Chemicals	0.71	0.54	1.25	1.63	0.39	2.02	0.44	0.17	0.61
Petroleum and coal products	0.00	NA	NA	NA	NA	NA	2.83	0.14	2.97
Nonmetallic products	NA	NA	NA	0.72	0.11	0.83	0.44	0.13	0.57
Iron and steel	0.50	0.87	1.37	1.39	0.58	1.97	1.52	0.96	2.48
Nonferrous metal	0.48	0.46	0.94	8.40	0.34	8.74	0.62	0.35	0.97
Metal products	0.85	1.16	2.01	1.52	0.75	2.27	0.57	0.63	1.20
General machinery	0.35	0.50	0.95	2.02	0.43	2.45	0.28	0.20	0.48
Electrical machinery	0.37	0.84	1.21	1.25	0.47	1.72	0.39	1.45	1.84
Transportation machinery	2.95	0.79	3.74	3.76	0.71	4.47	0.56	0.20	0.76
Precision instruments	—	—	—	0.54	0.47	1.01	0.05	—	—

Source: Noland (1993a).

capital subsidy to investment for fourteen industries in 1968, 1976, and 1984.[13] The low interest rate loans have generally been of greater quantitative significance than the special depreciation provisions. With the exception of mining, where investment has been weak and the involvement of public financial institutions high, the implicit capital-subsidy-to-investment ratio has been low, generally less than 5 percent. After mining, the greatest beneficiary of the reduced interest burdens has been the transportation machinery industry, which includes shipbuilding, motor vehicles, and aircraft.[14]

Certain tax and budget policy provisions beyond the relatively uniform low subsidy ratios reported in table 2 have been used to promote high technology sectors. Special depreciation provisions are provided for the purchase of numerically controlled machine tools, computers and terminals, computer aided design equipment, and industrial robots. Additional tax incentives exist for the use of these products by small businesses, though the amounts appear to be relatively small. Other special tax provisions exist for the software industry.[15] The Japanese computer and robotics industries have been further assisted by the Japan Development Bank and Small Business Finance Corporation funding, including the establishment of special leasing corporations to encourage the leasing of Japanese computers and robots, especially by small firms.[16]

13. The implicit subsidy provided through the provision of these low interest loans has been calculated as the difference between interest rates charged by private and public sector financial institutions multiplied by the amount of government financial institution loans. In the case of the tax provisions, the special tax depreciation can be thought of as an interest-free loan; thus the subsidy value of the special depreciation provisions is the implicit interest burden reduction associated with the loan.

14. Japanese policymakers also have access to off-budget funds for industrial promotion through revenues of quasipublic organizations such as the Motor Boat Racing Association and the Japan Bicycle Rehabilitation Association (Prestowitz, 1988). The amounts of these funds do not appear to be particularly large, however. Saxonhouse (1983) cites *The Wall Street Journal* to the effect that no more than $500,000 a year from these sources was made available to the Japan Machine Tool Builders Association.

15. The tax benefits are not contingent on the origin of the purchased software or equipment, so the impact of these provisions has been to expand the Japanese market for these products, not assist Japanese manufacturers per se. Likewise, special provisions that allow computer manufacturers to deduct expected losses on the return of equipment offered to users on a trial basis do not discriminate by origin and thus in principle could be used by domestic manufacturers, local subsidiaries of foreign manufactures, or importers.

16. Unlike the tax provisions, which are justified on the grounds of promoting the diffusion of new technologies and do not discriminate between domestic and foreign products, the leasing schemes specifically apply to Japanese-made equipment. The amounts of money involved appear relatively small, however.

The government has also promoted high technology sectors through direct subsidies to R&D activity, special deductions for R&D costs, and reduced interest burdens through the provision of low interest loans by public financial institutions. Tax preferences were provided through a variety of schemes. The most important channel of direct subsidies to R&D activity in quantitative terms has been the system of research contracts on large-scale industrial technology R&D established in 1966. Of particular significance were subsidies to promote the development of computers in the 1970s, and research contracts on next-generation industrial technology, including new materials, biotechnology, and new electronic devices, in the 1980s.

Lastly, private R&D has been subsidized through the provision of low interest loans by public financial institutions for financing development of new technology. Private R&D activities are provided indirect support by a number of government-supported institutions. These include national and public research institutes, private nonprofit research organizations, special public corporations, and the mining and manufacturing technology research associations, such as the Very Large Scale Integration Research Association.

The direct subsidies are the most important component quantitatively of government R&D support, about twice as large as the tax provisions in most years. Implicit subsidies through the provision of low interest loans have been relatively unimportant; government support for research organizations is approximately as large as direct subsidies. Assessing the sectoral pattern of R&D is difficult. Direct subsidies from the government, public corporations such as Nippon Telephone and Telegraph (NTT), and special R&D tax deductions are only reported at the aggregate level. Sector-specific indirect support through research associations is difficult to ascertain, partly because individual associations frequently encompass more than one sector and partly because the budgets of these organizations include private, as well as government, funding.

Data on the government subsidy share of total R&D expenditures are reported in table 3. Government support of R&D activities is low, with total government support, allowing for nonsubsidy financing, accounting for less than 5 percent of private R&D expenditures for the economy as a whole. This is far less than the comparable figure for the United States. Within individual sectors, government R&D as a share of total R&D has been highest in the declining mining industry, followed by the energy-related sector of petroleum and coal products and, as in the case of capital subsidies, the transportation equipment industry, which includes aerospace.

Table 3. Japan: Government Subsidy Share of Total R&D
Percent

Industry	*1968*	*1976*	*1984*
Mining	3.2	3.2	14.0
Food processing	0.0	0.1	0.4
Textiles	0.7	0.2	1.1
Pulp and paper	0.8	0.3	0.0
Chemicals	0.5	0.3	0.8
Petroleum and coal products	1.0	0.3	7.2
Nonmetallic products	1.0	0.8	1.8
Iron and steel	0.2	0.6	1.7
Nonferrous metal	0.8	1.5	2.9
Metal products	0.1	0.2	0.2
General machinery	1.4	2.2	1.2
Electrical machinery	1.7	1.5	1.4
Transportation machinery	1.0	4.4	4.7
Precision instruments	1.8	0.3	0.1

Source: “Kagaku Gijutsu Kenkyu Chosa Hokoku (Report on the Survey of Research and Development),” various issues.

With respect to external relations, some researchers emphasize the government’s role as a doorman, “determining under what conditions capital technology and manufactured products enter and leave Japan” (Borrus, D’Andrea Tyson, and Zysman, 1986, p. 98). Table 4 shows the effective rates of protection (ERPs), computed from tariff data and the Japanese input-output table.[17] In 1968, ERPs were above 10 percent in all manufacturing sectors except publishing, where the ERP was negative. The highest ERPs—in excess of 40 percent—were in food processing, textile products, and transportation machinery. The estimates for food processing and textile products are probably upwardly biased indicators of the true ERPs, however, since in these cases major inputs were subject to quota protection not included in the ERP calculation. By 1975, ERPs had fallen for most manufacturing categories. The reductions in ERPs were most dramatic in the machinery sector, where the ERPs for transportation and precision machinery fell by approximately 40 and 20 percentage points, respectively. The final column in table 4 presents estimates of ERPs for 1987, based on tariff cuts agreed under the Tokyo Round negotiations. Except in the aberrant cases of

17. The ERPs for the primary product sectors are misleading because they do not take into account quotas in agriculture and subsidies in agriculture and mining.

Table 4. Japan: Effective Rates of Protection
Percent

Industry	*1968*	*1975*	*1987*[a]
Traded Goods	24.9	19.3	15.8
Primary	5.9	5.5	4.5
Agriculture	7.6	9.4	7.6
Forest	–1.0	–0.1	–0.1
Fishery	13.9	8.2	6.7
Mining	–0.6	–0.7	–0.5
Manufacturing	26.7	20.6	16.9
Food processing	45.4	55.6	54.1
Textile spinning	21.0	10.8	12.5
Textile weaving	33.6	92.6	94.2
Textile products	41.0	35.4	35.1
Wooden products	18.7	8.9	6.6
Pulp and paper	21.9	21.9	13.5
Publishing	–3.4	–3.3	–2.3
Leather and rubber	26.0	23.5	22.0
Chemicals	18.9	15.7	12.3
Petroleum and coal products	10.9	6.7	7.0
Nonmetallic mineral products	17.7	8.8	6.4
Iron and steel	28.9	20.8	14.9
Nonferrous metals	31.0	32.2	20.1
Metal products	18.7	8.6	6.3
General machinery	17.9	8.2	6.2
Electrical machinery	21.0	13.4	6.5
Transport machinery	45.4	5.4	1.4
Precision machinery	27.3	8.7	7.2
Miscellaneous products	28.0	20.4	9.9

Source: Shouda (1982).
a. Figures for 1987 are estimates.

food processing and textiles, the ERPs are under 10 percent for most manufacturing categories, indicating a general fall in rates of protection over a twenty-year period. Again, these calculations are based on tariff protection only; they do not take nontariff barriers into account, and the sectors are relatively aggregated. Nonetheless, barring a dramatic increase in nontraditional protection, most manufacturing sectors appear to have undergone a gradual liberalization.

The Japanese government also bargained with foreign technology suppliers, acting as a monopsonist. Goto and Wakasugi (1988) give the example of royalty payments on the importation of a particular Austrian steel production technology, which were held down to 1 cent per ton for Japan through an agreement between the Ministry of International Trade and Industry (MITI) and the industry, whereas U.S. firms paid up to 35 cents per ton for the licensing of the same technology (p. 190). For the microelectronics industry, Borrus, D'Andrea Tyson, and Zysman (1986) describe how the Japanese government used its monopsonistic power to extract very low prices for technology transfers from U.S. firms in the 1960s and 1970s. Nevertheless, the saving thus achieved was miniscule compared to either export revenues or GDP.

Government procurement is another channel through which the government of Japan sought to tilt the playing field. Bergsten and Noland (1994), for example, calculate that if in 1990 Japanese public purchases of supercomputers produced by Japanese and U.S. firms (the only non-Japanese producers) had followed the pattern exhibited in the European Union (the only third market), then U.S. producers would have increased their sales by $30 million annually, supporting nearly $5 million in additional R&D.[18] The authors obtain similar, and quantitatively larger, results for public procurement of nonsupercomputers. In another public procurement case, the 1980s dispute over the FSX fighter agreement could be interpreted as an attempt by the U.S. government to use its market power to counterbalance the Japanese government's monopsony position vis-à-vis General Dynamics. All of these cases—steel, numerically controlled machine tools, microelectronics, and possibly aircraft—display a common pattern of selective protection, strict regulation of inward foreign direct investment and technology transfer, and preferential tax treatment and access to capital until the industry achieved international competitiveness. Rosovsky calls this pattern "the denial of the profits of innovation."[19]

2.1 Assessment

A number of researchers attempt to model the impact of Japanese industrial policies on output, trade, and welfare in a cross-industry framework.[20] Lee (1993) examines the impact of Japanese industrial policies using a computable general equilibrium model. Unfortunately, the high degree of aggregation (only three traded goods sectors) and the

18. The same calculation found that the U.S. government discriminated reciprocally against Japanese supercomputer producers in its procurement decisions.
19. H. Rosovsky, "Trade, Japan and the Year 2000," *New York Times*, 6 Sept 1985.
20. See Baldwin and Krugman (1988) and Flamm (1996) for models of single industries.

calibration assumption (industrial policies in the 1950s had no impact) render his results suspect.

Noland (1993a) evaluates the impact of these policies on the Japanese economy. The results obtained indicate that trade protection, as measured by the ERPs in table 4, was generally associated with worse-than-expected performance in net exports, apparently contradicting the notion that Japanese policymakers successfully promoted infant industries.[21] Indirect subsidies, however, were associated with the expansion of output and better-than-expected trade performance. In fact, the estimated effects were so large as to give credence to the argument that Japanese industrial policy acted as a signaling device to private investors, either because the government was better able to process information than private agents or because government participation in a sector or project created a moral hazard or one-way bet. While the industrial policies were effective in the sense that market interventions appear to have had an impact on sectoral resource flows, on the whole they did not appear to be welfare enhancing, when the Itoh-Kiyono model, which runs off of terms-of-trade effects, was used to evaluate policy impact. Indeed, from this perspective welfare-enhancing interventions appear to have been the exception, not the rule.

Considerable evidence supports the unsurprising notion that during the postwar period, Japan's comparative advantage shifted into R&D-intensive activities (Balassa and Noland, 1989; Vestal, 1989; Grossman, 1990). Evidence on the impact of public policies is more scarce. Noland (1996) disaggregates R&D into basic, developmental, and applied activities and separates public and private sources of funding. At the end of the sample period 1969–1989, Japan had a comparative advantage in goods intensive in total, privately funded, and applied R&D activities, and a comparative disadvantage in publicly funded and basic R&D-intensive goods. However, the change in coefficient values over the course of the sample period suggests that publicly financed R&D had a large positive impact on sectoral trade competitiveness through the late-1970s and early 1980s. This result could be interpreted as being consistent with the notion that the relative impact of public support can be relatively high at early stages of development before the private sector R&D capacity is significantly developed and during the period of technological catch-up when R&D priorities can be relatively well defined on the

21. Noland (1997) obtain more ambiguous results for a more detailed menu of Japanese trade policies. Audretsch and Yamawaki (1988) investigate the impact of Japanese industrial policies by including a dummy variable for favored industries in a regression on U.S.-Japan bilateral trade. The coefficient was significant with the expected sign.

basis of existing technologies.[22] Sakakibara (1997) casts doubt on even this modest formulation, however, arguing that participation in publicly supported R&D consortia was concentrated in slow-growth sectors and that sharing fixed costs was not an important factor in determining participation.

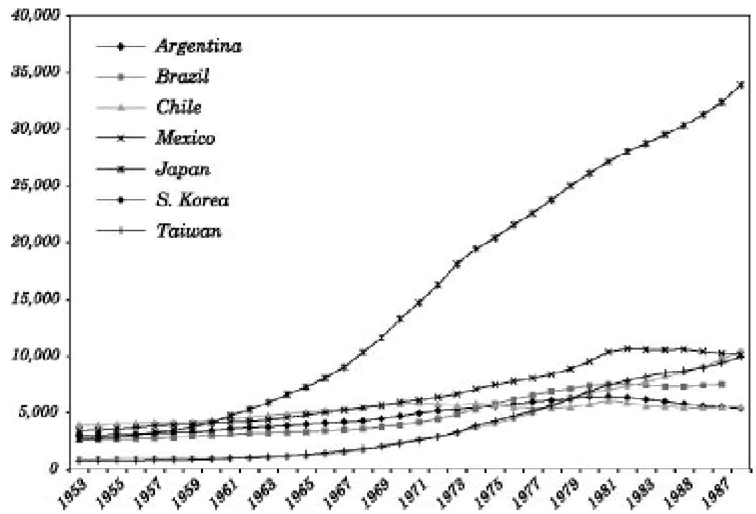
Beason and Weinstein (1996) directly confront the issue of industrial policies and sectoral TFP growth. Working with a sample of thirteen sectors for the period 1955–1990, they fail to uncover evidence that taxes, subsidies, or industrial policies (as measured by the ERPs reported in table 4) targeted sectors with increasing returns to scale or that industrial policies contributed to TFP growth. They do find some evidence that industrial policies targeted sectors with high labor usage prior to the first oil shock. Lawrence and Weinstein (2001) extend this work on a slightly different dataset and find that differential corporate tax rates had an impact on sectoral TFP growth, while direct subsidies and subsidized loans did not. Moreover, they find that the ERP measure is negatively associated with sectoral TFP growth and that imports, not exports, are positively associated with TFP growth.

Imports can contribute to increasing productivity through at least two channels. The first is by providing domestic producers with new, improved, or highly specialized intermediate inputs to which they would not otherwise have access. The second is by competing with domestic products and thereby acting as a constant spur to domestic producers to cut costs and improve quality. Lawrence and Weinstein divide imports into competitive and noncompetitive imports, and in the case of Japan, they find evidence to support the second hypothesis. They conclude that Japan's growth would have been even faster if it had cut tariffs and exposed a greater share of its domestic producers to foreign competition.

It is more difficult to assess the impact of the informal policies, if for no other reason than that they are less amenable to formal modeling. For this reason, it would be desirable to develop better descriptions of the workings of the industry councils (*shingikai*) and the process of setting targets, as well as better accounts of the penalties and rewards used to encourage adherence to informal guidance. The one study that attempts to model the impact of administrative guidance (Weinstein, 1995) finds that administrative encouragement of cartels had only a minor impact on prices, margins, and sectoral resource allocation dur-

22. Kim and Oh (1999) analyze annual data on research and development expenditures for 1971–1997 and find that public R&D expenditures Granger-cause private R&D in Japan during this period. Unfortunately, their limited sample size precludes the testing of this result for subperiods.

Figure 2. Capital Stock per Capita



ing the period 1957–1988. Sakakibara and Porter (2001), who examine the impact of the tolerance of cartels on domestic competition and international trade performance, find that cartels are negatively associated with domestic competition, which, in turn, is positively associated with international competitiveness. They interpret their results as undercutting what they perceive as the conventional wisdom that industrial policies promoted Japanese competitiveness.

This discussion has focused on issues relating to cross-sectoral resource allocation. Some argue that Japanese policy has had a proproducer bias and that this may have contributed to Japan's growth performance by increasing incentives to save and thus providing Japanese firms with a ready supply of low cost capital.[23] As shown in figure 2, Japan (as well as Korea and Taiwan) did, in fact, accumulate capital more rapidly than the major Latin American economies. This argument is seldom formalized, however, and while it has some surface plausibility, it is hard to square with the life-cycle hypothesis. Furthermore, research on Japanese saving behavior has not uncovered links between industrial policies and national saving.[24] Yano

23. A largely closed capital account up through the mid-1980s facilitated the maintenance of a pool of captive saving, though this is not absolutely necessary if there is home-bias in portfolio allocations.

24. See Balassa and Noland (1988, chap. 4); Horioka and Watanabe (1997).

(2001), however, demonstrates that in a dynamic two-country model, lax competition policies with respect to the nontraded sector of a large trade-surplus economy can act as a beggar-thy-neighbor policy, shifting real income to itself from its trade-deficit partner.

2.2 Politics and Implementation

Industrial policies intrinsically support some sectors to the detriment of others. It seems plausible that this would be manifested in conflict among sectors and among their bureaucratic counterparts. Within ministries, the bureaucratic hierarchy can ensure plan consistency, with conflicts resolved through conventional means. Ensuring consistency among plans of different ministries in Japan has proved far more problematic.

Indeed, conflicts between competing ministries are a recurrent feature of Japanese politics. For example, the Ministry of Economy, Trade, and Industry (METI, formerly the Ministry of International Trade and Industry, or MITI)—which represents the interests of the electronics firms—is in perpetual conflict with the Ministry of Public Management, Home Affairs, Posts, and Telecommunications (formerly the Ministry of Posts and Telecommunications, or MPT)—which represents the interests of NTT.[25] Inevitably, what is at issue is the desire of the electronics firms for telecommunications reform that would encourage the growth of electronic data transmission and other activities expected to increase demand for electronic equipment such as computers. These disputes have often resulted in protracted periods of uncertainty and policy paralysis. One could interpret the results reported above, that policy interventions were not welfare enhancing, as evidence of a lack of overall policy coherence.

The degree of ministerial coordination in formulating industrial policy points to the use of rewards and punishments to encourage compliance. An important question is whether the government can coordinate its incentives across ministries. Could, for example, bureaucrats threaten recalcitrant firms with retribution through actions, such as tax harassment or exclusion from government procurement, that are the purview of another ministry? Put differently, is the game firm versus ministry or firm versus government? There is little evidence of cross-ministry coordination, and although most of the political science literature extolling the

25. In 2001, Japan undertook a number of telecommunications reforms. Nevertheless, the principal theme of METI's 2001 White Paper, which was released after the telecom reforms were enacted, was the need for further reform of the telecom sector—the purview of another ministry.

impact of industrial policy implicitly assumes benevolent bureaucrats, Ramseyer and Rosenbluth (1997) argue that Japanese industrial policies can best be understood as a product of self-interested political actors.

2.3 Conclusions

There is considerable evidence that industrial policies have influenced the sectoral composition of output and trade in Japan. Rather than being the forward-looking drivers that proponents of industrial policies envision, however, the evidence suggests that industrial policies were aimed overwhelmingly at internationally noncompetitive natural-resource-based sectors, at least in terms of measurable interventions. Indeed, once general equilibrium considerations are taken into account, the manufacturing sector as a whole probably experienced negative net resource transfers. This supposition is borne out by table 5, which reports sectoral tax rates normalized for the overall corporate tax level. The normalized tax rates for the manufacturing sector are almost uniformly negative—that is, the sector was paying higher-than-average taxes. Within manufacturing, the strategy might then be regarded as a compensatory policy toward some favored activities or firms.

The diverse empirical estimates reviewed here thus indicate that there is no firm evidence that industrial policies were welfare- or growth-enhancing in the period after the postwar reconstruction period. This could be due to the inability of policymakers to identify market failures and design appropriate interventions. However the evidence that most resource flows went to large, politically influential, "backward" sectors suggests that political economy considerations may be central to this outcome.

3. Industrial Policy in Korea

Korea's experience with industrial policies has generated significantly less attention than the Japanese case. Korea is a smaller economy, Korea poses less of a competitive threat to U.S. industry and hence has attracted less attention from U.S.-based scholars, and limitations in the Korean data on the relevant policy instruments severely constrain researchers' ability to do the kind of applied work carried out on Japan.

Like Japan, Korea went through an extended period of relative isolation from the rest of the world, which came to an end in the late nineteenth century. Korea was occupied by Japan in 1905, and formally annexed in 1910. Japanese colonial rule ended with Japan's defeat in 1945,

Table 5. Japan: Normalized Sectoral Tax Rates

	1955–1990		1955–1973		1974–1990	
Industry	*Normalized tax rate (%)*	*Industry rank*	*Normalized tax rate (%)*	*Industry rank*	*Normalized tax rate (%)*	*Industry rank*
Electrical machinery	–0.403	8	–0.26	8	–0.56	10
General machinery	–0.403	8	–0.26	8	–0.56	10
Transport equipment	–0.403	8	–0.13	7	–0.56	10
Fabricated metal	–0.069	7	–0.26	8	–0.35	8
Petroleum and coal products	–0.009	3	0.30	3	0.14	3
Precision Instruments	–0.403	8	–0.26	8	–0.35	7
Ceramics, stone, and glass	–0.009	3	0.30	3	–0.56	10
Pulp and paper	–0.891	13	–0.13	6	0.00	5
Chemicals	–0.009	3	–1.72	13	0.04	4
Basic metals	–0.069	6	0.30	3	–0.35	8
Processed foods	–0.736	12	–1.52	12	0.00	5
Mining	6.658	1	0.92	2	1.04	1
Textiles	0.719	2	11.68	1	0.50	2

Source: Beason and Weinstein (1996, table 1).

Table 6. Science and Engineering Students

Country	*Year*	*Total*	*Share of science and engineering students in tertiary education*
Japan	1955	589,903	0.152
Korea	1956	80,935	0.206
Philippines	1957	224,988	0.145
Malaysia	1967	8,455	0.142
Argentina	1955	142,522	0.161
Mexico	1961	94,073	0.255
Chile	1957	18,185	0.214

Source: UNESCO.

and the peninsula was divided into U.S. and Soviet zones of military control. The partition of the peninsula was formalized in 1948.

Considerable industrialization and technological learning occurred during the Japanese colonial period, though most of the industry was located in the northern part of the peninsula, while the southern part of the peninsula served as the breadbasket.[26] Japanese economic institutions and practices were transferred to the peninsula. As in the case of Japan, operation of the economy during the period of U.S. military occupation was characterized by a high degree of state control and use of quantitative allocations.

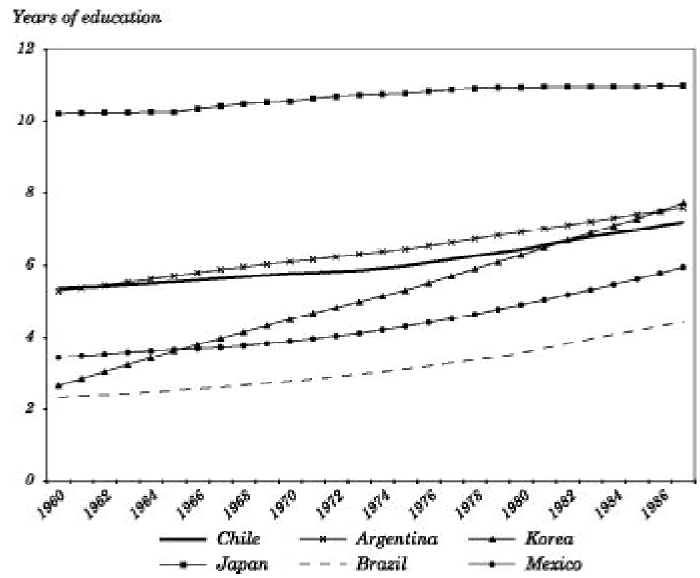
During the Korean War (1950–1953), the armies of both sides traversed the peninsula several times, destroying much of the capital stock. Mass population movements presumably resulted in a net flow of human capital from the North to the South. As in the case of Japan's emergence from the Second World War, in the aftermath of the Korean War, South Korea's endowment of human capital was high relative to its contemporaneous income level (see table 1).[27] South Korea continued to accumulate human capital rapidly after the war (figure 3). Its students were relatively concentrated in science and engineering, though not remarkably so. In fact, the Asian and Latin American countries look strikingly similar in this regard (table 6).

The maintenance of negative real interest rates until the 1960s inhibited the development of the banking sector, which was permitted little freedom from government control, and encouraged the channeling

26. See Noland (2000a) for additional details and references to the relevant literature.

27. Rodrik (1995) makes the same point.

Figure 3. Mean Total Years of Education



of capital to large, politically influential borrowers. As the prominent South Korean economist Cho Soon observes, "the most notable feature of the [South] Korean economy during the 1950s was its dependence on U.S. economic aid" (Cho, 1994, p.13).[28]

The orientation of Korean policy changed significantly in the mid-1960s following a military coup that brought General Park Chung-hee to power. Export performance was seized as a barometer of success. As one observer put it, "they were the only statistics that couldn't be faked." Multiple exchange rates were unified and the currency devalued in 1964. Export targets were formulated in considerable detail by product, market, and exporting firm. Firms not achieving their targets were not subject to penalty; however, the targets were sometimes

28. This assistance was not entirely without merit, however. South Koreans were able to expand their skill base through cooperation with the United States. American aid directly contributed to the rapid expansion of education within South Korea and made overseas training and education possible for thousands of Koreans (Westphal, Rhee, and Purcell, 1981), including some of its future economic policymakers. Some transfer of technical skills and management techniques undoubtedly occurred through close contact with U.S. military forces, but its significance is difficult to assess. Likewise, local firms certainly benefited from participation in local military procurement programs and later from offshore procurement programs during the Vietnam War (Rhee, 1994).

negotiated jointly with wastage allowances, and firms achieving their targeted goals could expect more favorable tax treatment (Westphal and Kim, 1982).

At the same time, the government introduced a wide range of export promotion measures. A government-subsidized organization, the Korea Trade Promotion Corporation (KOTRA), was established to promote exports and perform market research. Exporters were provided exemptions from duties on imported intermediates, tax incentives, preferential access to capital, special depreciation allowances on imported capital equipment, and a variety of nonpecuniary awards. Exporters also received generous wastage allowances on duty-free imports and reduced prices for electricity and rail transport.[29] The export-import link allowed exporters to earn rents through the importation of restricted items. Overall, the trade regime can be characterized as modestly pro-export biased, with established industries receiving roughly neutral effective incentives, while a few infant industries were actively promoted (Westphal and Kim, 1982).[30]

Economic policy changed in the 1970s in response to a variety of internal and external political developments. Korea initiated the heavy and chemical industry (HCI) drive to steer the composition of industrial output toward capital- and technology-intensive sectors and engineering-intensive products, in an attempt to reduce reliance on low real wage levels, upgrade the country's export profile, and reduce reliance on imported arms. Industrial policies efforts were intensified, and in a break from the relatively rules-based policies of the 1960s, greater policy discretion and selectivity was introduced.

The financial liberalization policy was reversed in 1972, when interest rates were lowered and direct government control of the banking system was increased in order to channel capital to preferred sectors,

29. The excess wastage allowances on duty-free imports for export production allowed export-oriented firms to divert these duty-free inputs into the production of goods for local sale, to their competitive advantage in the domestic market.

30. While the trade regime was being recast toward greater export orientation, reforms were also implemented in other areas of economic policy. In 1963, the military government revised the labor laws to discourage the establishment of independent labor unions, instead encouraging the organization of unions within a centralized system to facilitate government control. This system was tightened further in 1971 by the introduction of legislation banning strikes, which made virtually any form of collective bargaining or action illegal (Haggard, 1990; Cho, 1994). Financial reform began in 1965, when interest rates were raised to encourage saving and financial deepening, as well as more efficient use of capital. The national saving rate doubled in five years, and the ratio of M2 (a broad definition of the money supply) to GNP nearly tripled over the same period.

projects, and firms. Special public financial institutions were established to finance large-scale projects, and commercial banks were instructed to make loans to strategic projects on a preferential basis. By the late 1970s, the share of these so-called policy loans had risen to 60 percent (Yoo, 1994). These loans carried negative real interest rates, on average, and the annual interest subsidy grew from about 3 percent of gross national product (GNP) in 1962–1971 to approximately 10 percent of GNP, on average, between 1972 and 1979 (Pyo, 1989). Capital channeling policies were augmented by extensive tax incentives for the priority industries. The special tax measures are estimated to have reduced the marginal corporate tax rate from 50 percent to 20 percent for the targeted industries, which also received trade protection. This era came to a close in late 1979 as a result of the combined effect of the second oil shock and the assassination of Park that same year. Subsequent Korean governments have attempted to scale back industrial policies, with varying degrees of enthusiasm and success.

3.1 Assessment

For industrial policies to be successful, the market equilibrium must be suboptimal. Governments must be able to identify these opportunities for welfare-enhancing interventions, formulate and implement the appropriate policies, and prevent political market failures from leading the policies astray. Industrial policies in Korea clearly affected the cross-sector allocation of resources. Yoo (1994) estimates that the HCI credit, tax, and trade policies resulted in around 80 percent of fixed investment in the manufacturing sector going to the favored heavy and chemical industries in the late 1970s. During the first three years of the Fourth Five Year Plan (1977–1981), investment in basic metals and chemicals was 130 percent and 121 percent, respectively, of the targets for the entire period, while textiles and other light industries received only 50 percent and 42 percent, respectively, of their planned investment (Balassa, 1990). Whether this resource channeling was welfare enhancing or growth promoting is less clear.

Kim (1990) surveys the fiscal, credit, tax, and trade policies undertaken during this period and concludes that the strategy was unsuccessful: it had the predictable result of generating excess capacity in favored sectors while starving nonfavored sectors for resources, as well as contributing to inflation and the accumulation of foreign debt. Moreover, “the government [was] reckless in its selection of launch enterprises and in its almost haphazard provision of generous incentives…

[Its] direct, unlimited role in industrial promotion placed it in the position of an implicit, de facto risk partner, thus complicating the efforts at market-determined adjustment" (p. 44).

Yoo (1990) covers similar terrain, distinguishing between the less selective efforts at export promotion in the 1960s and the more aggressive industrial promotion efforts of the 1970s. He directly confronts the argument that the HCI policy was a success inasmuch as the favored industries became major exporters in the 1980s. He addresses this argument by posing two counterfactuals: what would the Korean economy have looked like in the absence of the policy, and how would the Korean trade structure have looked in its absence? Using reasoning similar to Kim's, Yoo concludes that the Korea economy would have been better off in macroeconomic terms without the HCI policy. But what about industrial upgrading? Yoo compares the Korean experience with other, similarly endowed economies (in particular Taiwan) and finds that the HCI policy was not successful in terms of either upgrading or trade performance. Given the high rates of return on capital, the opportunity costs of prematurely promoting a sector may have been enormous.

Park and Kwon (1995) conclude that the establishment of oligopolistic positions by the *chaebol* during the HCI drive retarded technological change. They argue that once scale economies were taken into account, TFP, correctly measured, actually turned negative, though the disentangling of scale economies from TFP is not straightforward.[31] Similarly, Kwon and Paik (1995) use a computable general equilibrium model calibrated to 1978 to investigate the potential magnitude of these directions. They find that resource misallocation reduced GDP by less than one percent if capital is assumed to be immobile and by more than three percent if it is mobile. The calculated welfare impact is higher.

Very few papers directly address the linkage between industrial policies and sectoral productivity growth. Lee (1997), who examines a panel of thirty-eight Korean industries over the period 1963–1983, finds that trade protection in the form of tariff or nontariff barriers is negatively associated with the growth rate of labor and total factor productivity. Tax incentives and subsidized credit are

31. See Kwack (2000, tables 7 and 8) for a summary of twenty-three studies of Korean TFP growth. In Kwack's own estimation, he finds, like Kwon and Park, that Korean TFP growth declined over time and, in the case of light industry, actually turned negative. It is hard to understand how resource misallocation driven by favoritism toward heavy industry could result in light industry TFP turning negative. These TFP estimates are unlikely to be very robust, depending on both theoretical specifications and delicate estimates of capital stocks during a time of both rapid capital accumulation and technological obsolescence.

uncorrelated with sectoral productivity growth. Yoo (1993) analyzes the determinants of the cross-sectional pattern of trade protection. The results are not robust, but they suggest that political economy rather than efficiency considerations determined the pattern of protection. Finally, Pack (2000) finds that TFP growth in the heavy and chemical industry sectors was not sufficiently large to have exerted a major impact on aggregate growth.

These results cast doubt on the efficacy of resource channeling. Other studies, however, make a case for Korea's choice of strategies. Pack and Westphal (1986) and Okuno-Fujiwara (1988) focus on interindustry linkages and the potentially welfare-enhancing coordination role for the government. Pack and Westphal suggest that Korea's policy of selective intervention might have been successful in fostering infant industries without significant losses in efficiency in the early stages of development (the mid-1960s to early 1970s). The key was to capture latent interindustry pecuniary and nonpecuniary externalities. "The Korean government can be seen as having achieved integrated decisionmaking by acting as a central agent mediating among market agents, forcing and facilitating information interchange,... ensuring the implementation of decisions reached,... weighing costs and benefits from a collective standpoint, and often intervening to reward cooperative players and punish uncooperative ones" (1986, p.99)

In both this model and that of Okuno-Fujiwara (1988), the same outcome could presumably be attained through organizational integration. Pack and Westphal argue, however, that this was not feasible in the case of Korea: "The externalities may flow in complex and inseparable patterns among (actual and potential) agents covering most if not all of the industrial sector" (1986, p.99), necessitating government intervention.[32] Investment coordination may have helped to overcome these patterns in the early stages of industrialization, but by the 1970s the growth of the *chaebol* undoubtedly reduced the importance of government coordination. While none of these giant firms produced the entire range of industrial products, the owners of the firms knew each other and private coordination undoubtedly occurred. While government intervention might have reduced some interpersonal transaction

32. Auty (1991) provides detailed descriptions of indivisibilities and other entry barriers in the HCI industries. Even after assessing possible pecuniary and nonpecuniary externalities, however, he concludes that from an economy-wide perspective, resources were misallocated.

costs, many of the potential externalities were presumably dealt with by Coasian agreements among the firms.[33]

The key to successfully implementing welfare-enhancing industrial policies through government coordination activities to capture interindustry externalities lies in the existence of interindustry externalities, which when captured, expand the production set of the economy. It is difficult to model this rigorously. The likely scope for growth-enhancing interventions would be increased, however, if the industries targeted for intervention met three criteria. First, they should have strong interindustry linkages to the rest of the economy. Second, they should be leading in a causal sense, so that growth stimulus would be transmitted forward through the economy. An input-supplier industry in the Okuno-Fujiwara model is an example. Finally, variations in output should have a strong industry-specific component; otherwise, variations in output might simply be due to common macroeconomic shocks and there is little scope for industry-specific stimulus. The existence of industry-specific variation in output suggests the possibility for industry-specific technical change, as well as scope for industry-specific policy interventions to increase output. Noland (1993b) examines data on twenty-six Korean manufacturing industries over the period 1960–1989. He identifies four sectors that possibly met these criteria—wood products, paper, petroleum and coal products, and nonferrous metals—and a fifth—nonmetallic products—that arguably did. These are not the typical sectors associated with industrial policies, nor, with the exception of nonferrous metals, were any of them promoted during the HCI drive.

Pack (2000) provides another test of potential interindustry externalities. Industrial policies could have generated benefits in other sectors as a consequence of three developments: domestic production of intermediate goods with special characteristics that were not available internationally but that improved productivity in the local purchasing firm; movement of workers and managers from firms in promoted sectors to firms in other sectors, in which the movers brought with them uncodified knowledge; and direct interactions on equipment design by producers and local buyers of machinery that led to adaptations to machinery that were particularly suitable for local firms. All three externalities could potentially increase TFP growth in the neglected

33. If anything, this argument seems more applicable to the Japanese case, since vertical integration is less complete in Japan. The *keiretsu*, networks of affiliated firms, strike a balance between the coordination advantage of full integration and the maintenance of competition among suppliers. In this more loosely organized system, the government's coordinating role could be larger.

sectors, in addition to any benefits accruing to the directly promoted sectors. The potential quantitative importance of specialized nontraded intermediate inputs and uncodified knowledge transmitted by workers depends on how much the neglected sectors interact with the promoted ones. One way to gauge the potential benefits is to measure the purchases of inputs from a favored sector per won of gross output in the neglected sector. The larger the purchase, the more likely it is that the neglected sector may derive some benefits from the existence of local producers. The neglected sector may also derive greater benefits if there are few imports, which constitute an alternative source of specialized inputs.

We assume that the first and second externalities depend on the magnitude of interaction with the promoted sectors. Such interactions can be measured by Leontief input-output coefficients. The n x n input-output coefficient table, A, consists of two sets of flows, the domestic intersectoral flows, A_D, and the import flow matrix, A_M, $A = A_D + A_M$. The coefficient a_{ij} is a typical coefficient of the domestic flow table, while m_{ij} denotes elements of the import matrix. The extent of interaction between favored and neglected sectors is given by the domestic input-output coefficient, a_{fn}, which measures the purchases of an input from a favored sector per dollar of gross output of the neglected sector. The larger is a_{fn}, the more likely the neglected sector may derive some benefits from the existence of local producers.[34] The neglected sector may derive greater benefits if there are m_{ij} few imports that constitute an alternative source of specialized inputs. Thus, the lower is m_{ij} relative to a_{ij}, the larger the potential impact of the availability of local production.

Several measures of the magnitude of interaction between the promoted and neglected sectors in Korea are presented in table 7. The average input-output interaction between favored and neglected sectors is quite small. The favored sectors account for a very small portion of the domestically purchased inputs of most neglected sectors. Second, the heavy industries purchase extensively from one another. Third, the imports of the neglected sectors in Korea are, on average, twice the size of the combined purchases from the favored domestic sectors (.134 versus .068).

34. It is possible to test whether indirect interactions mediated through other sectors have an effect by using the inverse coefficients of the Leontief matrix. However, the sources of real external economies enumerated above are not easily extended to indirect interactions.

Table 7. Korea: Intersectoral Purchases, 1985

	Source of purchased materials			
Purchasing sector	*All domestic sectors*	*Heavy industries*	*Chemical industry*	*Foreign suppliers*
Neglected sectors				
Food	0.147	0.007	0.021	0.029
Beverages	0.290	0.025	0.012	0.019
Tobacco	0.048	0.002	0.006	0.009
Textiles and clothing	0.522	0.007	0.125	0.099
Leather	0.319	0.003	0.055	0.355
Wood and wood products	0.240	0.026	0.043	0.060
Paper	0.422	0.019	0.044	0.183
Printing and publishing	0.408	0.017	0.042	0.039
Petroleum and coal	0.053	0.003	0.003	0.009
Rubber products	0.373	0.025	0.121	0.124
Nonmetallic minerals	0.293	0.029	0.020	0.029
Misc. manufacturing	0.402	0.096	0.087	0.123
Neglected sector average	0.293	0.021	0.047	0.134
Favored sectors				
Chemicals	0.357	0.010	0.249	0.209
Heavy industries				
Iron and steel	0.542	0.466	0.009	0.131
Metal products	0.412	0.335	0.031	0.143
Nonelectric machinery	0.387	0.334	0.016	0.163
Electric machinery	0.324	0.245	0.034	0.272
Transport equipment	0.388	0.332	0.015	0.173
Heavy industry average	0.411	0.342	0.021	0.176

Source: Authors' calculations, based on input-output tables contained in Bank of Korea, *Monthly Statistical Bulletin*, various issues.

These patterns suggest several probable effects on nonpromoted sectors. First, it is unlikely that the promoted sectors were quantitatively critical in increasing the range of available inputs. Although industrial policies may have encouraged the domestic production of some unique nontraded inputs, the overall impact was small relative to all domestic and foreign purchases. Unless there was very low substitutability between local and foreign inputs, the quantitative effect of local supply of such inputs was limited. Rosenberg (1976) cites the importance of local interactions in situations in which both user and producer are themselves at the world frontier and there are no suppliers in other countries. In contrast, Korean firms in the periods considered were not at the world frontier in the neglected sectors and had many opportunities for obtaining specialized inputs from abroad. The imports into all sectors demonstrate that this opportunity was used.

Second, insofar as movement of workers and managers might provide important knowledge transfer, the small purchases from the promoted sectors imply that such knowledge transmission would have been limited. Any tacit knowledge brought by worker mobility, about the special properties of purchased inputs or how to use them more effectively, would affect only a small component of total costs. While one can posit, as in the case of specialized inputs, that there is a critical piece of knowledge whose possession has exceptionally high marginal productivity for the recipient sector, the quantitative case does not seem plausible. Moreover, such knowledge could have been obtained from technology licensing agreements and consultants from abroad.

Third, promoted sectors are substantial purchasers of one another's inputs, at least in the metal-based sectors. The necessary condition for investment coordination benefits thus existed in 1985. By that year, however, these sectors were already large exporters and importers of products within the sector (see column 4). The possibility of investment coordination cannot be dismissed, but the extent of international trade suggests it was unlikely to be decisive.

Finally, some interactions are not captured by the input-output transactions shown. In particular, the interactions between the producers and final purchasers of machines are not given, since investment is a final demand. An analysis of the ratio of imports to domestic production of machinery is telling. In Korea in 1985, imports of nonelectrical machinery were three times that of domestic production (3.04), compared with 0.06 in Japan in 1980. The ratios with respect to electrical machinery were 0.27 for Korea and 0.04 for Japan. It is difficult to argue that there were no imported substitutes or that special adaptations to local conditions were quantitatively significant. Even if locally produced equipment conferred some cost reductions on its users that would not have been garnered from internationally available equipment, it would have affected only one-quarter of annual general machinery investment as late as 1985.

3.2 Politics and Implementation

The impact of industrial policies on growth is less clear in the case of Korea than in the case of Japan. If anything, the Korean case underlines the problematic nature of the actual implementation of industrial policies. There have been two interrelated problems. First, the involvement of the state in both the implementation and financing of industrial policies gave rise to enormous problems of moral hazard and the socialization of risk. The *chaebol* could use capital from favored projects to cross-subsidize other ventures, confident that the government would not allow them to fail. The result was investment without regard to rates of return and weak corporate balance sheets. Given the lack of workable bankruptcy or exit policies to discipline failures, management strategy amounted to unlimited expansion, or what Yoo (1999) calls "survival of the fattest." Statistics on *chaebols* do not exist for the 1960s (because of lack of balance sheet data), but SaKong (1993) documents that the share of the top ten *chaebol* in South Korean GDP rose from 5 percent to 23 percent in the decade between 1973 and 1982.

According to the Organization for Economic Cooperation and Development (OECD), "shareholder value was systematically destroyed from the late 1980s onward" (OECD, 1998, p. 23). The events of recent years are a testimony to this weakness: the $73 billion bankruptcy of Daewoo, the country's second-largest *chaebol*, was the largest corporate failure in world history, and Hyundai, the country's largest *chaebol*, is currently facing exceptional stress under market pressure.

Second, the availability of subsidized resources and the centrality of government relations to corporate success gave rise to an orgy of rent-seeking and corruption that continues to bedevil Korean business-government relations.[35] In Transparency International's Corruption Perceptions Index 1999, South Korea ranked fiftieth out of ninety-nine, tied with Jamaica and Lithuania.[36] This lack of transparency imposes a penalty on financial transactions in the South Korean market, increasing investor hurdle rates and inhibiting the ability of good firms to access capital. The transparency risk premium, separate from and in addition to conventional country and currency risk, inhibits investment in the South Korean economy.[37]

3.3 Conclusions

As a former colony of Japan, Korea inherited certain Japan institutions and tendencies in the economics sphere. Like Japan, it suffered significant devastation through war, and its level of human capital and

35. For an entertaining account of business-government relations through the early 1990s, see Clifford (1997). For more recent material, see Noland (2000a); Woo-Cumings (2001).

36. Available at www.transparency.org.

37. For more detail, see Noland, "Economic Reform in Korea: Achievements and Future Prospects" (www.iie.com/papers/noland0201-3.htm [2001]).

social capacity in the 1950s was high relative to contemporaneous income. The Korean government pursued industrial policies even more intensely than Japan.

Most of the evidence on resource channeling suggests that the strategy did not have a major impact on growth after the initiation in 1973 of the program to encourage the engineering and chemical sectors. If anything, the impact appears to be negative. Evidence abounds, however, on the detrimental impact that industrial policies has had on business-government relations and corporate governance after the initiation of the HCI effort. As state intervention into the economy grew in the 1970s, political connections became increasingly important relative to business acumen in determining success. Korea still lacks viable exit mechanisms for failing firms, and business-government relations remain seeped in nontransparency and corruption.

4. Industrial Policies in Taiwan

Taiwan, like Korea, is a former Japanese colony, and like Japan and Korea, it also had an Olsonian upheaval, in this case associated with the conclusion of the Chinese revolution and the decampment of the Nationalist government and thousands of its supporters to Taiwan at the end of 1948.

Taiwan's experience with industrial policy has generated considerable analysis. The standard neoclassical interpretation (Little, 1979) is that Taiwan's development was primarily attributable to a low level of trade protection, the availability of inputs to exporters at international prices, a conservative macroeconomic policy manifested in limited inflation, and competitive factor markets. The last points are suggested by positive real rates of interest and the absence of duality in the wage structure, either by size of firm or by sector. Wade (1990) contends that a critical component of Taiwan's success was its industrial policy, which helped to establish new and successful manufacturing sectors.[38] This and similar studies document the extensive employment of tariffs, quantitative restrictions, and selective credit policies, arguing that Taiwan's success in the period considered was attributable to an intensive effort by the government to direct the sectoral evolution of the economy. This was implemented by a variety of means: the establishment of public enterprises when private initia-

38. See, for example, Clark (1989), Gold (1986), and the papers in Winckler and Greenhalgh (1988).

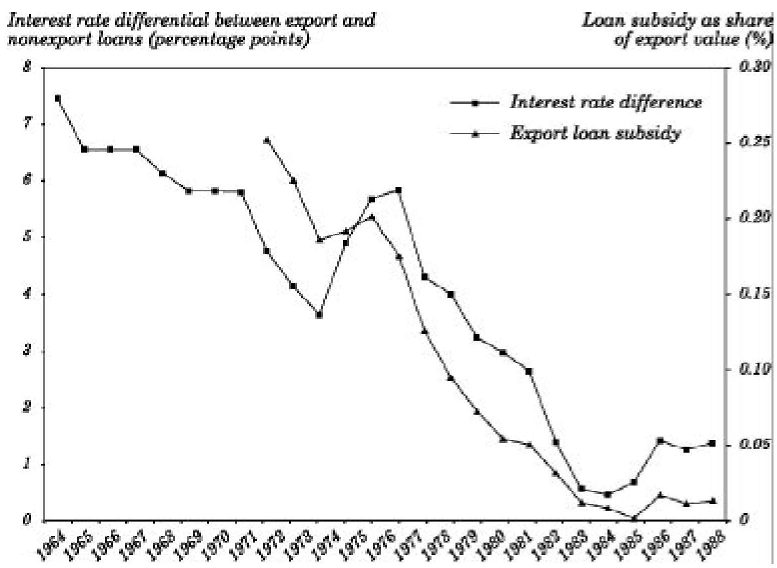
tive was not forthcoming or the capital markets were reluctant or unable to fund very large projects; extensive employment of tariffs and quantitative restrictions on imports; and direction of credit to preferred industrial sectors through the highly controlled financial sector. The view that Taiwan approximated the laissez-faire environment of Hong Kong is untenable in light of the carefully accumulated facts. Moreover, the data on which earlier interpretations are based—namely, the fairly low (but by no means single digit) effective protection rates—were estimated in the late 1960s. As in the case of Japan and Korea, Taiwan's industrial policy may have helped to jump-start the economy from its low 1950 levels, and much of the evidence on the role of the government focuses on the 1960s and early 1970s. The benefits from industrial policy in the succeeding years are not easily shown, however, although efforts in this vein undoubtedly continued.

The basic fiscal incentive program was the Statute for the Encouragement of Investment (SEI), which was in place from 1961 to 1990. Available to both foreign and domestic firms, it targeted specific industries, though the focus shifted over time from exporting (1960s) to capital-intensive sectors (1970s) to technology-intensive sectors (1980s). Under this program participating firms could choose either tax exemptions or accelerated depreciation on capital equipment, with most firms taking the former option.

In 1987 the government commissioned a study to examine the program. The report concluded that while the program might have contributed to economic development at the outset, by the 1980s it had outlived its usefulness. Specifically, the report cited four problems: (1) the program was contributing to highly uneven tax burdens across firms; (2) the complexity of the law was creating insurmountable difficulties in administration; (3) the creation of groups with a vested interest in the continuation of the status quo was inhibiting the adoption of more rational policies; and (4) the correlation between participating firms and productivity or profitability was low.

In response, the government discontinued the SEI in 1990, replacing it with the more functionally oriented Statute for the Upgrading of Industry (SUI). Under SUI firms are eligible for tax relief based on their expenditure on socially favored activities such as R&D or pollution-control, although some industry-specific incentives in the high-technology sector were retained. Interestingly, Taiwan's president at the time, Lee Teng-hui, was a U.S.-educated Ph.D. economist who had coauthored the first study of effective incentives in Taiwan (Lee and Liang, 1982).

Figure 4. Taiwan: Export Loan Subsidy

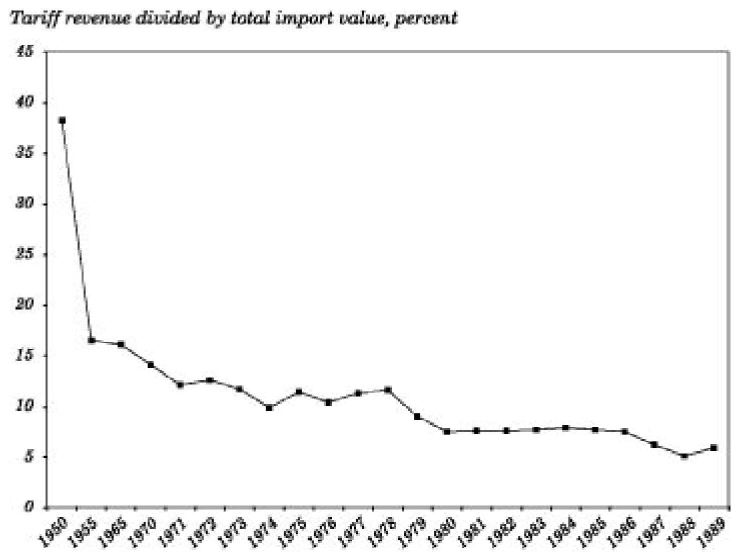


Source: Smith (1997, table 4; 2000, table 2.7).

A second industrial policies tool was directed credit. Like Japan and Korea, Taiwan maintained a relatively repressed financial system and channeled credit, though not to the extent the Koreans did. Smith (2000) shows that public utilities were the largest recipient of loans to promote strategic industries, followed by chemicals. The most important subsidized credit program was export finance to support preshipment expenses and the importation of raw materials. As shown in figure 4, the differential in the interest rate between export loans and nonexport loans was significant in the 1960s and 1970s. The volume of these loans were rather small, however: at least since 1971 (the first year for which data are available), the subsidy component was less than one-quarter of one percent of the value of exports. High technology industries were not major recipients of either strategic or export loans.

The third major tool of industrial policies was trade controls. Taiwan pursued import substitution industrialization (ISI) policies in the 1950s, and its trade regime in the 1960s and 1970s was characterized by relatively high nominal tariffs, especially in agriculture; ubiquitous

Figure 5. Taiwan: Average Tariff Burden



Source: Smith (1997, table 2; 2000, table2.2).

nontariff barriers, again especially in agriculture; restrictions on inward foreign investment; and the promotion of state-owned firms. Beginning in the 1960s, however, policies were adopted to limit the inefficiencies associated with trade protection. With respect to domestic sales, producers seeking protection had to justify protection on the basis of their ability to compete against imports, and they were subject to time-phased price controls that forced them to reduce prices in the local market to within five percent of comparable imports by 1973 (Lee and Liang, 1982). With respect to foreign sales, the impact of trade protection was partly offset by various tax rebate schemes, duty drawbacks (as in the case of Korea), and the creation of export processing zones and bonded manufacturing warehouses. The latter institutions eventually accounted for a significant share of Taiwanese exports. As a consequence of these policies, actual tariff collections were well below statutory rates (figure 5). Beginning in 1989, the government undertook a far-reaching trade liberalization that brought the level of trade protection down to developed country levels, at least in the manufacturing sector.

Smith (2000) combines the tax, subsidy, and trade components to calculate effective rates of assistance. Her tables make interesting reading. In 1989, for example, assistance was so great in miscellaneous food products, nonalcoholic beverages, wool and worsted fabrics, certain chemical products, cement products, industrial fertilizers, other artificial fibers, medicines, and motor vehicles that these sectors were producing negative value-added at world prices. As Smith observes, a number of these sectors were characterized by the presence of state-owned firms. Whatever the extent of industrial policy interventions in the 1950s and 1960s, the government became convinced by the 1970s and especially the 1980s that its industrial policy interventions were having only a modest impact at considerable cost, and authorities actively attempted to scale back incentives. This attempt to rationalize industrial policy efforts ran into political constraints, however. Smith's estimates of the effective rate of assistance actually exhibit greater cross-sectoral dispersion at the end of the 1980s than at the beginning of the decade, as politically influential sectors were able to preserve their perquisites in the context of overall shrinking support to industry.

Beyond these standard industrial policy tools, the Taiwanese government introduced another set of policies conducive to the development of the manufacturing sector, namely, the establishment of a large number of institutions that were designed to identify, transfer, diffuse, and efficiently absorb foreign industrial technologies and then to undertake innovation. These latter policies were largely implemented in the late 1970s and 1980s, though precursors existed in the 1960s. Examples include the Hsinchu Science Park and the Industrial Technology Research Institute (ITRI).[39] These efforts reflect the fact that unlike Korea and Japan, Taiwan's policies were more neutral with respect to firm size. Much of its industrial development was based on firms with fewer than a hundred employees. Centralized research (as conducted at ITRI) could be justified on standard grounds that social rates of return to R&D exceed private returns, while the science park served as a means of generating economies of scope in the use of critical services such as accounting and consulting, which were provided by the park. The science park also sought to demonstrate to expatriate Taiwanese, largely in the United States, that Taiwan was committed to a serious effort in high technology. Whether this was as important as the high salaries in luring engineers back to Taiwan is unknown.

39. The most thorough analysis of these institutions is contained in Dahlman and Sananikone (1997).

The government fostered the creation of venture capital funds to provide capital for these start-ups. Intellectual property rights (IPR) protection, which had been notoriously lax in Taiwan, was tightened in the 1990s in response to both internal factors (the growth of domestic IPR-producing activities) and external pressures for better IPR enforcement, which were generated bilaterally from the United States, regionally through the Asia-Pacific Economic Cooperation (APEC), and multilaterally through Taiwan's negotiations to enter the World Trade Organization (WTO).

A variety of studies examine the effectiveness of these policies in stimulating rapid growth. Smith (2000) presents work that generally fails to find links between the industrial policy interventions and sectoral TFP growth or trade performance. Rather, the pattern of industrial policy intervention appears to be driven more by political economy considerations, such as sectoral employment, the presence of large firms, or the degree of sectoral concentration, than by dynamic comparative advantage.

Pack and Lin (2001) follow a different strategy, in which they assume the presence of nonmeasured forms of stimulation such as the subsidy equivalent of the establishment of industrial parks, centralized research institutes, and centralized productivity centers. These may be large and have a limited correlation with the ERP or the effective rate of subsidy (ERS). They then assume that any exceptional growth in the favored industrial sectors was due entirely to industrial policy and that the TFP growth rate in such sectors was doubled. These assumptions are very favorable to finding a positive role industrial policy, and Pack and Lin find that industrial policy could have added 2 percentage points of TFP growth in manufacturing. Given that manufacturing accounted for about 30 percent of GDP, this would have increased aggregate TFP by roughly 0.6 percent per year out of a total GDP growth rate of 10 percent per year in the period 1962–1989. That figure is certainly not trivial, but it hardly represents the entire story of Taiwan's development. The high rate of TFP growth in all sectors, even neglected ones, the high rate of saving and investment over and above the high levels induced by industrial policy, and the acquisition of skills through education all played a significant role. Industrial policy may have played a more significant role if one accepts the most optimistic assumptions. Even if one accepts the most optimistic assumptions, which raise the estimated role of industrial policies considerably, the strategy still accounts for a relatively small proportion of Taiwan's success.

The preceding assumes that the impact of selective industrial policies benefited only the promoted sectors and that the high rate of productivity growth in the neglected sectors was not affected by spillovers. If, however, the rate of TFP growth in neglected sectors was increased indirectly by the growth of the favored sectors, the calculated increment to TFP may underestimate the impact of industrial policy. Indeed, proponents of industrial policies often argue that some of their major effects are manifested indirectly in other sectors, and they dismiss as inconsequential evidence about the limited impact in the targeted sectors. When Pack and Lin (2001) employ an input-output approach similar to that described above for Korea to obtain some measure of the potential indirect impact of the promoted sectors, they find similarly small evidence of potential gains accruing to the neglected sectors.

5. Latin American Experience

In the 1950s, while Korea and Taiwan were quite poor and often exhibited incoherent economic policies, many Latin American economies embarked on systematic import substitution industrialization (ISI) programs reflecting the regnant view of Raul Prebisch and the United Nation's Economic Commission for Latin America and the Caribbean (ECLAC). In some cases, ISI was initiated well before ECLAC was established, partly out of disillusion with world trade prospects during the depression of the 1930s and the disruptions of World War II. Insofar as this policy, by definition, discriminated among industrial sectors, it constituted a systematic attempt to pursue industrial policy. As is well known, the attempt failed, at considerable economic cost. This section briefly considers why Latin America experienced failure, while in Asia the policies appear not to have damaged the economies during their high growth period and may even have had slight benefits, as indicated above.

The answer to the question has two strands: initial conditions and the mechanism for monitoring the progress of industries benefiting from government encouragement. As has been emphasized in numerous studies, Korea and Taiwan exhibited higher literacy rates and arguably better infrastructure, such as roads and ports, at the beginning of their high growth episode. Even a brilliantly designed economic program would have floundered if exports—an important component of Korea's and Taiwan's success—could not have been moved to ports and if the ports had themselves not been fairly efficient. On the other hand, too much can be made of such differences and of the purported benefits of the long Japanese occupation that was responsible for the existing education and infrastructure, if only for their own benefit. Neither country had the university education levels or the health care system of Argentina or Chile (table 1), and both of the latter had sufficiently good transportation and ports to have engaged in significant primary product exports.

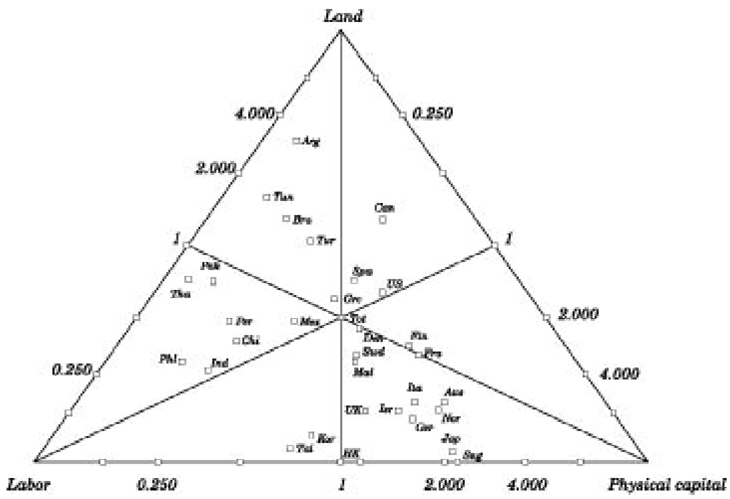
Some authors argue that Latin America had the luxury of attempting sustained ISI because it could fall back on natural resource exports. Moreover, its endowments militated in favor of natural-resource-based exports and against labor-intensive exports. Scatter plots of data on labor, physical capital, human capital, and arable land endowments for a number of countries in 1968 are shown in figure 6. Each of the four panels in the figure shows a barycentric projection of three endowments. Every endowment point on a ray emanating from one corner of the triangle has the same ratio of the other two factors; points lying closer to the corner of the triangle have a larger relative endowment of that factor. The point at which the three rays emanating from each vertex intersect in the middle of the triangle indicates the average endowment bundle of the sample.

In panel A, for example, Taiwan (TAI), Korea (KOR), Hong Kong (HK), and Singapore (SNG) are arrayed across the bottom of the triangle, far from the land endowment vertex, in order of increasing ratios of physical capital to labor. A similar pattern is found in each of the scatter plots, with the land-scarce countries of East Asia clustered across the bottom in panel A (indicating land scarceness), near the human capital vertex in panel B, and so on. In contrast, the Latin American countries tend to reveal relatively large endowments of land and low endowments of physical capital, with Argentina (ARG) being a clear outlier in panel A. In panel B, the large Latin American countries cluster near the arable land vertex, together with similarly endowed countries such as Tunisia (TUN), Turkey (TUR), Spain (SPA), Thailand (THA), and to a certain extent Pakistan (PAK). Finally, Chile (CHI) differs somewhat from Argentina, Brazil (BRA), and Mexico (MEX) as a result of its lower abundance of arable land.

These multifactor starting points are important. As Leamer (1987) shows, there is some econometric evidence that land-scarce countries (such as those of East Asia) tend to specialize in manufactures earlier (that is, at lower levels of per capita income) and more intensively (that is, with higher output-per-worker ratios) than economies with more diversified resource bases. Moreover, economies along the bottom of figure 6A will almost surely experience rising wages as physical capital is accumulated and capital-to-labor ratios rise, generating growth with equity.

Figure 6. Endowment Triangle:

A. Labor, Physical Capital, Land (1968 data)



B. Labor, Human Capital, Land (1968 data)

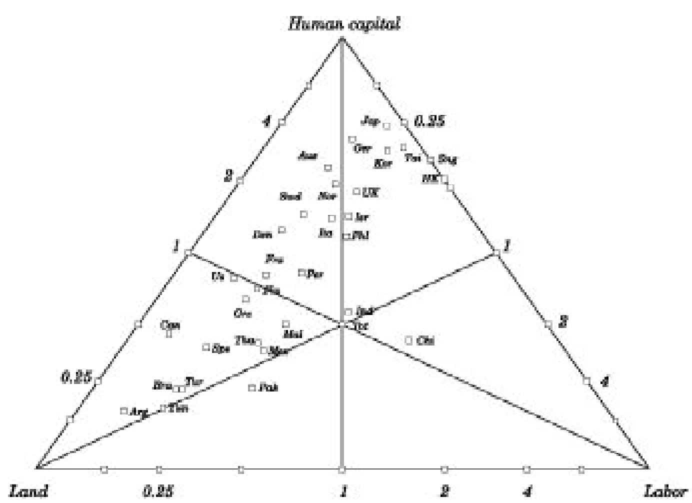
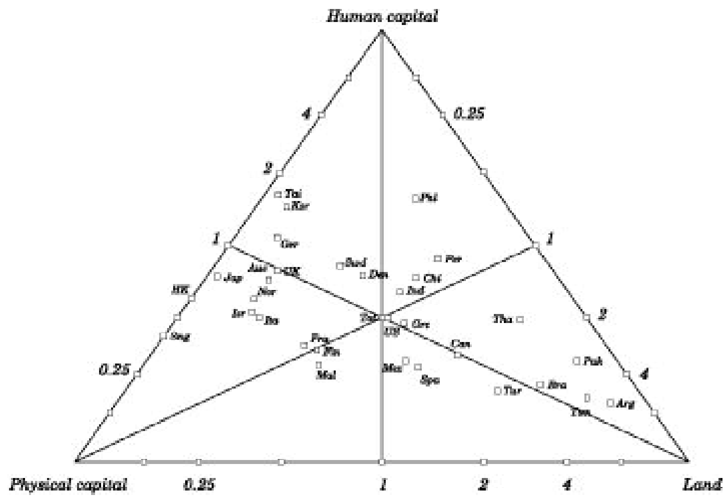
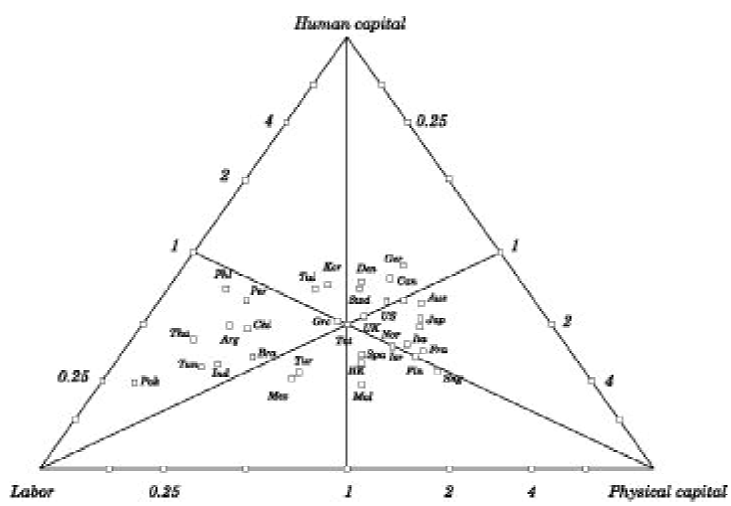


Figure 6. (continued)

C. Land, Physical Capital, Human Capital (1968 data)



D. Labor, Physical Capital, Human Capital (1968 data)



In economies with larger natural resource bases, the rents generated by resource extraction will retard specialization in manufacturing, thereby increasing the likelihood that capital accumulation might not be accompanied by rising wages (growth without development).

A full evaluation of this perspective would require examining the entire trade bundle, but some insights can be obtained from an analysis of the composition of manufacturing. The results obtained by the Inter-American Development Bank (IDB) in an investigation of this issue do not quite conform to simple expectations, although other tests of the hypothesis can certainly be constructed. Table 8 shows the revealed comparative advantage (RCA) in manufacturing in 1988–1990 for Latin America , the OECD countries, and industrializing Asia. Latin America's RCA in all manufacturing was slightly less, 1.62, than industrializing Asia's. Industrializing Asia also exhibited a greater RCA in unskilled labor than Latin America (3.38 versus 2.51), as well as a greater RCA in natural-resource-intensive products (1.91 versus 1.15). Industrializing Asia was thus able to import, process, and export resource-based manufactured products. The latter is a surprising result given the costs of importing raw materials. It implies that even in resource-based sectors, the efficiency of Latin American manufacturing was low. This implies that ISI probably had the effect of discouraging those sectors in which Latin America had a comparative advantage because of transportation costs, with the reverse holding true in Asia. This is simply another instance of the perverse effects of Latin America's efforts at selective promotion via ISI.

An interesting parallel to the Latin American experience is that of the Philippines. The country began the postwar period with many advantages, including high education (see tables 1 and 6), a large number of English speakers (conducive to trade relations), and close affiliation with the United States. Despite predictions in the 1950s that it would be the great success story in Asia (Morawetz, 1980), it performed dismally as a result of import substitution policies similar to those of Latin America. Most of the standard empirical studies of the impact of ISI, which is another version of industrial policy, bracket the Philippines with Latin American countries (see, for example, Little, Scitovsky, and Scott, 1970). Having a latitude and longitude that placed a country in Asia could not guarantee growth. Correct basic policies matter.[40]

40. Ironically, as detailed in Noland (2000b), the Philippines undertook considerable reforms in the 1990s, especially in the financial sector, and a variety of indices show that the country weathered the Asian financial crisis better than the other heavily affected economies.

Initial conditions are thus inadequate as the sole explanation of different economic outcomes. Differences in the nature of the industrial policies and their implementation are critical. Many sectors in Latin America received extensive protection, as evidenced by the high rates of effective protection calculated for all of the countries for which such estimates were made. While protection rates were generally highest for consumer goods and lowest for machinery, they were nevertheless high for most sectors. Firms in inefficient sectors could earn significant profits and their employees high wages (paid out of the rents collected from consumers) while facing little credible prospect that protection would be contingent on improved efficiency. There was simply no monitoring mechanism; once protection was granted, the levels were essentially not reduced until crises occurred in the 1980s and later.

In contrast, Japan, Korea, and Taiwan undertook continuous monitoring of firms' progress. The clearest example is provided by Korea, where subsidized credit and protection in the domestic market were contingent on export performance. Exports became the numéraire by which the progress of individual firms was measured. Current data on the exports of the individual firms within a given promoted sector were presented at quarterly meetings at the Blue House, the seat of the executive branch of government. The information was obtained not from the companies themselves, but from bills of lading at Korean ports. Realized exports were compared with targets set by the Economic Planning Board for each firm. Because the export targets were constantly increased, firms were forced to improve their productivity in order to lower marginal costs, the alternative being lower profits over time. While many firms initially subsidized their unprofitable exports by cross-subsidies from their profitable (protected) domestic market, this was clearly not a long-term solution in that the export targets were increased considerably faster than the growth of domestic sales. Firms were thus forced to concentrate on improving productivity, which stimulated enormous efforts to import and assimilate foreign technology.[41] Despite controversies about the precise levels of TFP growth in Korea and Taiwan, their rates were clearly far above those prevalent in Latin America during its import substitution phase (Nelson and Pack, 1999). In contrast, Latin America made no attempt to combine a

41. On Korea, see Westphal, Kim, and Dahlman (1985) and Kim (1999); on Taiwan, see Dahlman and Sananikone (1997) and Pack (2001).

Table 8. Revealed Comparative Advantage (RCA) in Manufacturing, Ranked by Factor Intensity[a]

	Latin America		OECD countries		Industrializing Asia[b]	
Category	*RCA 1988–1990*	*Change from 1978–1980*	*RCA 1988–1990*	*Change from 1978–1980*	*RCA 1988–1990*	*Change from 1978–1980*
Total manufacturing exports	1.62	0.08	1.02	0.01	1.86	–0.80
Human capital/technology-intensive	1.49	0.44	1.04	0.01	1.18	–0.05
Iron and steel	3.42	2.26	0.99	–0.01	0.70	0.15
Chemical elements and compounds	1.98	–0.05	1.03	0.02	0.32	0.12
Explosives, pyrotechnic products	1.61	–1.36	0.90	0.11	0.19	–0.12
Rubber manufactures	1.16	0.22	1.03	0.03	0.87	–0.25
Plastic materials	1.12	0.72	1.06	–0.03	0.57	0.35
Manufactures of metal	1.05	0.10	1.01	0.01	0.80	–0.12
Chemical materials and products	0.99	–0.50	1.06	0.02	0.40	0.22
Dyeing, tanning, coloring materials	0.91	–0.21	1.06	0.03	0.33	0.09
Plumbing, heating, lighting equip.	0.84	–0.03	1.04	0.03	0.63	–0.46
Essential oils, perfume materials	0.84	–1.34	1.05	0.04	0.42	–0.02
Transport equipment	0.83	0.13	1.08	0.03	0.29	–0.00
Nonelectrical machinery	0.75	0.05	1.05	0.01	0.64	0.39
Medicinal and pharmaceutical products	0.60	–0.67	1.05	0.05	0.17	–0.21
Misc. manufactured goods	0.46	–0.41	0.97	0.00	1.53	–0.53
Electrical machinery and appliances	0.43	–0.09	0.97	–0.02	1.89	0.12
Prof., sci., and control instruments	0.37	0.05	1.03	0.01	0.88	–0.56

Table 8. (continued)

Category	*Latin America*		*OECD countries*		*Industrializing Asia*[b]	
	RCA 1988–1990	*Change from 1978–1980*	*RCA 1988–1990*	*Change from 1978–1980*	*RCA 1988–1990*	*Change from 1978–1980*
Unskilled labor-intensive	2.51	–0.58	0.80	–0.03	3.38	–1.54
Leather and leather manufactures	5.50	–1.91	0.88	0.08	1.02	0.65
Footwear	3.74	0.48	0.71	–0.08	3.40	0.68
Textile yarn and fabrics	1.14	–0.60	0.85	–0.05	1.78	–0.21
Travel goods and handbags	1.10	–1.64	0.72	0.05	4.54	–2.91
Clothing	0.85	–0.69	0.63	–0.03	4.23	–2.28
Furniture	0.36	–0.14	1.04	0.03	0.68	0.01
Natural resource-intensive	1.15	–0.09	1.00	0.04	1.91	–0.34
Wood and cork products	1.48	–0.79	0.81	–0.01	3.38	–0.45
Manufactured fertilizers	1.22	0.37	0.95	0.01	0.68	–0.55
Nonmetallic mineral manufactures	1.11	0.12	0.97	0.05	0.52	–0.01
Paper manufactures	1.07	0.14	1.08	0.01	0.30	0.07
Mineral tar and crude chemicals	0.71	–0.50	0.86	0.34	2.64	–0.56

Source: IDB (1992, p. 204).
a. Based on regional RCA index values at the two-digit SITC code level for 1988–1990 and changes from 1978–1980. The totals for the three factor-intensity categories are trade-weighted averages of the individual product divisions. The total for all manufactures is calculated as the trade-weighted average of the three factor intensity categories. The ordering of product divisions within the three categories is based on the ranking of the product divisions in the Latin American region during 1988–1990.
b. Industrializing Asia includes Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, South Korea, and Thailand.

stick of control with the carrot of protection. We know of no instances in which a government actually reduced protection to a sector that did not perform well.

As noted above, it is impossible to confirm substantial benefits from industrial policies in Asia, but at least no major short-term damage was done, which is more than can be said for the Latin American experience with ISI. Korea and Taiwan experienced fairly high TFP growth rates compared with Latin America, although all calculations indicate that much of this would have accrued without selective intervention. The major difference is the use of a numéraire, particularly exports, to measure success, as opposed to the provision of open-ended protection for inefficient sectors. Nevertheless, even the benign experience in Korea and Taiwan during the heady days of intervention and growth may have had unfortunate long term consequences. Many of Korea's problems in recent years may have their origin in the policies pursued. The suppression of the financial system and the use of directed credit to individual firms discouraged the accumulation of normal financial evaluation skills and may have affected the quality of financial intermediation in Korea. Low-cost loans clearly encouraged many firms to expand beyond their core competence—capable manufacturing firms entered the resort industry, for instance.

The long-term benefits of industrial policy may have been partly offset by the unforeseen consequences of the policies themselves. Having carefully implemented the earlier policies, Japan, Korea, and Taiwan did not suffer serious consequences and may have extracted small benefits for several decades, though some argue that they could have done still better given their high saving and investment rates. Latin American nations, on the other hand, suffered almost immediately from protection combined with overvalued exchange rates that discouraged exporting. The Asian countries were thus able to zoom past their initial Latin American per-capita-income peers (or superiors) such as Argentina and Chile. To benefit from ISI, however, would have required a much different economic outlook than was the case, including a focus on some measure of efficiency and a political system capable of enforcing the requirement for improvements in productivity as the basis for receiving the rents extracted from consumers and taxpayers.

Perhaps one advantage of Japan, Korea, and Taiwan lay in the traumatic experiences following World War II. For reasons that differed in each case, the governments had little legitimacy. Japan had suffered a traumatic defeat after initiating the Second World War in the Pacific. Korea had gained independence from its Japanese colonial ruler, but it had then been partitioned and subject to a devastating three-year war that destroyed much of the infrastructure and caused enormous casualties in 1950–1952. Taiwan was the base of the defeated Kuomintang government that had hastily left the Chinese mainland in 1949. In each case, the government eventually tried to establish its legitimacy by emphasizing economic growth in the 1950s in Japan and early 1960s in Korea and Taiwan. In all three, land reform had overcome one set of opponents to policies that were conducive to growth with equity; in turn, this sharing in rapid growth may have led to a perception that government policies benefited the general population.[42] Thus the industrial policies implemented in these countries, which required a quid pro quo and in which exports were accepted as the numéraire, may have been easier to follow and may have allowed the authorities to avoid instituting protection without time limits and without the forced benefits of learning to compete internationally.

6. Conclusions

The weight of the evidence marshaled in this paper suggests that industrial policy made a minor contribution, at most, to the growth of East Asia. A large part of the Asian Miracle was attributable to nonmiraculous good macroeconomic policy, including limited government deficits, low inflation rates, and very stable real exchange rates. These were conducive to high rates of saving and investment, which are important components of the growth story. Another aspect, not discussed earlier, was a bias toward exporting that may have generated some benefits that would not have accrued from domestic sales (Pack, 1997).

Second, the Asian path is more likely than the Latin American strategy to generate growth with equity as capital is accumulated and less likely to run into problems with allocating rents derived from natural resources. The politics of industrial policies are likely to be less contentious, and their implementation in the manufacturing sector to be more widely perceived as “leaning with the wind” of comparative advantage, than in the case of ISI practices. In any event, the strategy may be irreproducible. The end of the Cold War and the concomitant willingness of the United States and other major trading powers to assert their economic interests, together with the existence of a stronger subsidies code and dispute settlement procedures in the WTO, may foreclose options that existed in the past.

42. Rodrik (1995) makes a similar argument.

Countries that have experienced slower growth than expected despite relatively good macroeconomic policies may be tempted to pursue industrial policies, although the large number of experiments with ISI suggest that this strategy has not been very successful. The Asian experience, especially in Korea and Taiwan, provide some guidelines to avoiding some of the potentially harmful consequences if industrial policy is nevertheless pursued. Even in these successful nations, however, the benefits appear to have been limited. Countries with less dedicated, less competent bureaucracies that are more amenable to lobbying pressures should expect even smaller net benefits.

While it is understandable that countries that have got the basics right are impatient for growth to accelerate, identifying broad sectors of growth, let alone specific ones, is particularly difficult. Food and wine exports from Chile, for example, have grown dramatically in the last fifteen years, yet it is unlikely that government officials considering promotion measures two decades ago would have included agriculture,—let alone peaches, grapes, apricots, and plums grown in November through March—on the list of potentially profitable export sectors. While governments can provide the broad infrastructure, such as education in agronomy, efficient airports, and adequate telecommunications, the detailed knowledge of the potential of such sectors is typically beyond the competence of officials.

The fact that sectorally targeted industrial policies were not the major source of either manufacturing or aggregate economic growth in the countries that implemented them does not mean that the government has no significant role in stimulating economic growth outside of macroeconomic management. Growth-enhancing measures that do not differentiate among sectors include large expenditures on primary and secondary education, the building of large and efficient social infrastructure, a favorable attitude toward international technology transfer (including both technology licensing and direct foreign investment), and a substantial investment in public technology institutions. The credible commitment of government to rapid development may itself have a positive effect on risk taking in the private sector and may lead firms to choose products or processes that promise greater return. Governments seeking a more active role in accelerating growth should consider these policies rather than selective industrial policies.

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Productivity and Economic Growth: The Case of Chile

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The crises that swept through Asia in late 1997 brought Chile's economic boom to an abrupt halt. After having grown at an average rate of 7.3 percent per year in 1984–97, the Chilean economy expanded by under 3 percent a year thereafter. So what happened? One answer, often put forward by the authorities, posits significantly worse external conditions as the basic explanation. Because Chile is a small open economy, the demand for Chilean exports declines when the world economy slows, leading to lower export prices and volumes. If the price of oil rises at the same time, this small open economy, which imports nearly all the oil it consumes, suffers even more. Things worsen further if net capital flows to emerging economies suddenly dry up.

Figure 1 plots the basic external variables affecting the Chilean economy for the period 1980–2001. Panel A shows growth of world gross domestic product (GDP) using data from the International Monetary Fund (IMF). Although there was an economic slowdown in 2001, the previous few years (particularly 1999 and 2000) were years of high growth for the world economy as a whole. Panel B shows Chile's terms of trade, defined as the price of its exports divided by the price of its imports, using data from the Central Bank of Chile. A sharp decline occurred in 2001, but the terms of trade over the previous few years (1998–2000) were around their average level for the whole period. Net

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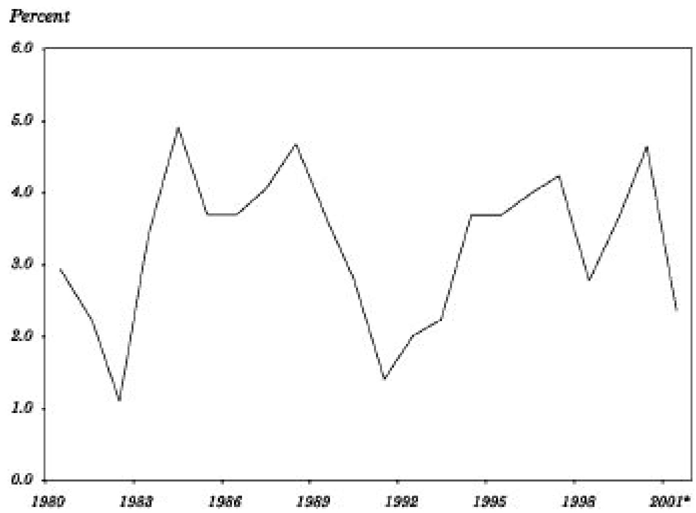
private capital flows to emerging markets are shown in panel C. These have clearly dropped off very sharply, badly hurting economies that are heavily dependent on external financing. This aspect of the situation is similar to most of the 1980s. Finally, panel D shows the path of the international interest rate over the last twenty years.[1] This is a key variable, since it affects the burden of the external debt, as well as the cost of new borrowing in the case of countries with access to international capital markets (including Chile). As this panel shows, interest rates stay at their lowest level throughout the period. This variable is clearly moving in the opposite direction of the other variables mentioned, for lower interest rates are positive for a country like Chile.

The external scenario is clearly important for an emerging open economy like Chile. However, it is difficult to blame all the slowdown in Chilean economic growth over the last few years on this factor, for three reasons. First, the deterioration in external conditions came after Chile's economic slowdown had already begun. In fact, 1998–2000 was not a bad period for the world economy, yet Chile grew by under 3 percent per year.[2] Average growth in the world economy for these three years was above the average for the last two decades. The same can be said about Chile's terms of trade: in 1998–2000 they were less than 1 percent below the average for the last twenty years. Second, although it is true that net private capital flows to emerging economies declined sharply beginning in 1996–97 and were almost nonexistent in the last couple of years, it can be argued that for any given country there is a degree of endogeneity in this variable. Chilean firms have been able to obtain financing abroad at relatively low interest rates during this period, and the government has issued new debt that has been readily accepted on the world capital market. Chile would thus appear to have access to the international capital market. Moreover, the most significant feature of the balance of payments in recent years has been a huge increase in capital outflows, as Chileans have increased their investments abroad. This could be because domestic interest rates (adjusted for country risk and expectations of devaluation) have been relatively low, or simply because there are not many investment projects in the country at the present time. Third, the final external variable, the international interest rate, has been quite favorable in recent years, with both nominal and real rates below their average for the 1980s and 1990s. The short-term rate has recently fallen to levels not seen in decades.

1. The 180-day U.S. dollar London interbank offered rate (LIBOR) is used here.
2. The world economy expanded faster in 2000 than at any time since 1988.

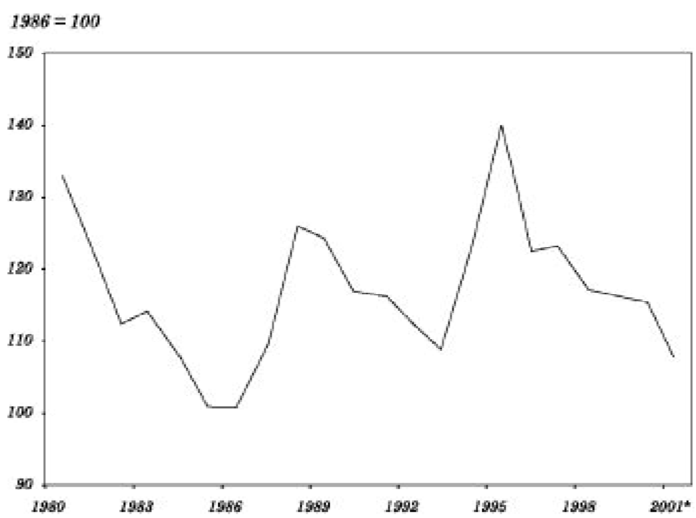
Figure 1. External Conditions Confronting the Chilean Economy

A. World economic growth



Source: International Monetary Fund (IMF).
* Estimated

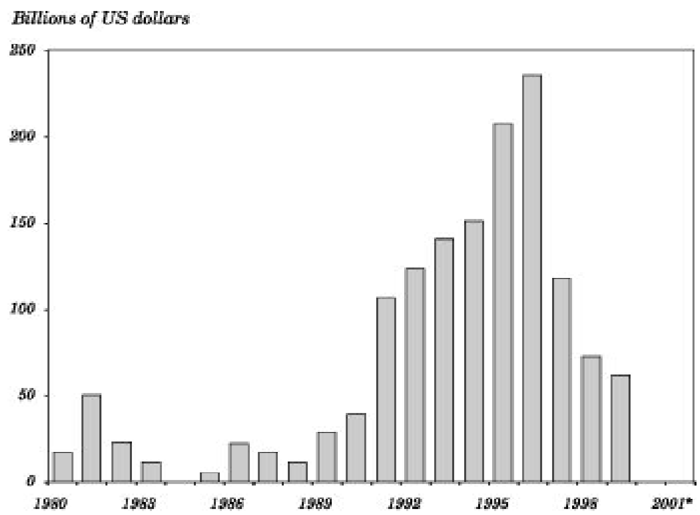
B. Terms of trade



Source: Central Bank of Chile.
* Estimated

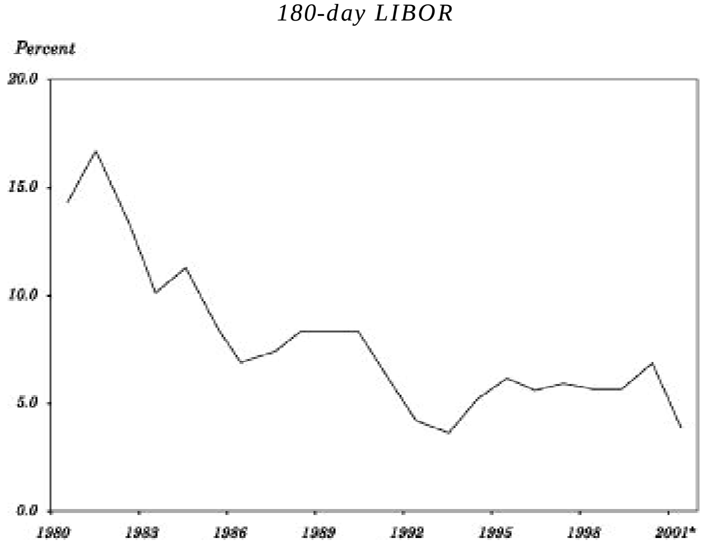
Figure 1. (continued)

C. Net capital flows to emerging economies



Source: International Monetary Fund (IMF).
* Estimated

D. International interest rate
180-day LIBOR



Source: Central Bank of Chile.
* Estimated

In short, although external conditions have clearly worsened, this provides only a partial explanation for the weak performance of the Chilean economy. Our impression is that the slowdown in economic growth can be at least partially reversed. This paper argues that the way to do this is by increasing the growth in total factor productivity (TFP). Chile's golden age in terms of economic growth was explained by a strong expansion in TFP. This, in turn, is explained by the productivity effects of the reforms implemented in the 1980s and early 1990s, which to some extent have now been exhausted. Accordingly, what Chile now needs to reinvigorate economic growth is a new wave of reforms in areas were it has fallen behind—areas relating mainly to the microeconomic foundations of growth, namely, institutions and the efficiency and efficacy with which they function. To put it differently, new microeconomic reforms are needed to enhance the efficiency with which available resources are used.

If economic growth is viewed not as a linear process, but rather as one marked by sporadic productivity shocks that lead to high growth for a period before fading in convergence until the next productivity boost, then Chile would currently be in a phase in which the most recent productivity shock is contributing its last ammunition. If this is the case, the country needs a new shock to kick-start a new period of rapid economic growth. This new boost could be a turn of luck, such as the discovery of oil or a significant positive terms-of-trade shock. Because luck is random, however, we prefer to consider a new productivity shock arising from economic policy initiatives aimed at improving economic efficiency. We argue that improvements in these areas are likely to produce a new surge in economic growth in Chile. Furthermore, the deterioration in external conditions increases the need for policies to boost the country's currently sluggish growth rate.

It could be argued that the slowdown that Chile has faced in the last years is the natural state of things. Countries cannot grow forever at 7 percent; at some point they must converge to more normal growth rates. Although the point is correct, international experience shows that several countries in Asia, Europe, and even Latin America have grown at rates in the neighborhood of 7 percent for longer periods of time—say, twenty, thirty, and even forty years.[3] The same evidence also suggests that it is possible to sustain longer periods of growth in total factor productivity. Hence, although Chile's fifteen years of 7 percent growth is a great achievement, the current slowdown should not be viewed as the natural end of an era.

3. See Maddison (2001).

The paper is organized as follows. Section 1 presents some stylized facts on the Chilean economy, beginning with an analysis of the behavior of total factor productivity over the last several years. Our conclusion is that the country is currently going through a significant productivity slowdown. We then identify several areas that have significant potential for increasing efficiency through economic reform. Finally, the section presents a number of indicators of microeconomic efficiency for Chile, showing that while the country is highly ranked in many areas, elsewhere it is well below the average for countries of similar per capita income levels. There is clearly room for upgrading Chile's institutions, and doing so could generate a new productivity boom.

Section 2 develops a basic model along these lines, showing how TFP can surge when institutions are upgraded. In section 3, we run cross-section growth regressions with TFP as the dependent variable. We construct several indicators of efficiency in institutions and examine their effect on growth, and we consider the potential effect on TFP in a country like Chile. The final section presents our conclusions.

1. TFP, Additional Reforms, and Microeconomic Efficiency in Chile: Some Stylized Facts

The central hypothesis of this paper is that Chile needs to upgrade its institutions if it is to achieve another decade of high growth. Some might argue that the country has already made all necessary reforms and extracted all the benefits from them. This view implies that Chile now has to get used to lower growth rates (say, 4 percent per year), which are achievable provided the country maintains its current level of institutions and pursues a prudent macroeconomic policy. There are at least three problems with this argument. First, while it is true that Chile's institutions function remarkably well in many respects, this is not the case across the board. There is significant room for improvement in many areas, as documented below. A new wave of reforms is therefore needed to modernize the country's institutions and boost economic growth. Second, periods of high economic growth in many recent success stories have lasted longer than in Chile.[4] The fact that Chile enjoyed nearly a decade and a half of rapid economic growth in the 1980s and early 1990s is certainly remarkable, but as mentioned

4. See, for instance, Maddison (2001).

previously, several countries in Europe, Asia, and Latin America have enjoyed two, three, and even four decades of rapid GDP growth. Moreover, Chile's per capita GDP does not make it one of the leading economies in the world, so it should not exhibit a natural tendency toward slower growth rates. Finally, rich countries are able to maintain reasonable rates of productivity growth despite their high levels of per capita income, which suggests that good economic policies and good institutions are able to introduce some continuity in TFP growth.

Most international rankings rate Chile's institutions as efficient in an aggregate sense given the country's per capita income.[5] This does not mean that those institutions cannot be improved, however, especially if growth has come to a relative standstill. Moreover, the same rankings show that Chile has not progressed in recent years, but has stayed more or less in the same place. Most of these indicators have to be understood dynamically, in the sense that once a country has achieved a specific place in the ranking, it can only hold that position by continuously raising the level of its policies and institutions. It is therefore possible to register a slowdown in productivity growth even in the absence of absolute deterioration in the institutional quality.

One of the majors concerns in Chile in recent years has been the efficiency of government spending and of the state bureaucracy. The 1990s saw a significant increase in government expenditure in the country, from 22 percent of GDP in 1990 to 26.4 percent by the end of the decade. This raises the question of whether higher government spending has resulted in more and better government services.

1.1 Total Factor Productivity

Table 1 presents data on TFP growth for Chile over the last two and a half decades. TFP is measured as the residual GDP growth that is not explained by labor or capital accumulation. There are no input quality adjustments. A productivity boom occurred in the second half of the 1970s in the wake of the first wave of structural reforms; this was followed by the crisis of the early 1980s. Recovery began in the mid-1980s, when there was a second productivity boom (associated with a second wave of reforms) that reached its peak in the first half of the 1990s. In the second half of that decade, productivity growth slowed once more, and it was negative in 1998–2001.

5. See, for example, World Economic Forum (2001); O'Driscoll, Holmes, and Kirkpatrick (2000).

Table 1. Components of Economic Growth in Chile

		Contribution to GDP growth (%)		
Period	*GDP growth*	*TFP*	*Labor*	*Capital*
1976–1980	6.8	3.7	2.3	0.8
1981–1985	–0.1	–2.2	1.2	0.9
1986–1990	6.8	2.3	2.5	2.0
1991–1995	8.7	3.7	1.5	3.5
1996–2000	4.1	0.1	0.5	3.6
1998–2001	2.4	–0.6	0.1	2.8

Source: Authors' estimations.

These calculations clearly show that the key difference between this latest period (1998–2001) and the previous fourteen years of high economic growth (1984–1997) is TFP growth. As table 1 shows, capital's contribution to growth has been between 2.0 and 3.5 percentage points since the mid-1980s (1986–2000) and has remained in the same range in recent years. Labor's contribution to growth, in turn, averages 1.5 points, but its share declined toward the end of the period owing to a significant increase in unemployment since 1998. Finally, as mentioned above, TFP rose from two to three percentage points before falling back to a negative figure in 1998–2001.

1.2. Areas for Structural Reforms

We recently edited a collection of works that identify ten areas with potential for improvement (Beyer and Vergara, 2001). If some reforms were made in these areas, the authors claim, they would trigger a new productivity boom and a new era of high economic growth. In what follows of this section, we discuss the problems and proposals for change in some of these areas.

Health reform

A recent study of the public health system by Rodríguez and Tokman (2000) shows that the growth of government spending in public health has not generated a corresponding increase in the services produced in this sector. While government spending on health has risen by 190 percent, total services have increased by only 22 percent. This means that the productivity of expenditure has fallen by over 50 percent. Beyer (2001) calculates that if productivity were at its 1990 level, the public health system today could provide additional services worth about 1.5 percent of GDP. On the other hand, there is also growing dissatisfaction with the private health sector, which has not been able to cope with the issue of catastrophic diseases. In addition, the number of people in the private health system has declined over the last few years because of cost considerations.

Beyer (2001) suggests three basic principles for health reform. First, the current system—in which everyone pays 7 percent of their income for health insurance, such that those who earn more subsidize those who earn less—should be transformed into a system in which people pay the real cost of their health plan. Anyone who could not afford minimum coverage would receive a government subsidy, and anyone who wanted broader insurance would—as they do now—have to pay for it. Second, the government subsidy should be portable. That is, people should be able to choose their health insurance institution (ISAPRE), and they could move with their subsidy to another institution whenever they wanted. ISAPREs would not be able to discriminate by health risk. Third, independent councils should administer public hospitals. The hospitals would not receive resources directly from the state, but only indirectly through the subsidies that poor people receive.

These mechanisms are aimed at improving the productivity of the private and public sectors. Beyer admits that is probably impossible to reach the productivity levels of the early 1990s, because those levels are overstated due to the declining resources of the public health system at that time. However, a significant improvement in the current efficiency levels is perfectly achievable.

Education reform

Human capital is one of the variables that attracts the most attention in the economic growth literature.[6] Barro (1999) applies his cross-section growth regressions to the Chilean case. He estimates that if the quality of education in this country were at a level compatible with its per capita income, growth would be as much as two percentage points higher per year. Barro uses scores achieved in an international science test to measure education quality.[7] Education is one of the major forces

6. See Lucas (1988); Barro and Sala-i-Martin (1995); Barro (1991).
7. See Barro and Lee (1997, 2000).

behind economic growth, yet international examination scores clearly reveal that Chile performs well below its development level in terms of education quality. This suggests that improving education quality could significantly accelerate growth. We return to this point in section 3.

The education budget grew from 2.5 percent of GDP in 1990 to 4.2 percent of GDP in 2000, but the education system shows no clear signs of any improvement in quality. While it is true that education is a long-run issue, the emphasis seems to have been on throwing additional resources at the sector, rather than on how to actually improve educational outcomes.[8]

Eyzaguirre and Fontaine (2001) propose setting explicit targets for school achievement, with the use of external national tests to verify whether the targets are being met. These authors emphasize the need to improve the information that parents get about the quality of schools. This would increase the pressure on schools to improve their quality. These proposals are complemented with calls to increase the autonomy of public schools, especially regarding the administration of human resources (teachers). The current system of subsidies for children attending public schools should remain in effect, but it should be made progressive, with the poorest students getting a higher subsidy.[9]

Labor reform

As documented by Heckman and Pagés (2000), firing costs in Chile are among the highest in Latin America. They estimate a significant effect of these costs on employment, especially on youth unemployment. The present value of the expected cost of firing a worker is well above the average for the region. The labor reform approved in 2001 exacerbates the problem by moving in the direction of less, rather than more, flexibility.[10]

Other microeconomic reforms

Several additional microeconomic reforms could increase productivity, and these aim largely at improving the efficiency of institutions.[11] For instance, Paredes (2001) finds that the antitrust regulation and

8. See Eyzaguirre and Fontaine (2001).

9. The current system encompasses both municipal schools and private schools with state subsidies.

10. For a proposal to increase the flexibility in the labor market in Chile, see Coloma (2001).

11. Beyer and Vergara (2001).

institutions in Chile are obsolete. They do not have a clear objective, and the type of problems that they should address has not been clearly defined. The author also claims that these institutions need greater autonomy than they currently enjoy. The issue of antitrust is becoming increasingly important because the Chilean industrial sector has followed the world trend of growing concentration. Achieving the objective of an efficient market economy requires professional and efficient institutions to safeguard the preservation of competitive markets. The current system in Chile needs an upgrade to guarantee the achievement of this objective.

Irarrázaval (2001) finds that the government programs directed at poverty reduction are similarly obsolete. They were designed in the 1980s, when more than 40 percent of the population was defined as being poor. Poverty has since been reduced to about 20 percent of the population, however, and, it is necessary to focus efforts on this smaller group of people. If programs such as the family subsidy, the drinking water subsidy, and the assistance pension program were focused on the poorest 30 percent of the population, costs would be reduced by between one-third and two-thirds, and the resources could be redirected to other social programs. However, while focalization is necessary, it is also very difficult to achieve.

Finally, regulation needs to be updated in several sectors, including electricity, telecommunications, and banking. Environmental policy and regulation are also on the list.[12]

1.3 Microeconomic Efficiency

Several different variables have been used in the literature to capture a country's degree of microeconomic efficiency. In some of these indices, Chile is well placed relative to other developing countries, albeit well behind developed countries. In others, however, it lags behind countries at a similar level of development.

Djankov and others (2000) present data on the time and costs involved in starting up a new firm. The process takes seventy-eight days in Chile, ranking it fifty-fifth out of seventy-five countries—far behind countries like Canada (two days), the United States (seven days), and even South Africa (30 days). Chile performs worse on this measure than most countries with a similar per capita income. In terms of monetary costs (in relation to per capita GDP), Chile ranks twenty-fifth at 12 percent of per capita GDP. This is good compared with, say, Israel (20 per-

12. For a specific proposal and analysis, see Beyer and Vergara (2001).

cent), but the level is much higher than in the United States or Canada (1 percent), Australia and Norway (2 percent), and Turkey (3 percent).

The current competitiveness index published in the *Global Competitiveness Report* (World Economic Forum, 2001) also provides information on microeconomic efficiency. This aggregate index is intended to capture an economy's effective utilization of its current stock of resources. The index is constructed from several variables, such as the number of permits needed and days taken to start up a new firm, bureaucratic red tape, and so forth. In terms of days taken to start up a new firm, Chile has more or less the same position as in the previous index (fifty-fourth out of seventy-five countries). In terms of permits, Chile ranks thirty-fifth with five permits, which is more than the United Kingdom (two), New Zealand (three) or the United States (four), but less than Brazil (seven) or Mexico (ten).

Evans and Rauch (1999) study the effects of state bureaucracy on growth, considering in particular salary structure and policy, along with the procedures used for hiring top managers in public administration. They find that the more that public managers are hired on merit and the more attractive their salaries, the higher is the economic growth of the country concerned. Valdés (2001) uses the coefficients obtained by Evans and Rauch and finds that if the quality of Chile's public administration had been equal to that of Hong Kong in 1970–90, its growth rate would have been as much as 1.5 percentage points higher per year.

Kaufmann, Kraay, and Zoido-Lobatón (1999) construct a database with a number of variables on governance, including the regulatory framework. Here, Chile ranks eighteenth out of 145 countries, which puts it above most other countries of similar per capita income, but well behind countries such as the United States, the United Kingdom, and New Zealand. Corruption is a variable that undermines the proper functioning of institutions. These authors also construct an index of corruption control, in which Chile is again well ranked (twenty-fourth out of 136), but still far behind the leaders. The index ranges from +2.5 (less corrupted) to –2.5 (more corrupted). Chile scores 1.03, which is well above the mean but behind countries such as New Zealand (2.1), Canada (2.1), and the United States (1.4).

2. Some Theoretical Considerations

We focus our analysis mainly on the growth of total factor productivity. Early growth studies generally start by considering an aggregate Cobb-Douglas production function with technological change, so that growth in output can be expressed as a function of capital accumulation and labor accumulation. Under the assumption of perfect competition, the weights of the inputs are their respective shares. These studies find that the unexplained part of output growth, the residual or total factor productivity (TFP), is the most important element in explaining the growth rate of different countries. For example, Solow (1957) finds that TFP explains 52 percent of the growth rate of the United States between 1909 and 1949. Denison (1967) estimates that for the period 1950–62, TFP explains 40 percent of the U.S. growth rate, while it contributes 62 percent, on average, in a group of European countries. These high rates of TFP growth immediately triggered debate in the profession. Some researches, such as Jorgenson and Griliches (1971), pointed out that these early studies fail to recognize the heterogeneity of the different inputs. New estimates of TFP were calculated, with inputs categorized by type so that the growth of capital and labor became a weighted average of the growth of the different input types. The weights were the income shares of the different types of labor and capital in total labor and capital compensation, respectively. This procedure thus corrected for marginal productivity of the different input types. Using this corrected methodology, Jorgenson (1995) finds that TFP accounts for only 21.6 percent of the growth rate of the United States in the period 1947–85. Capital accumulation is the most important factor in explaining growth.

A second strand of the literature uses the evidence from these early studies to argue that there is something wrong with the neoclassical theory of growth. These economists argue that if the main source of economic growth is left unexplained, then the profession has no satisfactory theory of growth (see, for example, Romer, 1986). New models of growth were developed to deal with this problem. This is the origin of the endogenous growth literature. In Romer (1986) and Lucas (1988), the basic idea is that individuals do not internalize the externalities associated with the accumulation of knowledge. These so-called AK models (in which K is broadly defined) have strong implications. For instance, if differences in savings rates among countries or in population growth result in permanent differences in economic growth rates, the strong implication is no convergence in per capita income among countries as predicted by the neoclassical theory of growth.

The constant marginal product of capital and the (conditional) divergence in per capita income are not sustained empirically, however. Although the empirical growth literature tends to support endogenous growth theory, it also reports conditional convergence and diminishing returns to capital.[13] The failure of the AK models to adequately predict these facts has led to a revision of these early endogenous models. The augmented Solow model of Mankiw, Romer, and Weil (1992) more adequately fits the data. The basic model is augmented to include human capital. Their empirical results are consistent with decreasing returns to capital and a slow convergence to the steady state. Moreover, the model is able to reconcile large differences in output per capita once differences in the savings rate and population growth are accounted for, which is a clear improvement on the basic Solow model.

Although the augmented Solow model does a much better job of fitting the actual data than either the basic model or the AK models, it has an evident shortcoming. In the steady state, the growth rate of per capita income is defined by the rate of technological change, which is exogenously determined and therefore unexplained. An important amount of effort has been put toward trying to understand the forces behind the rate of technological progress. The most successful studies in this line of research are those linked to the Schumpeterian tradition of growth through creative destruction. In the basic model (see Aghion and Howitt, 1992), succeeding vintages of intermediate goods embody quality improvements that render their predecessor obsolete. These quality improvements are a source of economic growth, but they are the result of an uncertain research process leading to a stochastic growth. The possibility of monopoly profits introduces incentives to hire labor for research instead of hiring it for the manufacturing of the latest generation of intermediate goods. In the steady-state equilibrium, the division of labor between research and manufacturing remains unchanged, although growth is stochastic given the nature of research activities. The average growth rate in this steady-state equilibrium depends on the propensity to save, the productivity of the research technology, and the degree of market power enjoyed by a successful innovator.

Chile put in an impressive economic performance over the last fifteen years.[14] Hence, identifying areas that have been important obstacles to Chile's economic growth is not an easy task. The recent slowdown is largely the result of the world economic downturn, although, as we argued above, there are indications that Chile's productivity slowdown is independent of the current international scenario and may be the result of institutions and policies that perform badly. If these institutions or

13. For a review of the empirical growth literature, see Barro and Sala-i-Martin (1995).

14. Only fourteen countries had a larger rate of GDP growth than Chile in the period 1980–2001. Bear in mind that GDP fell 15 percent in 1982.

policies affect the accumulation of both human and physical capital, lead to misspending of resources, or impede efficiency gains, they will be unable to promote growth. Most countries, in fact, rely on institutions and policies that deprive their economies of the necessary fuel for starting the growth process, rather than providing the right incentives for growth. This is the only explanation for why so many countries have been unable to achieve a more permanent process of economic growth. Institutions and policies must therefore be measured against their ability to promote growth.[15] If they do not measure up, then they must be amended. In the case of a conflict with another objective, the political process is responsible for balancing the two objectives.

To model the impact of institutions and policies on growth, we expand the framework developed by Mankiw, Romer, and Weil (1992). The level of GDP is determined by

$$Y(t) = K^{\alpha}(t)H^{\beta}(t)\left[A(t)L(t)\right]^{1-\alpha-\beta}, \tag{1}$$

where K, H, and L represent physical capital, human capital, and basic labor, respectively. As usual α is the partial elasticity of output with respect to K, and β is the partial elasticity of output with respect to H. $A(t)$ is assumed to have two components: the level of economic efficiency, $E(t)$, which depends on the quality of economic policies and institutions, and the level of technological progress, $\Phi(t)$. We further assume that $E(t)$ can be written as a log linear function of economic policies and institutions and that $\Phi(t)$ grows at an exogenous rate of $g(t)$[16]. After making the usual assumptions about the dynamics of K and L we have the following system:

$$\begin{aligned}
\dot{K}(t) &= s_K Y(t) \\
\dot{H}(t) &= s_H Y(t) \\
\dot{L}(t) &= nL(t) \\
A(t) &= E(t)\Phi(t) \\
\ln E(t) &= \lambda_o + \sum\nolimits_i p_i \ln I_i(t) \\
\dot{\Phi}(t) &= g(t)\Phi(t),
\end{aligned} \tag{2}$$

15. We are not suggesting that every institution or policy has to be measured against that benchmark, but rather are thinking of those institutions and policies that are more directly or exclusively involved with the economic sphere.

16. This rate of technological growth could eventually be endogenized by assuming, for example, that it is the result of intentional investment in research and development (R&D) by profit-seeking firms. These firms invest in R&D to capture monopoly rents associated with a product innovation.

where the variables I_i stand for the different policies of interest. Defining k, h, and y as $K / \Phi L$, $H / \Phi L$, and $Y / \Phi L$, respectively, we can write the first two equations of the former system as follows:

$$\begin{aligned}\dot{k}(t) &= s_k E(t)^{1-\alpha-\beta} k(t)^{\alpha} h(t)^{\beta} - (n+g)k(t) \\ \dot{h}(t) &= s_h E(t)^{1-\alpha-\beta} k(t)^{\alpha} h(t)^{\beta} - (n+g)h(t).\end{aligned} \tag{3}$$

Solving for the steady-state values of physical capital and human capital generates the following expressions:

$$\begin{aligned}\ln k^* &= \frac{1-\beta}{1-\alpha-\beta}\ln s_k + \frac{\beta}{1-\alpha-\beta}\ln s_h + \ln E(t) - \frac{1}{1-\alpha-\beta}\ln(n+g) \\ \ln h^* &= \frac{\alpha}{1-\alpha-\beta}\ln s_k + \frac{1-\alpha}{1-\alpha-\beta}\ln s_h + \ln E(t) - \frac{1}{1-\alpha-\beta}\ln(n+g).\end{aligned} \tag{4}$$

The level of per capita income in this steady-state equilibrium is as follows:

$$\ln y^* = \ln E + \frac{\alpha}{1-\alpha-\beta}\ln s_k + \frac{\beta}{1-\alpha-\beta}\ln s_h - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g). \tag{5}$$

Note that the level of per capita income in the steady-state equilibrium is influenced by the quality of economic policies and institutions.[17] This last specification is valid only if countries are in their steady state. Since this is not the case, the dynamics have to be modeled explicitly. If we consider the production function defined earlier and the equations of motion for k and h, we can take a log-linear first-order Taylor approximation around ln k^* and ln h^* (that is, the steady-state values of h and k) to obtain the following balanced growth path:

$$\frac{d[\ln y(t)]}{dt} = -(1-\alpha-\beta)(n+g)[\ln y(t) - \ln y^*], \tag{6}$$

which shows that y converges to y^* at a rate of $(1 - \alpha - \beta) \cdot (n + g)$. This is a differential equation with the following solution:

$$\ln y(t) - \ln y^* = e^{-(1-\alpha-\beta)(n+g)}[\ln y(0) - \ln y^*], \tag{7}$$

17. We have dropped the time subscript from the variable associated with the quality of economic policies and institutions, which indicates that we assume they do not change persistently in the long run.

which implies that y approaches y^* exponentially. To find an expression for the growth of per capita income, we add ln y^* – ln $y(0)$ to both sides, producing the following growth equation:

$$\ln y(t) - \ln y(0) = \left(1 - e^{-(1-\alpha-\beta)(n+g)t}\right) \cdot \ln y^* - \left(1 - e^{-(1-\alpha-\beta)(n+g)t}\right) \ln y(0), \quad (8)$$

where $(1 - \alpha - \beta) \cdot (n + g)$ determines the speed of convergence and indicates how rapidly an economy's per capita output, y, approaches its steady-state value, y^*. The starting level of per capita income is given by $y(0)$. Having solved for ln y^*, we can substitute the expression into the previous equation to obtain the following equation.

$$\begin{aligned} \ln y(t) - \ln y(0) = {} & \left(1 - e^{-(1-\alpha-\beta)(n+g)t}\right) \cdot \left[\lambda_o + \sum\nolimits_i p_i \ln I_i(t)\right] \\ & + \left(1 - e^{-(1-\alpha-\beta)(n+g)t}\right) \frac{\alpha}{1-\alpha-\beta} s_k \\ & + \left(1 - e^{-(1-\alpha-\beta)(n+g)t}\right) \frac{\beta}{1-\alpha-\beta} s_h \qquad (9) \\ & - \left(1 - e^{-(1-\alpha-\beta)(n+g)t}\right) \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g) \\ & - \left(1 - e^{-(1-\alpha-\beta)(n+g)t}\right) \ln y(0). \end{aligned}$$

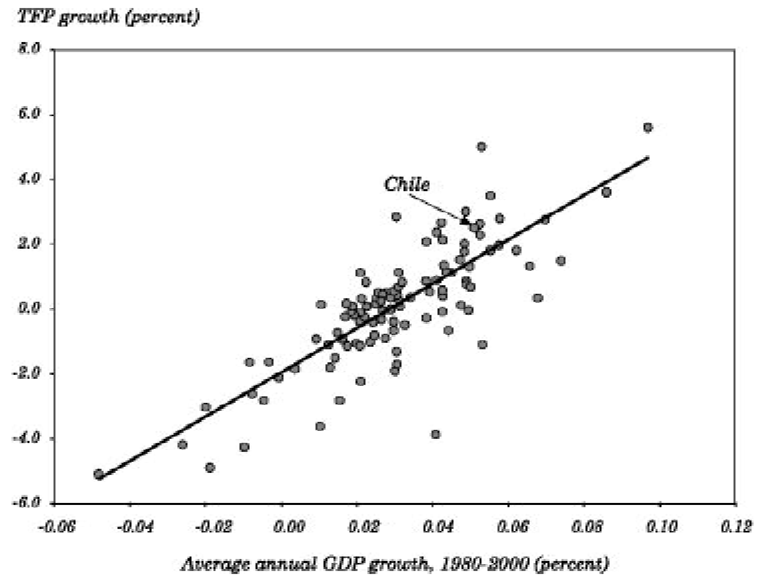
This function can be empirically tested. We are especially interested in the growth rate of total factor productivity, since it is a natural framework for thinking about economic policies and institutions. The contribution to economic growth of similar rates of accumulation in physical capital or human capital accumulation will differ across countries if their economic policies and institutions also differ. The early empirical studies of growth capture the effect of these variables in the so-called residual. The researchers were aware that this residual was the result of an omitted factor influencing the growth process, and they knew that exogenous technological progress was a convenient way of expressing the output growth resulting from factors unrelated to the accumulation of inputs. For example, Denison (1967) breaks down the residual obtained in his growth estimation into several components, including advances in knowledge, improved allocation of resources, and economies of scale. These concepts are fully integrated in the modern endogenous growth models.

The lack of both formal models and adequate data to test them were important factors behind the slow move toward an endogenous theory of economic growth. In addition, the residual was widely perceived as the outcome of several, equally important factors. As Harberger (1990) puts it, the residual is best understood in terms of a reduction in real costs. Almost anything fits in this definition.

Recent studies, however, build on the idea that TFP has been overestimated as a source of growth (for example, Young, 1995). In our opinion, whether TFP calculations are large or small is not a relevant issue for growth theory, unless there is a satisfactory theory of what makes TFP large or small. Input accumulation is clearly important for growth, and there are quite satisfactory theories on how input accumulation occurs. Differences in growth stemming from differences in capital accumulation are easily understand by the profession. We have a lot of insights into why investment rates differ across countries. We do not have many insights, however, into why TFP rates differ across countries. The argument that TFP increases with efficiency gains is appalling. An example illustrates this idea well. Assume that a firm is not fully utilizing its existing economies of scales. A rearrangement in production (probably an increase at the plant level) should therefore produce an advance in TFP, because the reduction in average costs associated with a complete utilization of economies of scale makes room for a possible increase of the rewards to the existing productive factor without an increase in output prices. An increase in the payments to productive factor represents an increase in value added and thus in growth. Consequently, it becomes almost inevitable to think about economic growth as a very decentralized process that occurs at the level of individual firms. In such a scenario, the relevant policy questions are related to the general question of how to facilitate this process of efficiency gains to the individual firms.

But is TFP an important source of economic growth? Put differently, is economic growth affected by the quality of policies and institutions? To answer this question, we do a very simple exercise in growth accounting for the period 1980–2000, in which we estimate the unexplained rate of GDP growth after controlling for investment and increases in employment. We used the IMF data from the *International Financial Statistics*. We take the labor share in GDP to be 0.6. Assuming a stock of capital that is 2.5 times output and a depreciation rate of 5 percent, this implies an average rate of return to capital of 11 percent, a reasonable return for the entire physical capital stock. Since we do not have consistent data on employment for our

Figure 2. TFP and GDP Growth



sample, we use population data. TFP is the result of calculating the following equation:

$$TFP_t = \hat{Y}_t - (r + \delta)I_t - s_L \hat{L}, \tag{10}$$

meaning that TFP is the result of subtracting from the GDP growth rate net investment weighted by the gross rate of return to capital (δ is the depreciation rate) and the growth rate of labor weighted by labor's share in GDP.

TFP is undoubtedly an important explanation of growth. Figure 2 draws the relationship between TFP and the rate of economic growth for the period 1980–2000. Two-thirds of the variance in growth rates is explained by variations in the rate of TFP growth. This is not to say that factor accumulations do not play a role in explaining the differences in economic growth among countries. Our calculations may exaggerate the actual importance of TFP, since our estimations do not correct for human capital. It would be surprising, however, if the inclusion of human capital significantly reduced the importance of TFP.[18] Chile shows a

18. Indeed, for a smaller sample and for the period 1970–1991, Beyer (1997) corrects for human capital accumulation and finds that on average, TFP fell 0.48 percentage points, ranging from 0.04 to 1.01 percentage points.

Table 2. Sources of Growth[a]
Average growth rate (percent)

	Output	*Factor Accumulation*	*TFP*
Top 10 % fastest growing countries	7.55	3.88	3.67
Bottom 10 % slowest growing countries	–1.19	2.29	–3.48
Difference	8.74	1.59	7.15

a. Sample comprises 214 observations, based on two ten-year averages (1980–1990 and 1990–2000) for 107 countries.

very good rate of economic growth that is explained by an important TFP growth rate. This reflects the impact of the many reforms that transformed Chile from a very closed and overregulated economy in an open and competitive one.[19] Repeating these high TFP growth rates is precisely the challenge for Chile, though as the figure shows this is not an easy task. Many countries had TFP growth rates close to zero, and some had negative rates.

Table 2 confirms the role that TFP plays in economic growth. We were able to build TFP for 107 countries in the period 1980–2000. If we take the ten-year average growth in TFP for each country, we have 214 periods for analysis. We then select the top and bottom 10 percent of the periods in terms of economic performance and compare the importance of TFP in explaining the differences in the GDP growth rate.

The differences in GDP growth rates among countries is explained almost exclusively by differences in the TFP growth rate, whereas factor accumulation plays a relatively modest role. That TFP is an important source of economic growth for every country is confirmed if we concentrate our results on specific groups of countries. We begin by using the Penn World Tables to rank the 107 countries according to the level of their per capita GDP in 1980 (the first year of our analysis) (Heston and Summers, 1991). For the group of countries whose per capita GDP is in the top quartile of the ranking, we select the subquartiles with the highest and lowest periodic rates of economic growth. The time spans are 1981–1990 and 1990–2000. The next step is to compare the average economic growth rates across the two groups. These calculations are presented in table 3, which also reports the results of the same exercise carried out for the countries in the bottom quartile of the per capita GDP ranking.

19. See Larraín and Vergara (2000) for a description of these reforms.

Table 3. Sources of Growth among the Top and Bottom Quartiles[a]
Average growth rate (percent)

	Output	*Factor Accumulation*	*TFP*
Top quartile			
Highest periodic growth rates	4.57	3.48	1.09
Lowest periodic growth rates	0.50	2.79	–2.29
Difference in mean	4.07	0.69	3.38
Bottom quartile			
Highest periodic growth rates	6.22	3.10	3.12
Lowest periodic growth rates	–0.21	2.08	–2.29
Difference in mean	6.43	1.02	5.41

a. Quartiles determined by ranking the 107 sample countries according to their 1980 levels of per capita GDP. Each quartile is then divided into subquartiles based on growth rates in the periods 1981–1990 and 1990–2000.

Growth rates differ substantially among similar countries from one period to the other and from one country to the other. Differences in capital accumulation do not provide a consistent explanation for these significant variations. Rather, the important discrepancies in economic growth rates have to be linked to the differences in the rate of TFP growth. In both rich and poor countries, the rate of factor accumulation is quite high in periods of low growth, and it is the TFP growth rate that determines whether the period will be bad or good in terms of economic growth. Because the table is built on ten-year averages, it is not capturing cyclical downturns in the economy.

These very simple exercises demonstrate the importance that TFP plays in the process of economic growth. Of course, the exercises may contain flaws that we do not take into account (for example, that TFP may be correlated with investment), but the general picture is still valid: TFP and thus policies and institutions play a major role in the process of economic growth. Any attempt to foster economic growth in Chile must therefore look carefully at the performance of Chilean institutions and policies.

3. Economic Growth, Policies, and Institutions

The previous sections showed that growing countries exhibit positive rates of TFP growth and that factor accumulation does a poor job in explaining differences in economic growth across countries. Hence, if we want to explain growth, we have to explain TFP growth, which is strongly linked to the quality of institutions and economic policies. Which institutions and economic policies have the greatest impact on economic growth? In the case of Chile, we must further identify the marginal initiatives that will increase economic growth in an economy that already enjoys high growth. The candidates for increasing growth are not as obvious here as in the case of an economy that is not growing. The extensive research of the last two decades indicates very broadly how to increase economic growth, but it is not conclusive on specific policy recommendations. A large body of literature (for example, Easterly, 1993; Krueger, 1990) points out that bad economic policies may affect economic performance heavily. This is not the case in Chile: while the country's economic policies may show room for improvement, they are generally sound and respond more or less to economic dictums. A related literature targets the role of institutions in the process of economic growth (for example, North, 1990). Modifying institutions is a very hard task, and the impact of such efforts is less obvious than other forms of policy actions. Here, however, there is more room for improvement in Chile. As stated at the beginning of the paper, the educational sector and the government bureaucracy are obvious targets for reform. Their impact on economic growth is indirect but highly significant. An inefficient government bureaucracy, for example, may permanently hinder efficiency gains. A reform that substantially improves the efficiency of the state bureaucracy could generate an almost continuous increase in the country's economic efficiency if it results in the entry of new economic activities. The same thing can be said of a once-and-for-all improvement in the quality of education. Productivity will increase as the new school graduates enter the labor force, and the increases will continue until the old labor force is completely replaced. This may occur even if the schooling level of the new workers is the same as that of the workers leaving the labor force.

One of the problems associated with empirical work on this subject is the lack of data on many of the economic policies and institutions in which we are interested. In the last two decades, different organizations have systematically collected reliable data on the quality of economic policies and institutions, but much of the data rely on subjective measures of institutional quality. Another problem is that different indicators tend to be highly correlated within each dataset. This is not really surprising, since most high quality policies and institutions come in a package. A country with a good regulatory framework probably also has a highly qualified bureaucracy and low levels of corruption,

Table 4. Basic Model of TFP Growth[a]

Explanatory variable	*Coefficient*	*Standard error*	*t statistic*	*Probability*
Constant	0.123152	0.032756	3.759660	0.0003
ΔLogGDP	–0.016339	0.004187	–3.902475	0.0002
Openness	0.015492	0.005549	2.792071	0.0066
TYR 15–80	0.002132	0.001064	2.004475	0.0486
LogPC/GDP	0.005847	0.003210	1.821676	0.0725
Summary statistics				
Adjusted R^2	0.210759			
Standard error of regression	0.014345			
F statistic	6.274045			
Probability (F statistic)	0.000207			

a. The dependent variable is the rate of growth of TFP for the period 1980–2000. The independent variable is the log of GDP per capita in 1980 (ΔLogGDP, which controls for convergence; the data are from the Penn World Tables), the degree of openness (Openness, from Sachs and Warner, 1995), total years of education of the population fifteen years and over in 1980 (TYR 15–80, from Barro and Lee, 2000), and the average ratio of private domestic credit over GDP for the entire period, in log form (LogPC/GDP, from the IMF's *Statistical Yearbook*). The regression method is ordinary least squares. The number of observations is 80.

while the reverse is true in the case of countries with a bad regulatory framework. Moreover, good institutions may be the result—and not the cause—of strong economic growth. Even so, there are good reasons to treat institutions as exogenous. Growing evidence indicates that most countries have had their institutions for a long time, and these have changed only modestly across time. The same evidence further shows that the institutions have affected economic performance.[20]

We take a somewhat loose empirical strategy in order to focus on reforms that may have a long-run impact on economic growth in Chile. Starting from a very basic empirical model, we look one by one at individual policies and institutions that, if upgraded, may contribute to an increase in the country's growth rate. The objective is to have a minimum check of the viability, in terms of economic growth, of the proposed reforms. We run cross-section regressions for our sample of countries. Table 4 presents the results of the basic model. The results are more or less in line with previous research on the subject. The larger the level of initial per capita GDP, the lower the rate of growth in TFP. Openness, educational level, and the depth of financial markets positively affect TFP growth.

20. On both aspects, see Acemoglu, Johnson, and Robinson (2001).

Table 5. The Impact of Governance on Economic Growth[a]

Explanatory variable	*Coefficient*	*Standard error*	*t statistic*	*Probability*
Constant	0.139951	0.034232	4.088356	0.0001
ΔLogGDP	–0.018198	0.004432	–4.105978	0.0001
Openness	0.011162	0.005284	2.112337	0.0381
TYR 15–80	0.001323	0.001149	1.151013	0.2535
LogPC/GDP	0.004529	0.003324	1.362517	0.1773
Governance	0.009108	0.004016	2.268082	0.0263
Summary statistic				
Adjusted R^2	0.241930			
F statistic	5.914752			
Probability (F statistic)	0.000123			

Source: Author's calculations, based on data from Kaufmann, Kraay, and Zoido-Lobaton (1999).
a. The dependent variable is the rate of growth of TFP for the period 1980–2000. The independent variable is the log of GDP per capita in 1980 (ΔLogGDP, which controls for convergence; the data are from the Penn World Tables), the degree of openness (Openness, from Sachs and Warner, 1995), total years of education of the population fifteen years and over in 1980 (TYR 15–80, from Barro and Lee, 2000), the average ratio of private domestic credit over GDP for the entire period, in log form (LogPC/GDP, from the IMF's *Statistical Yearbook*), and an index of governance (Governance; see text for description). The regression method is ordinary least squares. The number of observations is 78.

Table 5 evaluates the impact of governance on economic growth. The data are from Kaufmann, Kraay, and Zoido-Lobatón (1999). These authors aggregate different measures of governance, originating from various sources of information, into six robust indicators: voice and accountability (VA) measures the extent to which citizens of a country are able to participate in the selection of governments; political instability and violence (PIV) measures perceptions of the likelihood that the government will be destabilized; government effectiveness (GE) captures the quality of government by combining perceptions of the quality of public services with the independence and competence of the civil service, among other indicators; regulatory burden (RB) captures the extent to which a country's policies are market unfriendly, as well as perceptions of the burdens imposed by excessive regulation; rule of law (RL) includes several indicators that measure the extent to which agents have confidence in and abide by the rules of society; and finally, graft (CP) measures perceptions of corruption. The choice of units of governance ensures that the governance estimates have a mean of zero, a standard deviation of one, and a range from around –2.5 to around 2.5. Higher values correspond to better outcomes.

One of the problems with these indicators is that they cover the years 1997–98. Some are less time invariant than others. For example, political systems have changed substantially in some countries in the last two decades, which may affect substantially VA and PIV. RL may also be influenced heavily by such changes. GE, CP, and RB are probably less sensible to changes in political systems. Since our dependent variable covers the period 1980–2000, these latter indicators are the best candidates for use in our regression. However, these measures are highly correlated with partial correlations ranging from 0.68 to 0.93. We therefore include in the regression an average of the three indexes as a measure of government efficiency. This index has a mean of 0.11, a maximum value of 1.75, a minimum of –2.09, and a standard deviation of 0.775. Chile ranks high with a value of 1.031, suggesting that the Chilean government is doing a relatively good job. The index proves to be highly significant. Despite Chile's good performance, a plausible objective is to shorten by half the distance between the maximum value in the ranking and Chile's value. This would add about 0.4 percentage points to Chile's TFP growth.

An alternative measure of government effectiveness is provided by the *International Country Risk Guide*, published by the PRS Group. This guide evaluates the risks faced by business in countries around the globe. It includes the IRIS dataset, which compiles country scores for six variables: corruption in government, rule of law, bureaucratic quality, ethnic tensions, repudiation of contracts by government, and risk of expropriation. We use the scores for bureaucratic quality as a measure of government effectiveness. The scores range from 1 (low quality) to 4 (high quality). Data are available for 1982–97, although only a few countries have data for the entire period. For each country, we take the mode of the available data. Table 6 shows the results of this exercise. This measure of government effectiveness is positively correlated with TFP growth. Increasing Chile's current score of 3 to the highest level may increase TFP growth by 0.8 percentage points. This result confirms our previous finding and suggests that a state reform on economic growth may have a significant impact.

Finally, we measure the potential impact of the quality of education using data from Barro and Lee (2000). Specifically, we incorporate their data on achievements on international mathematics into our basic empirical model. If no mathematics tests are available, we use the country's achievement on the science test. If neither test is available, we use achievements in reading. We took the last observation available. In some cases, the only tests available were conducted

Table 6. The Impact of Bureaucratic Quality on Economic Growth[a]

Explanatory variable	*Coefficient*	*Standard error*	*t statistic*	*Probability*
Constant	0.115096	0.034068	3.378392	0.0012
ΔLogGDP	-0.016723	0.004400	-3.801046	0.0003
Openness	0.009717	0.005714	1.700565	0.0934
TYR 15–80	0.000424	0.001194	0.354892	0.7237
LogPC/GDP	0.004157	0.003220	1.290733	0.2010
BUREAQUAL	0.008245	0.002980	2.766967	0.0072
Summary statistics				
Adjusted R^2	0.281880			
Standard error of regression	0.013845			
F statistic	6.966372			
Probability (*F* statistic)	0.000024			

Source: Author's calculations, based on data from the the *International Country Risk Guide.*
a. The dependent variable is the rate of growth of TFP for the period 1980–2000. The independent variable is the log of GDP per capita in 1980 (ΔLogGDP, which controls for convergence; the data are from the Penn World Tables), the degree of openness (Openness, from Sachs and Warner, 1995), total years of education of the population fifteen years and over in 1980 (TYR 15–80, from Barro and Lee, 2000), the average ratio of private domestic credit over GDP for the entire period, in log form (LogPC/GDP, from the IMF's *Statistical Yearbook*), and an index of bureaucratic quality (BUREAQUAL; see text for description). The regression method is ordinary least squares. The number of observations is 77.

in the early 1970s. This should not introduce serious errors, however, since educational institutions do not change rapidly. We upgrade the Barro and Lee data with the results of the 1999 TIMSS and the Laboratorio Latinoamericano de Educación. We convert the achievements in the latter test to the scale used in the TIMSS based on the performances of Chile and Colombia, which participated in both. Following Barro and Lee, we recalibrated the different tests to a uniform scale of 0 to 100. Table 7 presents the impact of our indicator of educational quality on the per capita income growth rate. This last variable enters very strongly in the regression, suggesting that a good education may increase TFP growth significantly. Since Chile is almost 11 percentage points below the average in the TIMSS, achieving that average may increase TFP by almost 0.7 percentage point.

Chile has a lot to gain by improving its educational system. An average achievement would put the country at the level of Thailand and Lithuania, and below countries like Latvia, Malaysia, and Bulgaria. None of these countries have a higher per capita GDP than Chile at purchasing power parity (PPP) levels. Figure 3 shows the

Table 7. The Impact of Educational Quality on Economic Growth[a]

Explanatory variable	*Coefficient*	*Standard error*	*t statistic*	*Probability*
Constant	0.087146	0.031603	2.757507	0.0083
DLogGDP	–0.014769	0.003477	–4.247755	0.0001
Openness	0.014842	0.005947	2.495772	0.0161
TYR 15–80	0.000588	0.001017	0.578089	0.5660
LogPC/GDP	–0.000596	0.002572	–0.231658	0.8178
TIMSS100	0.062497	0.030439	2.053175	0.0456
Summary statistics				
Adjusted R^2	0.399600			
Standard error of regression	0.010986			
F statistic	7.921788			
Probability (*F* statistic)	0.000018			

Source: Author's calculations, based on data from the *International Country Risk Guide.*
a. The dependent variable is the rate of growth of TFP for the period 1980–2000. The independent variable is the log of GDP per capita in 1980 (ΔLogGDP, which controls for convergence; the data are from the Penn World Tables), the degree of openness (Openness, from Sachs and Warner, 1995), total years of education of the population fifteen years and over in 1980 (TYR 15–80, from Barro and Lee, 2000), the average ratio of private domestic credit over GDP for the entire period, in log form (LogPC/GDP, from the IMF's *Statistical Yearbook*), and a measure of educational quality (TIMSS100; see text for description). The regression method is ordinary least squares. The number of observations is 53.

comparative performance of Chilean students in the TIMSS mathematics test. The results are plotted against the level of per capita GDP (PPP-adjusted). Chile is well below its level of per capita GDP. The challenge is clear.

One of the main factors behind the underachievement of Chilean students is that schools are rarely held accountable for their performance (Eyzaguirre and Fontaine, 2001). It is therefore urgent to reform educational institutions in order to ensure accountability among schools. Although Chile finance its schools through a voucher, parents currently do not exercise their choice to move their children to better schools. Part of the problem is that the information on school performance does not flow easily to parents. Results on school achievements have only been available since 1995, and they are difficult to understand. It is indispensable that parents be alerted to bad school performance and that they be able to move their children to better schools.

A major problem in this respect is that in many counties parents must choose among municipal schools that perform equally badly. In such cases, parents should have the possibility of opting out through

Figure 3. Mathematics Scores (TIMSS) and per Capita GDP Growth (PPP adjusted)

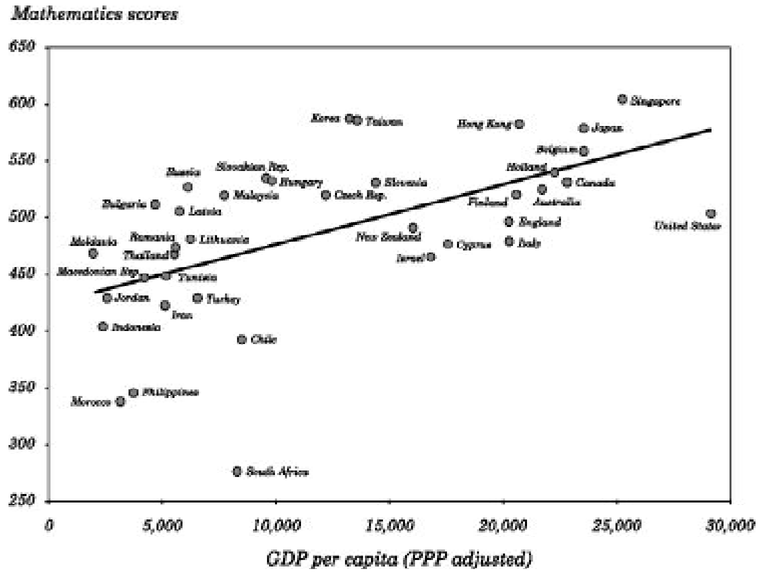


Figure 4. A Comparison of Chile and Malaysia: Achievement on the TIMSS Mathematical Test

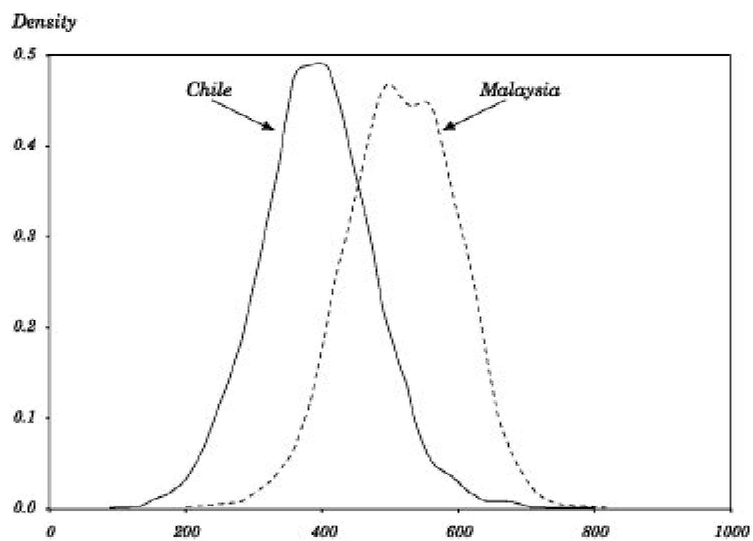


Table 8. Complementary Information on Chile and Malaysia

Variable	*Chile*	*Malasia*
Per capita GDP, in 1970 (at 1990 PPP prices)	5,293	2,079
Per capita GDP, in 1998 (at 1990 PPP prices)	9,757	7,100
Population 15 and over with no education, in 1970 (% population)	13.60	41.40
Gini coefficient	0.52	0.49
Ratio of income earned by fifth quintile over first quantile	13.50	12.00
Public expenditures in education (% GDP, 1998)	4.20	4.00
Total expenditures (% GDP, 1998)	7.30	4.70
Population, 1998 (in millions)	14.79	20.93
Primary enrolment (% population)	96.40	100.00
Public expenditures per primary student (US$ PPP 1998)	1,764	1,123
Public expenditures per secondary student (US$ PPP 1998)	1,713	1,460

Source: Maddison (2001); Barro and Lee (2000); OECD (2001); UNESCO (2000).

transport vouchers or through direct intervention in the management of these schools. Introducing this last alternative would require reforming the teachers' labor statute, which protects teachers heavily without assigning clear obligations. Under this statute, it is almost impossible to fire teachers regardless of student performance. Comparing Chile with Malaysia shows how far Chile is from achieving a good educational system (see figure 4 and table 8). Even Chile's best students from expensive schools are heavily outperformed by the Malaysian students. If Chile fails to achieve high standards in education, maintaining a rapid rate of economic growth will prove very difficult.

4. Conclusions

We have argued that the rate at which economies grow is constrained not only by their level of resources and technology, but also by the structure of incentives embodied in their institutions and economic policies. In particular, Chile's economic success in recent years is associated with the application of sensible economic policies and the existence of a sound institutional environment. If the country is able to maintain and improve these policies and institutions, it will ensure an additional period of high growth. The major gains in economic growth for a country like Chile may come from an improvement in its educational system. Reasonable and reachable improvements may increase Chile's TFP growth rate by 0.7 percentage points. Further gains are possible if government efficiency is improved. Taking our results together, we conclude that modest changes in the country's policies and institutions may increase Chile's rate of growth in 1.5 percent points.

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Finance and Growth: New Evidence and Policy Analyses for Chile

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Nobel Prize winners sharply disagree about the role of the financial sector in economic growth. Finance is not even discussed in a collection of essays by the so-called pioneers of development economics, including three winners of the Nobel Prize in Economics (Meier and Seers, 1984). Similarly, Nobel Laureate Robert Lucas (1988) dismisses finance as a major determinant of economic growth. Building on prescient insights by Bagehot ([1873] 1962), Schumpeter ([1912] 1934), Goldsmith (1969), and McKinnon (1973), however, a new wave of research indicates that financial systems play a critical role in stimulating economic growth (Levine, 1997). Moreover, recent work suggests that both stock markets and banks independently influence growth (Levine and Zervos, 1998). Nobel Laureate Merton Miller (1998, p. 14) similarly rejects the more dismissive views of the finance-growth nexus, remarking, "[the idea] that financial markets contribute to economic growth is a proposition almost too obvious for serious discussion."

The recent empirical investigations of the impact of stock markets and banks on economic growth have their shortcomings, however. Researchers either use pure cross-country analyses that do not account for possible biases induced by endogeneity and omitted variables (Levine and Zervos, 1998) or complex, hard-to-interpret panel estimates that do not address the potential influence of outliers (Rousseau and Wachtel,

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2000; Beck and Levine, 2002b). Furthermore, most studies use data through the mid-1990s and thus do not capture the financial and economic disruptions of 1998. Yet researchers must incorporate data on the recent financial crisis if they are to provide a balanced assessment of the connection between economic growth and both stock market and bank development.

The first part of this paper addresses some of the shortcomings with existing work on stock markets, banks, and economic growth while focusing on Chile. Specifically, we extend the pure cross-country analyses through 1998 to include the initial impact of the financial crisis and to examine the importance of outliers for the results. We complement these cross-country regressions with panel techniques to control for a variety of statistical biases. We also document how Chile fits into these analyses and highlight distinguishing characteristics of Chile's finance-growth experience.

The results emphasize the growth-enhancing role of stock markets and banks and document unique aspects of Chile's experience. Subject to some qualifications, stock markets and banks each exert an independent, positive influence on economic growth. Endogeneity, omitted country factors, macroeconomic policies, and outliers do not drive these findings. Furthermore, the pure cross-country regressions and the panel procedures produce consistent results. Chile itself is an outlier, however. The country has remarkably large stock markets as measured by the ratio of market capitalization to gross domestic product (GDP). Just as remarkably, Chile's equity markets are surprisingly illiquid as measured by the value of transactions as a share of market capitalization (or as a share of GDP). Since the link between stock market development and growth runs through liquidity and not through size, Chile stands out as a country with an illiquid equity market that has managed to grow quickly. Chile's economic growth rate is similarly more rapid than that predicted by its level of banking development, which is measured as bank credit to private enterprises as a share of GDP. Chile's level of financial development (as measured by stock market liquidity and bank development) is lower than the level of financial development associated with other very rapidly growing economies, such as Hong Kong, Malaysia, Singapore, Taiwan, and Thailand. Although Chile and a few other countries are outliers in the cross-country growth regression, the estimated growth-finance relationship remains strong and positive even when omitting these outliers, using panel techniques that eliminate country-specific effects, and controlling for a variety of growth determinants.

Given that finance promotes growth, this paper motivates an inquiry into the legal, regulatory, and policy factors that support stock market and bank development. Part one finds that banking sector development and stock market liquidity exert a positive impact on economic growth. Part two then turns to policies. We use a unique international dataset to examine the relationship between commercial bank regulations and supervisory practices and banking sector development.

The second part of the paper both reviews the connections between bank development and commercial bank regulation and supervision and assesses how Chile compares internationally. Specifically, Barth, Caprio, and Levine (2001a) assemble a large cross-country dataset on supervisory and regulatory practices. They then consider which regulatory and supervisory practices best support bank development and stability (Barth, Caprio, and Levine, 2001c). In this paper, we use the Barth, Caprio, and Levine (2001a, 2001c) data and findings to identify where Chile stands in the cross-section of countries. Our aim is to foster informative discussions by documenting those commercial bank regulatory and supervisory practices that have led to success in other countries and then juxtaposing them with current practices in Chile. In conducting these analyses, we were able to obtain information on commercial bank regulations and supervisory practices in Chile during the 1987–1990 period. We thus document recent changes in regulations and supervision to see how the direction of change in Chile corresponds with successful international practices.

Our results demonstrate the importance of bank regulatory and supervisory strategies that emphasize private sector monitoring, competitive banking markets, and sound incentives. International comparisons highlight important features of Chile's bank regulatory and supervisory system that may deserve further attention. In terms of broad measures of the extent to which the regulatory structure encourages and facilitates the ability of private sector creditors to monitor banks, Chile is slightly below average for all upper-middle income countries. This is a relevant issue, given that regulatory structures that promote private sector monitoring of banks tend to boost bank development (Barth, Caprio, and Levine, 2001c). In terms of competitiveness, Chile imposes comparatively tight restrictions on banks engaging in nontraditional activities, and it has been extraordinarily reluctant to grant new banking licenses. The evidence suggests that restrictions on bank activities and entry hurt banking sector performance. Chile also grants comparatively generous deposit insurance, whereas the evidence indicates that overly generous deposit insurance augments bank fragility (Demirgüç-Kunt and Detragiache, 2002). In terms of changes over the last decade, Chile has significantly strengthened capital regulations and official supervisory power, but it has maintained a generous deposit insurance regime and tight controls on bank activities, and it has not boosted regulations that facilitate private sector monitoring of banks. In sum, these comparisons highlight areas that might deserve further attention from policy makers in Chile.

The careful reader will ask, what about stock markets? The first part of this paper motivates an inquiry into the laws, regulations, and policies underlying both markets and banks. We only study bank regulations, however, because we have detailed data on bank regulation and supervisory practices around the world (from Barth, Caprio, and Levine, 2001a, 2001c). In contrast, we do not have detailed data on stock market regulation around the world. Thus, we examine bank regulations and not stock market regulations because of data limitations, not because the data suggest that banks are more important than markets (Beck and Levine, 2002a; Levine, 2002).

We need to make two additional caveats before continuing. The paper's two parts are logically connected: the fact that stock markets and banks influence long-run growth motivates our inquiry into the regulatory determinants of well-functioning banking systems. We also show that bank regulations and supervisory practices influence bank development. However, the paper's two parts are not statistically connected. We do not estimate a structural model that traces the impact of bank regulation and supervision on bank development through to economic growth because we only have cross-country data on bank regulation and supervision in 1999.

Finally, while we use international comparisons to draw broad implications about finance and growth and to provide useful information to policymakers in Chile, our analysis has serious limitations. The broad, cross-country regressions—both the pure cross-sectional and the panel analyses—are just that: broad cross-country comparisons. We control for many variables, but we may miss key factors shaping economic performance in individual countries. There may be important omitted variables. We may not have sufficiently detailed measures of financial development. For example, we do not have information on the use of international financial markets or the special role played by Chile's private pension system. We therefore emphasize that Chile has comparatively illiquid markets, tight regulatory restrictions on bank activities and bank entry, generous deposit insurance, and weak rules encouraging private sector monitoring. We also emphasize that these features tend to be associated with suboptimal performance in a broad cross-section of countries. One should not recommend policy reforms in Chile based on these observations alone, but the observations do highlight specific regulatory and supervisory areas that might benefit from additional attention in Chile.

1. Stock Markets, Banks, and Economic Growth

This section discusses existing theoretical and empirical work and presents new evidence on the connections among stock markets, banks, and economic growth. We also examine how Chile compares internationally in terms of the relationship between these factors.

1.1 Theory

Theory provides conflicting predictions about the impact of overall financial development on growth and about the separate effects of stock markets and banks. Many models emphasize that well-functioning financial intermediaries and markets ameliorate information and transactions costs and thereby foster efficient resource allocation and faster long-run growth (Bencivenga and Smith, 1991; Bencivenga, Smith, and Starr, 1995; King and Levine, 1993). Similarly, financial market development may accelerate economic growth by enhancing risk diversification and thus encouraging risk-averse investors to shift toward higher-return, projects. Theory, however, also shows that financial development can hurt growth. By enhancing resource allocation and the returns to saving, financial sector development could lower saving rates through well-known income and substitution effects. Also, greater risk diversification in some models lowers precautionary savings and therefore may lower aggregate saving rates. If there are externalities associated with capital accumulation, this drop in savings could slow growth and reduce welfare. Theory thus provides ambiguous predictions about the growth effects of financial development.

Theory also generates conflicting predictions about whether stock markets and banks are substitutes or compliments and whether one is more conducive to growth than the other. For instance, Boyd and Prescott (1986) model the critical role that banks play in easing information frictions and improving resource allocation, and Stiglitz (1985) and Bhide (1993) stress that stock markets will not produce the same benefits as banks. On the other hand, some models emphasize that markets mitigate the inefficient monopoly power exercised by banks and that the competitive nature of markets encourages innovative, growth-enhancing activities as opposed to the excessively conservative approach taken by banks (Allen and Gale, 2000). Finally, some theories stress that the central issue is not banks or markets, but banks *and* markets: these different components of the financial system ameliorate different information and transaction costs.[1]

1.2 New Evidence on Stock Markets, Banks, and Economic Growth

Given the differing theoretical predictions about the impact of stock markets and banks on economic growth, this section evaluates the debate empirically. To assess the relationship between stock market development, bank development and economic growth in a panel, we use two econometric methods.

First, we use a standard, pure cross-country growth regression:

$$g_i = \alpha y_{i0} + \beta' X_i + \varepsilon_i \, , \tag{1}$$

where, g_i is real per capita GDP growth over the period 1975–1998 for country i, y_{i0} is the logarithm of initial real per capita GDP in 1975 for country i, X_i represents additional explanatory variables averaged over the period 1975–1998 for country i (including stock market development and bank development), and e is the error term.

The problems associated with the standard cross-country growth regression are well known. There may be omitted country-specific factors that induce omitted variable bias. Standard regressions do not control for endogeneity, which may cause simultaneity bias, and cross-country regressions do not exploit the time-series dimension of the data. Nevertheless, simple cross-country regressions provide a simple benchmark. Moreover, theory focuses on long-run growth, which implies using low-frequency data. Researchers, however, typically correct for statistical problems with standard cross-country growth regressions by moving to higher-frequency data that may not conform as closely to theory.

Second, we use panel econometric methods to confront potential biases inherent in the pure cross-sectional estimator. Consider a general panel growth regression:

$$y_{it} - y_{it-1} = \alpha y_{it-1} + \beta' X_{it} + \eta_i + \varepsilon_{it} \, , \tag{2}$$

1. See, Levine (1997); Boyd and Smith (1996); Huybens and Smith (1999); Demirgüç-Kunt and Levine (2001).

where y is the logarithm of real per capita GDP, X represents the set of explanatory variables other than lagged per capita GDP and including our indicators of stock market and bank development, η is an unobserved country-specific effect, ε is the error term, and the subscripts i and t represent country and time period, respectively. Time dummies are included in the regression, but omitted from the presentation.

Arellano and Bond (1991) propose differencing equation 2 to eliminate the country specific component:

$$\begin{aligned}(y_{it} - y_{it-1}) - (y_{it-1} - y_{it-2}) &= \alpha\left(y_{it-1} - y_{it-2}\right) \\ &\quad + \beta'\left(X_{it} - X_{it-1}\right) + \left(\varepsilon_{it} - \varepsilon_{it-1}\right).\end{aligned} \tag{3}$$

This, however, introduces a new bias. The new error term, $e_{it} - e_{it-1}$, is correlated with the lagged dependent variable, $y_{it-1} - y_{it-2}$. Under the assumptions that (a) the error term, e, is not serially correlated and (b) the explanatory variables, X, are uncorrelated with future realizations of the error term, Arellano and Bond (1991) propose a two-step generalized method of moments (GMM) estimator. In the first step, the error terms are assumed to be independent and homoskedastic across countries and time. In the second step, the residuals obtained in the first step are used to construct a consistent estimate of the variance-covariance matrix, thus relaxing the assumptions of independence and homoskedasticity. The two-step estimator is therefore asymptotically more efficient relative to the first-step estimator.

Rousseau and Wachtel (2000) use this difference estimator and annual data to study the relationship between stock markets, banks, and economic growth. This difference estimator has three main shortcomings, however. First, it eliminates the cross-country relationship between financial development and growth. Second, weak instruments can produce biased coefficients in small samples. Finally, differencing may exacerbate the bias resulting from measurement errors in variables (Griliches and Hausman, 1986).

We reduce these shortcomings by using an estimator that combines the regression in differences and the regression in levels in one system (Arellano and Bover, 1995; Blundell and Bond, 1998). The instruments for the regression in differences are the same as above. The instruments for the regression in levels are the lagged differences of the corresponding variables. We employ the system panel estimator to generate more consistent and efficient parameter estimates than in Rousseau and Wachtel (2000).[2]

The consistency of the GMM estimator depends on the validity of the assumption that the error terms do not exhibit serial correlation, as well as on the validity of the instruments. We use two specification tests to address these issues. The first is a Sargan test of overidentifying restrictions, which tests the overall validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation process. The second test examines the hypothesis that the error term, e_{it}, is not serially correlated. Failure to reject the null hypotheses of both tests gives support to our model.

Data

We analyze the link between stock markets, banks, and economic growth. The cross-country regressions use up to fifty-four countries. For the panel, data are averaged over five five-year periods between 1976 and 1998, data permitting.[3] The panel analyses are based on forty

2. Both the difference and the system estimator present certain problems when applied to samples with a small number of cross-sectional units. As shown by Arellano and Bond (1991) and Blundell and Bond (1998), the asymptotic standard errors for the two-step estimators are biased downwards. The one-step estimator, however, is asymptotically inefficient relative to the two-step estimator, even in the case of homoskedastic error terms. Thus while the coefficient estimates of the two-step estimator are asymptotically more efficient, the asymptotic inference from the one-step standard errors might be more reliable. This problem is exacerbated when the number of instruments is equal to or larger than the number of cross-sectional units. This biases both the standard errors and the Sargan test downwards and might result in biased asymptotic inference. Consequently, we use an alternative specification of the instruments employed in the two-step system estimator. Researchers typically treat the moment conditions as applying to a particular time period. This provides for a more flexible variance-covariance structure of the moment conditions because the variance for a given moment condition is not assumed to be the same across time. This approach has the drawback that the number of overidentifying conditions increases dramatically as the number of time periods increases and tends to induce overfitting and potentially biased standard errors. To limit the number of overidentifying conditions, we follow Calderón, Chong, and Loayza (2000) and apply each moment condition to all available periods. This reduces the overfitting bias of the two-step estimator. However, applying this modified estimator reduces the number of periods in our sample by one. While in the standard DPD estimator time dummies and the constant are used as instruments for the second period, this modified estimator does not allow the use of the first and second period. While losing a period, the Calderón, Chong, and Loayza (2000) specification reduces the overfitting bias and therefore permits the use of a heteroskedasticity-consistent system estimator.

3. The first period thus covers the years 1976–1980, the second period covers the years 1981–1985, and so on. The last period only comprises the years 1996–1998. Financial data are from Beck, Demirgüç-Kunt and Levine (2001).

countries and 106 observations. The difference in the number of countries included in the cross-country and panel investigations arises because in the cross-section analysis we require countries to have a minimum of thirteen observations, whereas for the panel, we require that countries have observations for a minimum of four out of the five panels. The theories we are evaluating focus on the long-run relationships between stock markets, banks, and economic growth. We thus use five-year averages rather than annual data to focus on longer-term relationships (Rousseau and Wachtel, 2000).

To measure stock market development, we use the turnover ratio measure of market liquidity, which equals the value of the shares traded on domestic exchanges divided by total value of listed shares. It indicates the trading volume of the stock market relative to its size. Some models predict that countries with illiquid markets will create disincentives to long-run investments, because it is comparatively difficult to sell one's stake in the firm. In contrast, more liquid stock markets reduce disincentives to long-run investment, since liquid markets provide a ready exit-option for investors. This can foster more efficient resource allocation and faster growth (Levine, 1991; Bencivenga, Smith, and Starr, 1995).

We also experiment with market capitalization, which equals the value of listed shares divided by GDP. The main shortcoming of this variable is that theory does not suggest that the mere listing of shares will influence resource allocation and growth. Levine and Zervos (1998) show that market capitalization is not a good predictor of economic growth. Our results confirm this finding.[4]

To measure bank development, we use bank credit, which equals bank claims on the private sector by deposit money banks divided by GDP. This measure isolates loans given by deposit money banks to the private sector. It excludes loans issued to governments and public enterprises.[5]

We assess the strength of the independent link between both stock markets and economic growth and bank development and

4. We also experimented with VALUE TRADED, which equals the value of the trades of domestic shares on domestic exchanges divided by GDP. VALUE TRADED has two potential pitfalls. First, it does not measure the liquidity of the market, but trading relative to the size of the economy. Second, since markets are forward looking, they will anticipate higher economic growth by higher share prices. Since VALUE TRADED is the product of quantity and price, this indicator can rise without an increase in the number of transactions. TURNOVER RATIO does not suffer from this shortcoming, since both numerator and denominator contain the price.

5. This is the same indicator of bank development used by Levine and Zervos (1998).

Table 1. Financial Development and Growth Data, 1975–1998

Country	*Bank credit*	*Turnover ratio*	*Market capitalization*	*Per capita growth (in percent)*
Argentina	0.16	0.33	0.07	0.96
Australia	0.48	0.32	0.61	1.75
Austria	0.82	0.41	0.08	2.16
Bangladesh	0.17	0.11	0.02	2.49
Belgium	0.44	0.14	0.30	1.89
Brazil	0.17	0.54	0.14	1.13
Canada	0.49	0.36	0.50	1.45
Chile	0.42	0.07	0.51	4.20
Colombia	0.14	0.09	0.09	1.74
Costa Rica	0.17	0.01	0.06	0.93
Côte d'Ivoire	0.32	0.03	0.06	–0.61
Denmark	0.39	0.25	0.25	2.21
Egypt	0.25	0.12	0.09	3.43
Finland	0.61	0.29	0.29	2.25
France	0.78	0.38	0.23	1.76
Germany	0.93	0.87	0.21	1.98
Greece	0.23	0.23	0.13	1.79
Hong Kong	1.36	0.39	1.42	4.20
India	0.22	0.48	0.15	3.05
Indonesia	0.29	0.27	0.09	3.45
Israel	0.53	0.52	0.36	1.63
Italy	0.55	0.38	0.14	2.05
Jamaica	0.23	0.08	0.26	–0.85
Japan	1.03	0.48	0.65	2.35
Jordan	0.55	0.13	0.54	1.36
Kenya	0.22	0.03	0.14	0.42
Korea	0.46	1.01	0.23	5.51

growth by controlling for other growth determinants. We include the logarithm of initial real per capita GDP (initial income) to control for convergence and the logarithm of initial average years of schooling to control for human capital accumulation. We also control for the black market premium; the share of exports plus imports to GDP (trade); the inflation rate; and the ratio of government expenditures to GDP.

Table 1 presents data on financial development and growth over the period 1975–98. Bank and stock market development vary widely across the sample. While Taiwan had a turnover ratio of 232 percent of GDP over the 1975–98 period, the corresponding ration in Nigeria was only 1 percent of GDP. Switzerland's banks lent 141 percent of GDP to

Table 1. (continued)

Country	Bank credit	Turnover ratio	Market capitalization	Per capita growth (in percent)
Malaysia	0.59	0.32	1.21	3.76
Mauritius	0.23	0.10	0.11	1.80
Mexico	0.14	0.47	0.17	1.23
Netherlands	0.77	0.46	0.53	1.89
New Zealand	0.47	0.24	0.56	0.68
Nigeria	0.11	0.01	0.05	–0.61
Norway	0.48	0.46	0.21	2.88
Pakistan	0.23	0.34	0.09	2.55
Peru	0.09	0.20	0.10	–0.12
Philippines	0.28	0.28	0.28	0.56
Portugal	0.69	0.28	0.11	2.93
Singapore	0.79	0.38	1.27	5.15
South Africa	0.51	0.08	1.25	–0.60
Spain	0.78	0.52	0.24	2.02
Sri Lanka	0.19	0.10	0.13	3.28
Sweden	0.42	0.35	0.47	1.23
Switzerland	1.41	1.64	0.89	0.95
Taiwan	0.83	2.32	0.42	6.14
Thailand	0.59	0.70	0.26	5.05
Trinidad and Tobago	0.28	0.08	0.18	1.40
Tunisia	0.50	0.07	0.10	2.36
Turkey	0.14	0.65	0.08	2.65
United Kingdom	0.75	0.38	0.84	1.98
United States	0.64	0.61	0.69	1.85
Uruguay	0.29	0.04	0.01	1.75
Venezuela	0.20	0.13	0.08	–0.86
Zimbabwe	0.15	0.07	0.18	0.15

the private sector over the 1975–1998 period, whereas Peru's banks lent only 9 percent of GDP. Similarly, Chile and the Asian Tigers (Hong Kong, Korea, Singapore, Taiwan, and Thailand) enjoyed greater than 4 percent per capita growth on an average annual basis over the 1975–1998 period, while many countries experienced negative growth. Table 1 also indicates that Chile, like South Africa, is a country with a large stock market (as measured by market capitalization) but an illiquid market (as measured by turnover ratio).[6]

6. Low turnover in Chile's equity market may reflect many factors besides legal, tax, and regulatory impediments to active share trading. These include concentrated ownership, a large role for the private pension funds that do not trade actively, and the use of American depository receipts (ADRs) by large Chilean corporations.

Table 2. Growth and Financial Market Variables[a]

	Full sample		*Sample excluding outliers[b]*	
Regressor	*(1)*	*(2)*	*(3)*	*(4)*
Constant	0.0361	0.0374	0.0335	0.0401
	(0.012)	(0.024)	(0.011)	(0.012)
Initial income[c]	–0.0049	–0.0058	–0.0073	–0.0069
	(0.030)	(0.022)	(0.002)	(0.019)
Schooling[c]	0.0044	0.0072	0.0095	0.0072
	(0.450)	(0.284)	(0.077)	(0.285)
Trade[d]	0.0001	0.0001	0.0001	0.00003
	(0.000)	(0.048)	(0.000)	(0.162)
Black market premium[d]	–0.0001	–0.0002	–0.0001	–0.0002
	(0.030)	(0.015)	(0.051)	(0.013)
Government spending[d]	–0.0007	–0.0009	–0.0006	–0.0008
	(0.020)	(0.017)	(0.027)	(0.028)
Inflation[d]	–0.0014	–0.0020	–0.0015	–0.0024
	(0.063)	(0.082)	(0.030)	(0.030)
Credit to the private sector[d]	0.0165	0.0352	0.0147	0.0318
	(0.030)	(0.001)	(0.017)	(0.001)
Turnover ratio[d]	0.0189		0.0242	
	(0.000)		(0.005)	
Market capitalization[d]		–0.0095		0.0003
		(0.273)		(0.953)
Summary statistics				
No. observations	53	54	46	53
R^2	0.6024	0.4847	0.699	0.5035

a. The dependent variable is per capita GDP growth; p values are in parenthesis below coefficients.
b. Outliers excluded from the full sample in column 3 are Chile, Denmark, Jamaica, Korea, the Phillipines, South Africa, and Taiwan. In column 4, only South Africa is excluded.
c. Initial value of the variable in logs.
d. Average value.

Cross-country results

Table 2 present pure cross-country, OLS growth regressions over the 1975–1998 period. The first regression includes the broad set of conditioning variables mentioned above, along with bank credit and the turnover ratio. The second regression is the same as the first except that it includes market capitalization instead of the turnover ratio.

The turnover ratio and bank credit are positively and significantly related to economic growth. The turnover ratio enters with a p value of less than 0.01 and bank credit with a p value of 0.03. The control variables also enter with the expected signs: initial income, government spending, inflation, and the black market premium enter with negative coefficients, while trade and schooling enter with positive coefficients.

The coefficients on the financial indicators are also economically large. For instance, a one-standard-deviation increase in turnover would increase long-run per capita growth by 0.7 percentage points per year (0.35*0.0189), which is large since average per capita growth is only 1.9 points per year in the sample. The coefficients suggest that if Chile increased its low level of turnover from 0.07 to the level existing in Thailand (0.70), then Chile have enjoy more than a full percentage point of extra per capita growth per year (0.63*0.0189). Similarly, a one-standard-deviation increase in bank credit would increase per capita growth by 0.5 percentage points per year (0.27*0.017), which is quite large given that 17 percent of the countries grew more slowly than this over the 1975–1998 period. If Chile increased its level of banking development from its average level of 0.42 to the level in Thailand (0.59), Chile's growth rate would jump about 0.3 percentage points per year (0.17*0.017), which would virtually eliminate the growth gap between Chile (0.042) and Thailand (0.050). These conceptual experiments are purely illustrative and should not be viewed as exploitable elasticities, but they do advertise the strong positive relationship between financial development and economic growth.

Consistent with Levine and Zervos (1998), we do not find a strong relationship between market capitalization and economic growth, as shown in regression 2 of table 2. While stock market liquidity (the turnover ratio) is positively and robustly associated with growth, market size is not. Banking sector development continues to enter with a positive and significant coefficient.

We focus on outliers and Chile in particular. Figure 1 provides a partial scatter plot of growth relative to turnover, which projects the multivariate regression plane of the first equation in table 2 into the two dimensional space defined by growth and turnover. As shown, some countries do not fall neatly along the regression line. In particular, Chile and Denmark have much faster growth rates than those associated with countries with low levels of stock market liquidity (after controlling for many other growth determinants). Some countries also have much slower growth rates than predicted by the regression line (namely, South Africa, Jamaica, and the Philippines). Korea and Taiwan are also outliers.

Figure 1. Growth versus Turnover: Partial Scatter Plot

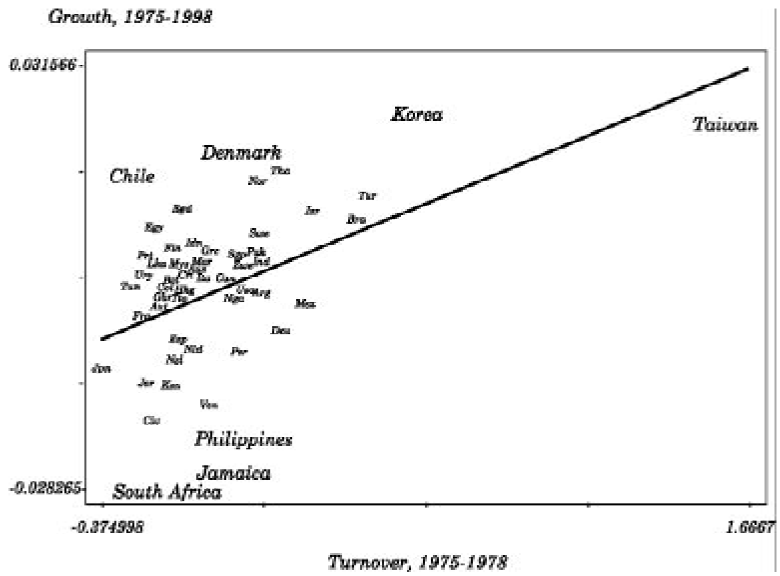
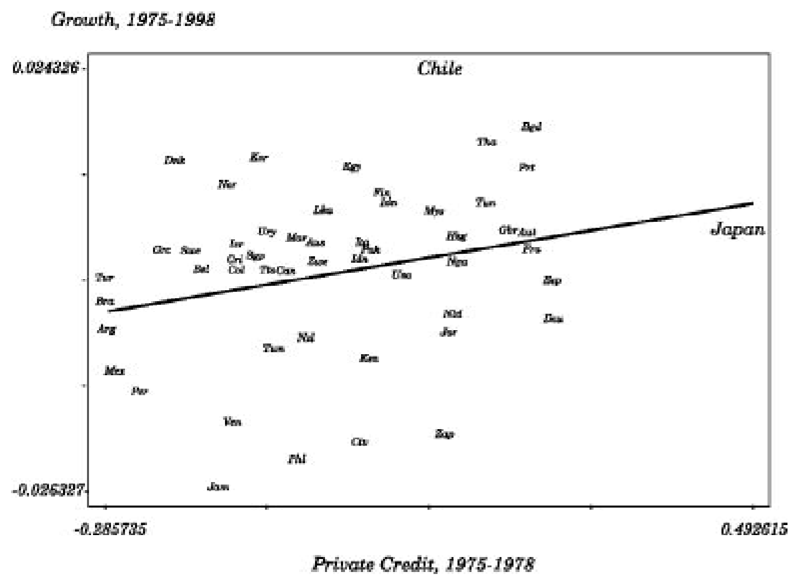


Figure 2 shows the partial scatter plot of growth relative to bank credit. Chile again enjoys faster growth than the regression line predicts. Even after controlling for many other growth determinants, Chile experienced unpredictably rapid economic growth relative to its level of banking sector development. More generally, Chile does not fit the growth regression very well. Its fitted values from the regression predict a growth rate of 1.9 percent, while its actual growth rate is 4.2 percent.

When we remove the outliers from the regression, we still get a strong positive relationship between growth and both turnover and bank credit. This is shown in the third regression of table 2. Thus, across countries, there is a strong, positive link between stock markets, banks, and economic growth even after controlling for other growth determinants and outliers.[7]

7. Note, removing outliers does not fundamentally alter the relationship between stock market size and economic growth. Namely, there is not a strong statistical relationship between stock market size and economic growth (as shown in table 2, regression 4).

Figure 2. Growth versus Private Credit: Partial Scatter Plot



Panel results

The dynamic panel results confirm that banking sector development and stock market liquidity exert a positive influence on economic growth (see table 3). These results are based on Beck and Levine (2002b). The dynamic panel results show that even after controlling for simultaneity bias, country fixed effects, and the biases induced by including lagged per capita GDP in the regression, financial development still has a robust, positive relationship with economic growth. Owing to severe data limitations, we do not simultaneously include each of the full conditioning information set in a single regression. As shown, we include the conditioning variables one at a time to demonstrate the robustness of the results.

Discussion

The results strongly suggest a positive relationship between financial development and economic growth. Even after controlling for outliers and including the initial years of the Asian financial crisis, we

Table 3. Stock Markets, Banks, and Growth: Panel GMM Estimator[a]

Regressor	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Constant	1.898	6.156	4.582	3.113	1.884
	(0.394)	(0.182)	(0.685)	(0.189)	(0.430)
Log of initial per capita income	–0.683	0.048	–0.299	–0.619	–0.723
	(0.275)	(0.945)	(0.691)	(0.249)	(0.239)
Average years of schooling[c]	–3.004	–3.738	–4.080	–3.221	–2.979
	(0.277)	(0.119)	(0.168)	(0.157)	(0.283)
Government consumption[b]		–2.581			
		(0.111)			
Trade openness[b]			–0.693		
			(0.753)		
Inflation rate[c]				–1.976	
				(0.079)	
Black market premium[c]					–0.069
					(0.966)
Bank credit[b]	2.202	1.762	2.133	1.954	2.262
	(0.001)	(0.025)	(0.048)	(0.003)	(0.001)
Turnover ratio[b]	0.993	0.944	0.736	0.950	1.058
	(0.012)	(0.064)	(0.172)	(0.008)	(0.014)
Summary statistics					
Sargan test[d] (*p* value)	0.448	0.554	0.649	0.698	0.552
Serial correlation test[e] (*p* value)	0.558	0.752	0.528	0.422	0.507
Wald test for joint significance (*p* value)	0.001	0.002	0.018	0.001	0.001
Number of countries	40	40	40	40	40
Number of observations	106	106	106	106	106

Source: Beck and Levine (2001).
a. The regressions use the Calderón, Chong and Loayza (2000) GMM estimator; .*p* values are in parentheses.
b. In the regression, this variable is included as log(variable)
c. In the regression, this variable is included as log(1 + variable)
d. The null hypothesis is that the instruments used are not correlated with the residuals.
e. The null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

continue to find that both stock market liquidity and banking sector development are positively linked to long-run growth.

Chile does not fit the regression lines very well. As noted, the predicted growth rate (1.9 percent) is less than half of the actual growth rate experienced by Chile (4.2 percent). In terms of the specific relationship between growth and finance, Chile has much lower market liquidity than other rapidly growing economies. The other control variables included in the regression do not account for the disparity between low stock market liquidity and fast growth in Chile. Chile also has average bank development but grew very rapidly. Again, the other control variables included in the regression do not account for the disparity between average bank development and superior growth. These results imply that (a) the growth process in Chile is fundamentally different from other countries, such that Chile should not be included in the analysis and the regression line should not be used to assess growth in Chile; (b) the regression omits key variables; (c) the regression is misspecified along a different dimension; or (d) Chile will need to improve bank development and stock market liquidity substantially to continue to enjoy exceptional growth in the future. We cannot unequivocally distinguish among these possibilities. Nevertheless, we do not know of convincing reasons for believing that Chile is fundamentally different. Nor do we believe that omitted variables drive the results, because we confirmed the results using an assortment of control variables and employing panel techniques that eliminate country-specific effects. The estimated regression could conceivably be severely misspecified along some important dimension, but we get remarkably similar results when using cross-country regressions over long horizons and when using panel techniques over five-year intervals.

2. Bank Regulation and Supervision

As noted in the introduction, we examine bank regulation and supervision and not stock market policies because we have access to a new dataset on bank regulation and supervision around the world (Barth, Caprio, and Levine, 2001a, 2001c), but we do not have comparable data on stock market policies. The choice is thus driven by data availability and not by an assessment that banks are more important than markets. Indeed, although Chile has a notably underdeveloped banking system relative to its rapid growth, the disparity between stock market liquidity and growth is much more notable. Another motivation for our focus on bank regulation, as emphasized in the introduction, is that banks are crucial to economic growth. Thus, this section's examination of bank regulation and supervision is logically connected to the last section's study of banks, markets, and economic growth. We do not, however, link the two sections statistically.

2.1 Data and Issues

This subsection briefly reviews the major theoretical and policy debates surrounding key issues in the regulation and supervision of commercial banks. We also describe the data. All of the data are taken from Barth, Caprio, and Levine (2001a, 2001c). Those two papers discuss the data in detail and also provide a more complete description of the theoretical and policy debates. This paper differs from the analyses undertaken in Barth, Caprio, and Levine (2001a, 2001c) in that we focus on comparing Chile with other countries.

Bank activity regulatory variables

Researchers and policy makers disagree about the efficacy of imposing regulatory restrictions on the activities of banks. Many argue that restricting banks from engaging in securities, insurance, and real estate activities and limiting their ability to own nonfinancial firms reduces conflicts of interest, constrains the banks' ability to assume excessive risk, and keeps financial intermediaries from becoming too large to supervise. On the other hand, others hold that permitting banks to engage in a wide assortment of activities allows them to exploit economies of scale and scope and thereby provide more effective financial services.

Barth, Caprio, and Levine (2001a, 2001c) measure the degree to which the national regulatory authorities in the sample countries allow banks to engage in the following activities. Countries receive a value between 1 and 4, where 1 means the activity is allowed within the bank, 2 means it is allowed within a subsidiary, 3 means there are regulatory restrictions on the activity, and 4 means it is prohibited.

Securities activities: the ability of banks to engage in the business of securities underwriting, brokering, and dealing, as well as all aspects of the mutual fund industry.

Insurance activities: the ability of banks to engage in insurance underwriting and selling.

Real estate activities: the ability of banks to engage in real estate investment, development, and management.

Bank ownership of nonfinancial firms: the ability of banks to own and control nonfinancial firms.

Restrictions on bank activities: total restrictions, including restrictions on securities, insurance, and real estate activities plus restrictions on the ability of banks to own and control nonfinancial firms. This variable is constructed by adding the values of the first four variables.

Competition regulatory variables

Economic theory provides conflicting views on the need for and the effects of regulations on entry into the banking sector. A Pigouvian view holds that governments overcome information problems, screen out bad banks, and thereby reduce contagious and socially harmful bank failures. Also, banks with some monopolistic power may possess considerable franchise value that enhances prudent risk-taking behavior. Alternatively, some authors argue that while there may exist valid economic reasons for regulating entry, politicians and regulators often use entry restrictions to reward friendly constituents, extract campaign support, and collect bribes (Shleifer and Vishny, 1993). Furthermore, an open, competitive banking sector may be less likely than a restricted one to produce powerful institutions that unduly influence policymakers in ways that adversely affect bank performance and stability.

We use two of the Barth, Caprio, and Levine (2001a, 2001c) measures of regulatory impediments to the entry of foreign and domestic banks.

Requirements for entry into banking: a measure of the specific legal requirements for obtaining a license to operate as a bank. These might be prudent requirements or excessive regulatory barriers, so their effects remain an empirical issue.

Fraction of entry applications denied: a measure of the fraction of applications denied, subdivided into foreign denials (the fraction of foreign applications denied) and domestic denials (the fraction of domestic applications denied).

Capital regulations

Bank regulators and supervisors frequently focus on capital regulations. Capital, or net worth, serves as a buffer against losses. In addition, with limited liability, greater capital reduces the incentives for bank owners to shift toward more risky activities. With deposit insurance (whether implicit or explicit), higher levels of capital may help align bank owners' incentives with those of depositors and other creditors. Researchers, however, disagree on whether the imposition of capital requirements actually reduces risk taking. Many doubt whether the capital standards set by regulators and supervisors mimic those that would be demanded by well-informed, private-market participants. Many hold that official capital requirements frequently increase risk-taking behavior. Theory thus provides conflicting predictions on whether capital requirements curtail or promote bank performance and stability.

We use the Barth, Caprio, and Levine (2001c) index of overall capital stringency to measure each country's policy toward capital regulations.

Capital regulatory index: measures the extent of regulatory requirements regarding the amount of capital that banks must have relative to specific guidelines, the extent to which the source of funds that count as regulatory capital can include assets other than cash or government securities and borrowed funds, and whether the sources of capital are verified by the regulatory or supervisory authorities. The index ranges in value from 0 to 9, with a higher value indicating greater stringency.

Official supervisory action variables

Many view supervisory power as critically important for developing a sound regulatory and supervisory regime. The line of reasoning is as follows. Depositors frequently have neither the ability nor the incentives to monitor banks, while banks are prone to contagious and socially costly bank runs stemming from informational asymmetries. Official supervisors can ameliorate these market failures and thereby improve bank performance and stability.

Others, however, emphasize the negative implications of powerful government regulators and supervisors. Powerful supervisory agencies may use this power to benefit favored constituents and extract bribes. Powerful supervision and regulation may thus boost corruption without improving either bank performance or stability.

Official supervisory power: measures the extent to which official supervisory agencies have the authority to take specific actions to prevent and correct problems. The measure includes information on the ability of the supervisory agency to meet with external auditors; take legal action against auditors; force banks to change their internal organizational structure; force banks to constitute provisions; suspend dividends, bonuses, and management fees; declare a bank insolvent; and remove and replace management and directors. It ranges in value from 0 to 14, with higher values signifying greater official supervisory power.

Private monitoring variables

Many countries promote private monitoring of banks. They do this by requiring banks to obtain certified audits or ratings (or both) from international rating agencies, by making bank directors legally liable if information is erroneous or misleading, or by compelling banks to produce accurate, comprehensive, and consolidated information on the full range of bank activities and risk-management procedures. Some analysts, however, question placing excessive trust in private sector monitoring, especially in countries with poorly developed capital markets, accounting standards, and legal systems. According to this perspective, countries with weak institutions may benefit more from official supervision and regulation than from increased reliance on private sector monitoring.

We use a variety of measures to gauge the degree to which regulations encourage private sector monitoring of banks.

Required certified audit: captures whether an outside licensed audit is required of the financial statements issued by a bank. Such an audit would presumably indicate the presence or absence of an independent assessment of the accuracy of financial information released to the public.

Rating of ten biggest banks by international rating agencies: the percentage of the top ten banks that are rated by international credit-rating agencies. The greater the percentage, the more the public may be aware of the overall condition of the banking industry as viewed by an independent third party.

No explicit deposit insurance scheme: takes a value of 1 if there is an explicit deposit insurance scheme, and 0 otherwise. A lower value would indicate more private monitoring.

Bank accounting: takes a value of 1 when the income statement includes accrued or unpaid interest or principal on nonperforming loans and when banks are required to produce consolidated financial statements.

Private monitoring index: includes the four preceding variables, as well as three other measures are included in the index based. In the case of the percent of ten biggest banks that are rated by international rating agencies, the index equals 1 if the percentage is 100; 0 otherwise.

Deposit insurance scheme variables

The pros and cons of deposit insurance have been debated for a century. Countries often adopt deposit insurance schemes to provide protection for unsophisticated and small depositors. Also, deposit insurance prevents—or at least restrains—poorly informed depositors from withdrawing their funds all at once from an illiquid but solvent bank. Potential gains from a deposit insurance scheme come at a cost, however. Deposit insurance encourages excessive risk taking since depositors have fewer incentives to monitor bank managers.

Moral hazard index: based on Demirgüç-Kunt and Detragiache (2002), who use principal components to capture the presence and design features of deposit insurance systems. We use their overall index of deposit insurance generosity, which is composed of nine specific components. Here, we list the specific components, summarize the Demirgüç-Kunt and Detragiache (2002) findings, and note Chile's policies according to each component.

(a) They find that countries with explicit deposit insurance tend to create greater moral hazard than countries with no deposit insurance or those with implicit insurance regimes. (Chile is explicit.)

(b) They find that coinsurance—in which depositors face a deductible on their deposits—limits the generosity of the deposit insurance regime and the extent of moral hazard. (Chile has some coinsurance.)

(c) They find that the extent of deposit insurance coverage—as measured by the coverage limit divided by per capita bank deposits—is positively associated with moral hazard. (Chile fully covers demand deposits.)

(d) They find that the coverage of foreign currency deposits increases moral hazard. (Chile covers foreign currency deposits.)

(e) They find that the coverage of interbank loans increases moral hazard. (Chile does not cover interbank deposits.)

(f) They find that fully funded schemes are more prone to moral hazard problems than partially funded or unfunded deposit insurance schemes. (Chile's system is not funded.)

(g) They find that government-funded deposit insurance schemes are associated with greater moral hazard than bank-funded schemes. (Chile's deposit insurance system is funded by the government.)

(h) They find that deposit protection systems managed by banks limit moral hazard to a greater extent than deposit insurance regimes managed by the government. (Chile's system is managed by the government.)

(i) They find that compulsory membership tends to reduce adverse selection, so compulsory systems reduce moral hazard to a greater extent than voluntary systems. (Membership in the deposit insurance program is compulsory in Chile.)

2.2 Past Results on Regulation, Supervision, and Bank Performance

Barth, Caprio, and Levine (2001c) document the links between bank regulatory and supervisory systems and banking sector performance. Their major findings can be summarized as follows:

Government corruption is positively associated with powerful official supervisory agencies, restrictions on bank activities, and tight entry restrictions, but it is negatively associated with regulations that promote private sector monitoring.

Bank development is negatively associated with restrictions on bank activities and tight entry restrictions; but it is positively associated with regulations that promote private sector monitoring.

Generous deposit insurance is positively associated with bank fragility.

Capital regulations, restrictions on bank activities, and powerful official supervision do not mitigate the destabilizing effects of generous deposit insurance.

These results are summarized in table 4, which presents regressions on the link between bank regulations and supervisory practices, on the one hand, and bank development, efficiency, and fragility, on the other. The regression results are based on Barth, Caprio, and Levine (2001c), who also conduct a battery of sensitivity checks, control for many other explanatory variables, examine the potential impact of outliers, and use instrumental variables to control for potential simultaneity bias. The first regression shows that countries with regulations and supervisory practices that promote private sector monitoring of banks and permit banks to engage in a variety of financial activities tend to have better-developed banks than countries that restrict bank activities and do not implement regulations and supervisory practices that encourage private sector monitoring of banks. The second regression examines interest margins, the differences between bank interest income and interest expense. The results indicate that barriers to entry, insufficient regulations that promote private monitoring, and regulatory restrictions on bank activities tend to be associated with higher bank interest income margins. Finally, the last regression examines the impact of regulations and supervisory practices on bank fragility. The dependent variable in regression three is a one-zero variable indicating whether the country experienced a systemic crisis.[8] We run a logit regression to assess the relationship between policies and bank fragility. The results indicate that countries with more generous deposit insurance, which is reflected in a larger moral hazard index, have a higher probability of suffering a systemic banking crisis. Also, banks in countries that restrict bank activities—so that banks are unable to diversify their income streams—have a higher probability of failing. The sample in the third regression is small because there is little country coverage on the data used to generate the moral hazard index. These regression results confirm the summary given above of the Barth, Caprio, and Levine (2001c) regressions.

8. See Barth, Caprio, and Levine (2001c) for details.

Table 4. Bank Regulation, Supervisory Practices, and Bank Performance[a]

	Dependent variable		
Regressor	*Bank credit*	*Interest margin*[b]	*Major crisis*[c]
Constant	0.596 (0.147)	0.019 (0.466)	–8.686 (0.040)
Private monitoring index	0.088 (0.002)	–0.005 (0.010)	0.485 (0.159)
Restrictions on bank activities index	–0.048 (0.015)	0.003 (0.045)	0.608 (0.002)
Entry into banking requirements	–0.008 (0.837)	0.004 (0.031)	0.276 (0.241)
Capital regulatory index	–0.005 (0.823)	–0.001 (0.793)	–0.468 (0.114)
Official supervisory power	–0.009 (0.498)	0.001 (0.588)	0.091 (0.566)
Moral hazard index			0.817 (0.000)
Summary statistics			
No. observations	76	75	48
R^2	0.27	0.19	0.39

a. The major crisis regression is estimated using a probit regression. The *R* squared statistic is the McFadden *R* squared statistic for logit regressions; *p* values in parenthesis below coefficients.
b. Interest margin equals interest income less income expense computed from bank level data (Barth, Caprio, Levine, 2001b).
c. Major crisis is a binary variable that indicates whether the country has experienced a systematic banking crisis.

The results raise concerns about the efficacy of a regulatory strategy that relies excessively on powerful official oversight of banks and tight capital regulations. Unfortunately, this is the approach currently being advocated by major international financial institutions. Indeed, the Barth Caprio, and Levine (2001c) results suggest that increasing the power of regulatory agencies tends to be most corrupting in countries with relatively closed political systems. Since developing countries tend to have more closed political systems than developed economies, the international financial institutions may be pushing client countries to adopt exactly the wrong approach to commercial bank regulation and supervision.

The Barth, Caprio, and Levine (2001c) results instead suggest that forcing information disclosure, empowering private sector monitoring of banks, and reducing the generosity of deposit insurance schemes to ease the moral hazard problem will foster improvements in bank performance and stability. These findings do not negate the importance of official supervision and regulation. Rather, the results stress that private sector monitoring of banks is positively and strongly linked with bank performance.

2.3 Chile: Past and Present

Given these findings, we now examine Chile's bank regulatory and supervisory system in an international context. Although we are not able to include many details and subtleties associated with bank regulation and supervision in Chile and other countries, we can place Chile in a broad international context and compare bank regulatory and supervisory strategies around the world.

Table 5 presents data on bank regulation and supervision in Chile, as well as in samples of all countries, upper-middle-income countries, and Latin American countries. This allows us to compare Chile with different groups of countries. We present data for Chile in 1999 and for the period 1987–1990 to trace changes in commercial bank regulation and supervision in Chile over the last decade.[9]

Chile has comparatively tight restrictions on bank activities. The overall restriction index is 12 in Chile in 1999, compared with 9.8, on average, both across all countries and among other upper-middle-income countries and 10.1, on average, in Latin America. Furthermore, this aggregate index of regulatory restrictions on bank activities has not changed much in Chile over the last decade. As Budnevich (2000, p. 13) explains, the 1997 reform to the banking law expanded the set of activities that banks can legally perform. This change, however, was not significant enough to alter the aggregate index of restrictions on bank activities constructed by Barth, Caprio and Levine (2001a). As noted above, Barth, Caprio, and Levine (2001c) find that countries with relatively tight restrictions on bank activities tend to have higher levels of government corruption, lower levels of bank performance, and greater bank fragility than countries with fewer restrictions on bank activities.

9. For an excellent review of Chile's banking system performance and the impact of the banking system on the macroeconomy since the banking crisis of the 1980s, see Valdés (1992).

Table 5. Information on Bank Structural, Regulatory, Supervisory, and Deposit Insurance Variables: Group Averages[a]

						Correlation		
Variable	*Chile 1999*	*Chile 1987–1990*	*All countries*	*Upper middle income*	*Latin America*	*Financial development*	*Corruption*	*GDP/capita*
Bank activity regulatory variables								
Securities activities	2.00	2.00	1.80	2.06	2.25	–0.3566*	–0.3446*	–0.2690*
Insurance activities	3.00	4.00	2.75	2.50	2.33	–0.3764*	–0.3407*	–0.4551*
Real estate activities	4.00	4.00	2.80	2.89	2.92	–0.3377*	–0.5331*	–0.4595*
Bank ownership of nonfinancial firms	3.00	3.00	2.43	2.39	2.58	–0.0857	–0.3769*	–0.1507
Restrictions on bank activities index	12.00	13.00	9.77	9.83	10.08	–0.4185*	–0.5637*	–0.4890*
Competition regulatory variables								
Requirements for entry into banking	3.00	n.a.	7.29	7.17	7.23	–0.0997	–0.1117	–0.0548
Number of new banks generated	0.00	n.a.	28.59	5.69	5.91	0.0430	0.1715	0.2333
New domestic banks generated	0.00	n.a.	22.34	2.62	3.09	0.0064	0.1391	0.1982
New foreign banks generated	0.00	n.a.	5.52	3.08	2.82	0.4453*	0.3902*	0.3711*
No entry applications	1.00	n.a.	0.08	0.23	0.17	0.1600	–0.1010	0.0693
No domestic applications	1.00	n.a.	0.21	0.29	0.25	0.1873	–0.0370	0.1778
No foreign applications	1.00	n.a.	0.25	0.38	0.33	–0.0200	–0.2034	–0.1111
Fraction of entry applications denied	n.a.	n.a.	0.22	0.11	0.13	–0.2120	–0.4815*	–0.4672*
Domestic denials	n.a.	n.a.	0.19	0.14	0.11	–0.0826	–0.3637*	–0.1836
Foreign denials	n.a.	n.a.	0.20	0.05	0.10	–0.3416*	–0.4570*	–0.5994*
Capital regulatory variables								
Capital regulatory index	5.00	2.00	5.54	5.39	5.38	0.0337	0.0759	0.0494

Table 5. (continued)

						Correlation		
Variable	*Chile 1999*	*Chile 1987–1990*	*All countries*	*Upper middle income*	*Latin America*	*Financial development*	*Corruption*	*GDP/capita*
Official supervisory action indices								
Official supervisory power	10.00	8.00	10.11	11.11	10.85	–0.0782	–0.3056*	–0.1875
Prompt corrective action	3.00	3.00	2.24	3.28	2.23	–0.2355*	–0.2644	–0.1481
Restructuring power	3.00	1.00	2.55	2.67	2.92	0.0111	–0.3024*	–0.1390
Declaring insolvency power	2.00	2.00	1.52	1.72	1.77	–0.1112	–0.2245	–0.2246
Private monitoring variables								
Ten biggest banks rated by international) rating agencies (yes = 1, no = 0	0.00	n.a.	0.26	0.33	0.15	0.3172*	0.3541*	0.3603*
Accounting disclosure and director liability	3.00	3.00	2.51	2.83	2.69	0.0806	–0.0032	0.2270
Private monitoring index	6.00	6.00	5.88	6.11	5.62	0.4242*	0.3943*	0.4454*
Deposit insurance scheme variables								
Moral hazard index	2.20	2.20	–0.04	1.46	–0.16	0.0711	0.1118	0.2547
Market structure indicators								
Bank concentration	0.59	0.51	0.66	0.61	0.60	–0.2968*	0.0747	–0.2144
Foreign bank ownership	0.32	0.27	0.25	0.27	0.26	–0.1818	–0.0351	–0.2072
Government-owned banks	0.12	0.19	0.22	0.18	0.17	–0.3063*	–0.4130*	–0.4965*

a. The sample includes countries with population above one million and excludes Persian Gulf oil-producing countries.

In terms of openness to competition, Chile has a comparatively low number of official entry requirements, but no new banks have been established. While the average number of new banks in 1999 was about six both in Latin America and among upper-middle income countries around the world, Chile had zero new banks. Foreign banks were allowed to enter Chile, but they had to purchase a domestic bank to do so; they could not simply apply and receive a new banking license. This situation is changing in Chile following the 1997 reform to the banking law. The 1997 reform specifies a series of objectives and prerequisites for domestic and foreign bank entry (Budnevich, 2000, p.12). These reforms should make the banking system more transparent and possibly more competitive. Barth, Caprio, and Levine (2001c) show that restrictions on foreign bank entry are positively associated with the likelihood of suffering a major banking crisis.

In terms of capital regulations and official supervisory power, Chile has tightened its regulations considerably over the last decade. Whereas the capital regulatory index was 2 in 1990, it rose to 5 in 1999. The official supervisory power index also rose in Chile, from 8 to 10. Chile is now almost equal to comparison countries with regard to capital regulations and official supervisory power,. As emphasized above, excessive reliance on official supervision tends to go hand-in-hand with higher levels of corruption and with no corresponding improvement in bank performance or stability (Barth, Caprio, and Levine, 2001c).

Chile is about average in terms of regulations that promote private sector monitoring, and its value has remained constant over the last decade at 6. The average across all countries is 5.9, and it is 6.1 for upper-middle-income countries. Chile has notably strong bank accounting standards. Specifically, accrued, but unpaid interest and principal do not enter the income statement; financial institutions must produce consolidated accounts covering all bank and nonbank activities; and bank directors are legally liable if disclosed information is erroneous or misleading. Barth, Caprio, and Levine (2001c) show, however, that countries that adopt regulations that foster private sector monitoring enjoy higher levels of banking sector development than countries that do not stress private sector monitoring. As Chile searches for policy reforms that will foster continued economic success over the next decade, enhanced regulations that promote private sector monitoring of banks may thus offer an opportunity for some small improvement. For instance, only 50 percent of

Chile's top ten banks were rated by international credit rating agencies in 1999, whereas the figure was 100 percent in Argentina and Brazil.[10] Also, banks do not have to disclose their risk-management procedures to the public, while other national regulatory agencies do force their banks to make this information public.

Finally, Chile has a generous deposit insurance program. The Demirgüç-Kunt and Detragiache (2002) index of deposit insurance generosity rates Chile at 2.2.[11] There are countries with more generous schemes (indicated by a higher value in the index). Mexico is most generous with an index of 4.0, and the United States has a generosity index of 3.3. Nevertheless, out of the fifty-two countries for which Demirgüç-Kunt and Detragiache compute the index, Chile ranks thirty-sixth. Demirgüç-Kunt and Detragiache (2002) show that higher levels of deposit insurance generosity positively predict systemic banking crises, a finding that is consistent with the result reported above that. more generous deposit insurance creating more intense moral hazard problems. Chile's level of deposit insurance generosity has not changed since the 1987–1990 period.

2.4 Discussion

Three points are worth emphasizing. First, Barth, Caprio, and Levine (2001c) identify key aspects of bank regulation and supervision that work—and don't work—around the world. Specifically, they find that bank development and efficiency are negatively associated with restrictions on bank activities and tight bank entry requirements, but positively associated with regulations that promote private sector monitoring. They also find that generous deposit insurance is negatively associated with bank stability. Second, when we compare key characteristics of Chile's regulatory and supervisory regime with the Barth, Caprio, and Levine (2001a,b) data and results, we find that Chile has comparatively tight restrictions on bank activities, tight restrictions on bank entry, weak regulations for promoting private sector monitoring, and generous deposit insurance. Policymakers in Chile may thus wish to take a close look at policies regarding restrictions on activities, restrictions on entry, regulations that encourage private monitoring of banks, and the generosity of the deposit insurance regime. Third, these cross-country comparisons alone should

10. Although in 1989 Chile required private risk assessments of banks (Leyes de Valores y de Bancos), credit rating agencies merely copied the risk assessments of the Superintendcia de Bancos (Valdés-Prieto, 1992, p. 440–1).

11. See Budnevich (2000) for a review of Chile's deposit insurance scheme.

not be used to motivate policy reforms in Chile. They represent the most detailed cross-country comparisons to date, but they do not capture the full range of details and complexities associated with banking sector policies. Our analysis simply motivates concern with a few key regulatory and supervisory policies in Chile.

3. Conclusions

This paper had two objectives. First, given differing theoretical predictions about the impact of stock markets and banks on economic growth and given shortcomings with existing empirical work, we sought to reassess the relationship between stock markets, banks, and economic growth. Our results are consistent with the view that stock markets and banks independently influence long-run growth, and the positive link between financial development and growth does not seem to be due to outliers, omitted variable bias, or endogeneity. We have also shown that Chile is an outlier: Chile has much less liquid markets and less developed banks than other rapidly growing economies, even after controlling for many other growth determinants.

The second goal of the paper was to examine commercial bank regulation and supervision. Barth, Caprio, and Levine (2001a,b) show that bank regulatory and supervisory policy that emphasize private sector monitoring, encourage competitive banking markets, impose few restrictions on bank activities, and limit the generosity of deposit insurance regimes enjoy greater banking system success than other policy regimes. Chile has strong commercial bank supervision and regulation, but it has comparatively few regulations to boost private sector monitoring, it has tight restrictions on bank entry and bank activities, and it has generous deposit insurance. This paper, therefore, motivates a rigorous review of specific regulation and supervisory practices in Chile.

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Coping with Chile's External Vulnerability: A Financial Problem

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With traditional domestic imbalances long under control, the Chilean business cycle is driven by external shocks. Chile's external vulnerability is primarily a financial problem. A decline in the Chilean terms of trade, for example, is associated with a decline in real gross domestic product (GDP) that is many times larger than one would predict in the presence of perfect financial markets. The financial nature of this excess sensitivity has two central dimensions: a sharp contraction in Chile's access to international financial markets when it needs it the most and an inefficient reallocation of this scarce access across borrowers during external crises. I argue that Chile's aggregate volatility can be reduced significantly by fostering the private sector's development of financial instruments that are contingent on the main external shocks faced by Chile. As a first step, the Central Bank or international financial institutions could issue a benchmark instrument contingent on these shocks. I also advocate a countercyclical monetary policy (also contingent on these shocks), but mainly as an incentive—that is, as a substitute for taxes on capital inflows and equivalent—rather than for ex post liquidity purposes.

The essence of the mechanism through which external shocks affect the Chilean economy can be characterized as follows. First, a deterioration of the terms of trade raises the need for external re-

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sources if the real economy is to continue unaffected, but this triggers exactly the opposite reaction from international financiers, who pull back capital inflows. The latter occasionally occurs directly as a contagion effect. Second, once external financial markets fail to accommodate the needs of domestic firms and households, these agents turn to domestic financial markets, in particular to commercial banks. Again, this increase in demand is not matched by an increase in supply since banks—particularly resident foreign institutions—tighten domestic credit, opting instead to increase their net foreign asset positions. Third, the domestic financial system experiences a significant “flight to quality,” which reinforces the above effects as large firms find it more attractive to seek financing in domestic markets, while the displaced small and medium-sized firms cannot access international financial markets at any price.

The costs of this mechanism are high. Widespread financial constraints are binding during the crisis, when major forced adjustments are needed. The sharp decline in domestic asset prices, and the corresponding rise in expected returns, is driven by the extreme scarcity in financial resources and their high opportunity cost. Even the praised rise in foreign direct investment (FDI) that occurred during the most recent crisis is a symptom of these fire sales. The fact that this investment takes the form of control purchases rather than portfolio or credit flows simply reflects some of the underlying problems that limit Chile’s integration to international financial markets: weak corporate governance and other “transparency” standards. Finally, the costs do not end with the crisis, since financially distressed firms are ill equipped to mount a speedy recovery. The latter often comes not only with the costs of a slow recovery in employment and activity, but also with a slowdown in the process of creative destruction and productivity growth. In the United States, the latter may account for about 30 percent of the costs of an average recession (see Caballero and Hammour, 1998), which is probably a very optimistic lower bound for the Chilean economy. Moreover, the presence of a severely large number of financially distressed small firms reduces rather than enhances the effectiveness of monetary policy in facilitating the recovery.

The distributional impact of this type of crisis is significant, as well. On one end, large firms are directly affected by external shocks, but they can substitute most of their financial needs domestically. They are affected primarily by demand factors. On the other, small and medium-sized enterprises (henceforth, SMEs) are crowded out and are severely constrained on the financial side. They are the residual claimants of the financial crunch.

This diagnosis points in the direction of a structural solution based on two building blocks. The first deals with the institutions required to foster Chile's integration to international financial markets and the development of domestic financial markets. Chile is making significant progress along this margin through its capital markets reform program. The second building block, which is necessary because of the unavoidably slow nature of the above process, is to design an appropriate international liquidity management strategy. This strategy must be understood in broader terms than the Central Bank's management of international reserves, and it must include the development of financial instruments that facilitate the delegation of this task to the private sector.

I focus on the latter type of solution in this paper.[1] I view the policy problem as one of remedying a chronic private sector underinsurance with respect to external crises.[2] After outlining the main sources of this problem and the corresponding solutions, I focus on two. First, to develop a key missing market, I propose the creation of a benchmark bond that is contingent on the main external shocks faced by Chile. This instrument should facilitate the private sector's pricing and creation of similar and derivative contingent financial instruments. Second, I discuss optimal monetary policy and international reserve management from an insurance perspective. Provided that the Central Bank of Chile has achieved a high degree of inflation-target credibility, the optimal response to an external shock is a moderate injection of reserves and an expansionary monetary policy. The latter, however, is unlikely to have a large real impact and indeed will imply a sharp, short-lived exchange rate depreciation. The main benefit of such a policy is in the incentives it provides. The main problem is that it is time inconsistent.

The following section describes the essence of the external shocks and the financial mechanism at work. Section 2 follows with a discussion of the impact of this mechanism on the real side of the economy and the different economic agents. Section 3 discusses policy options, and section 4 concludes.

1. See Caballero (1999, 2001) for a discussion of the structural reforms aimed at improving integration and the development of financial markets. More important, Chile is in the process of enacting a major capital markets reform.

2. See Caballero and Krishnamurthy (2001c) for a formal discussion of this perspective.

Table 1. The Relative Importance of Bank Loans[a]
Percent

Source of financing	*Stock*	*Flows*
Loans	43	51
Equity	54	33
Bonds	3	16

a. Participation levels were built using the stocks from December 2000. Flows were computed as the difference in stocks between December 1999 and December 2000, except for the flow of new equity, which was built using information on equity placement during the period.

1. The Shock and the Financial System

This section illustrates the mechanism through which external shocks affect the Chilean economy. I start off with a brief description of the Chilean financial sector. I then organize the discussion of the role played by the shocks and their amplification mechanisms around demand and supply factors affecting the domestic banking system—the backbone of the Chilean financial system. Finally, I focus on the most recent cyclical episode, because the changing nature of the Chilean financial system makes older data less relevant.

1.1 The Chilean Banking Sector

Banks are an important source of financing for Chilean firms. The composition of financing is similar to that of advanced European economies (see table 1). The maturity structure of Chilean bank loans, however, is more concentrated on the short end: 57 percent of total loans and 60 percent of commercial loans have a maturity of less than one year.[3] Chilean banks thus look like European banks in terms of their relative importance, but they are more similar to U.S. banks in their focus on short maturities.[4]

Chilean banks concentrate most of their activity on firms. Commercial loans represent around 60 percent of total bank loans. If trade loans are also taken into account, about 70 percent of total bank credit

3. Computed using the stock of loans in December 1999, as reported by the Superintendencia de Bancos e Instituciones Financieras.

4. In Germany, for example, more that 70 percent of the commercial loans are long term. In contrast, in the United States short-term loans account for about 60 percent of nonresidential loans.

supply is directed to firms. The remainder is allocated to mortgages (15 percent), consumption loans (10 percent), and other types of loans (5 percent).[5]

Chilean banks concentrate their lending activity on large firms, at least when firm size is approximated by loan size. Large loans of over US$1.4 million (in end-1999 dollars) capture 64 percent of the volume of commercial loans. In contrast, only 14 percent is allocated to medium-sized loans (between US$280,000 and US$ 1.4 million), while small loans (below US$280,000) account for the remaining 22 percent.[6]

Banks in Chile are important when compared with other financial institutions, as well. Banks' assets represent 60 percent of total assets, whereas pension funds control 30 percent and insurance companies 10 percent.[7]

Within the banking sector, foreign banks maintain a very significant presence. Loans by foreign banks represented 42 percent of total loans in 1999, versus 58 percent for domestic banks. Portfolio composition is roughly similar among the two types of banks, with loans accounting for the largest share of assets (67 percent for foreign banks and 80 percent for domestic). Considerable differences are seen, however, in the relative importance of foreign assets (15 percent for foreign banks versus just 6 percent for domestic), securities (14 percent versus 11 percent), and reserves (4 percent versus 3 percent).[8] Finally, note that Chilean Banking Law does not recognize subsidiaries of foreign banks as part of their main headquarters.

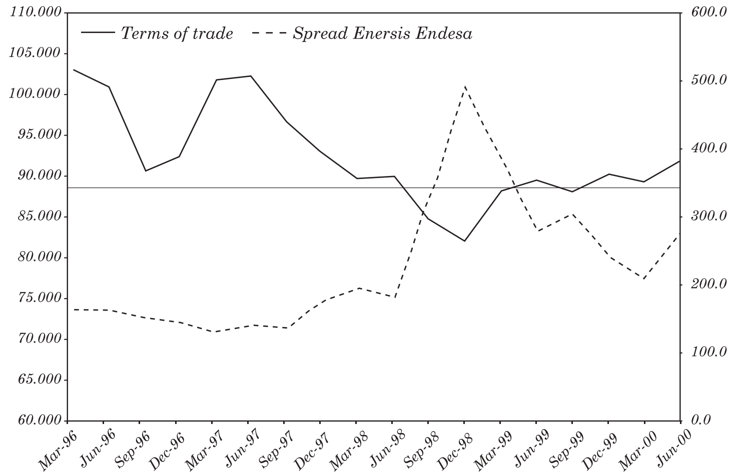
1.2 The External Shock and Its Impact on Domestic Financial Needs

The trigger of the mechanism is illustrated in figure 1. Panel A shows the path of Chile's terms of trade and the spread paid by prime Chilean instruments over the equivalent U.S. Treasury instrument. Chile was severely affected by both at the end of the 1990s. Panel B offers a better metric to gauge the magnitude of these shocks. Taking the quan-

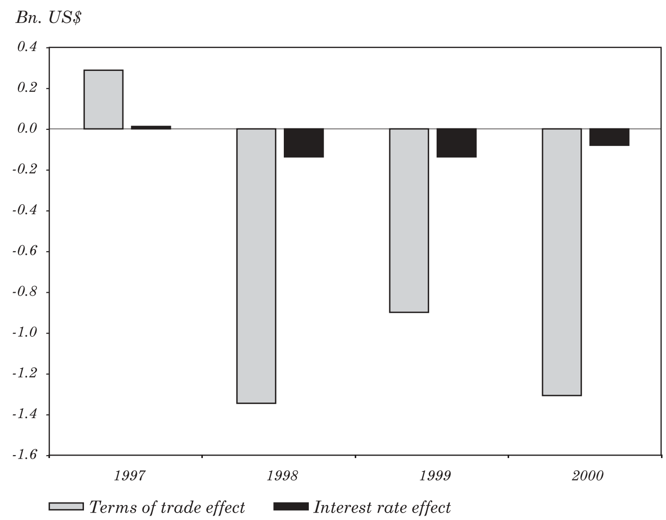
5. Superintendencia de Bancos e Instituciones Financieras.
6. Superintendencia de Bancos e Instituciones Financieras.
7. Total assets are calculated as the sum of financial and fixed assets. Fixed assets are not included for insurance companies, but they represent a very small fraction of financial institutions' assets. Ratios are based on the stock of assets in December 2000, as reported by the Superintendencia de Bancos e Instituciones Financieras and the Superintendencia de Valores y Seguros.
8. Superintendencia de Bancos e Instituciones Financieras.

Figure 1. External Shocks[a]

A. Terms of trade and sovereing spread



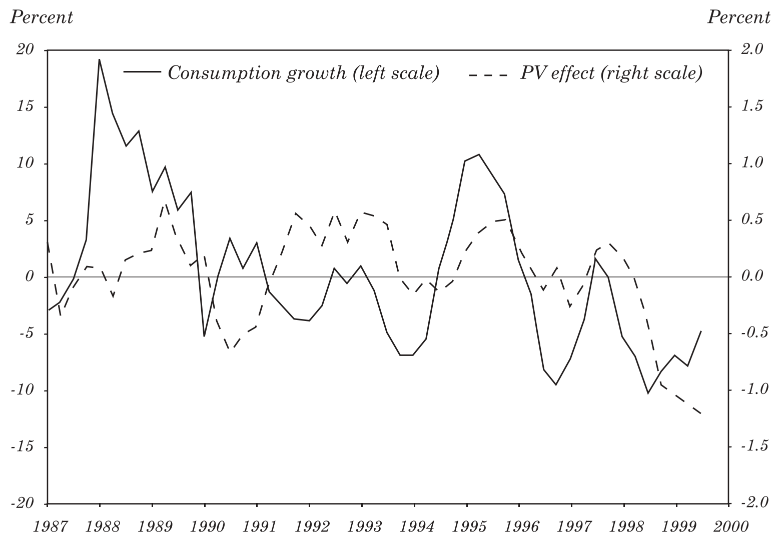
B. Terms of trade and interest rate effect (fixed quantities)



Source: Central Bank of Chile.

a. Preliminary data used for 1999 and 2000. The yearly figure for 2000 was computed by multiplying the three-quarter cummulative value by 4/3. In panel A, terms of trade is the ratio of export price index and import price index computed by the Central Bank of Chile. The sovereign spread was estimated as the spread of ENERSIS-ENDESA corporate bonds. The spread data for 1996 was estimated by the author using information from the Central Bank. In panel B, the terms-of-trade effect was computed as the difference between the actual terms of trade and the terms of trade at 1996 quantities. The interest rate effect was computed in similar fashion.

Figure 2. Excess Sensitivity of Real Consumption Growth to Terms of Trade Shocks[a]



Source: Consumption growth: *International Financial Statistics* (IFS); copper prices (London Metal Exchange): Datastream; copper exports: Chile's Ministry of Finance.

tities from the 1996 current account as representative of those that would have occurred in the economy absent any real adjustment, it translates them into the dollar losses associated with the deterioration in the terms of trade and interest rates. These losses amounted to about two percent of GDP in 1998, with similar magnitudes for 1999 and 2000.

How should Chile have reacted to this sharp decline in national income, in the absence of any significant financial friction (aside from the temporary increase in the spread)? Figure 2 hints at the answer. The thick line depicts the path of Chile's actual consumption growth, while the broken line illustrates the hypothetical path of consumption growth if it were perfectly integrated with international financial markets and if the terms of trade were the only source of shocks.[9] The figure has two interesting features. First, there is a

9. Consumption growth is very similar to GDP growth for this comparison. Adding the income effect of interest rate shocks would not change things too much, as these were very short lived. I neglect the presence of substitution effects because there is no evidence of a consumption overshooting once international spreads come down.

very high correlation between Chile's business cycle and shocks to its terms of trade. This correlation is not observed in other commodity-dependent economies with more developed financial markets, such as Australia or Norway (see Caballero 1999, 2001). Second, and more important for the argument in this paper, the figure demonstrates that the economy overreacts to these shocks by a significant margin. In the figure, the actual response of the economy is measured on the left axis, while the hypothetical response is measured on the right axis; the scale of the former is fully ten times larger than that of the latter. In practice, terms-of-trade shocks are simply too transitory—especially when they are driven by demand, as in the recent crisis—to justify a large response from the real side of the economy.[10] The income effect that is measured in panel B of Figure 1 should, in principle, translate almost entirely into increased borrowing from abroad, but it does not do so in practice.

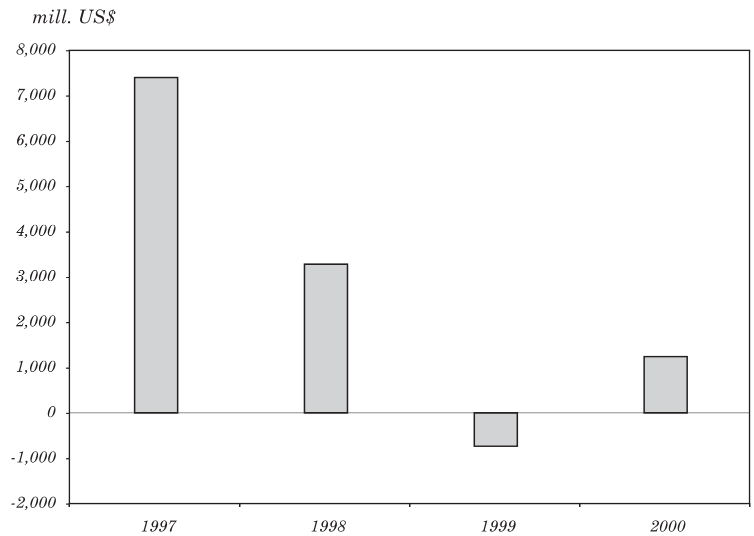
Returning to the crisis of the late 1990s, panel A of figure 3 illustrates that international financial markets not only did not accommodate the (potential) increase in demand for foreign resources, but capital inflows actually declined rapidly over the period. While the Central Bank offset part of this decline by injecting back some of its international reserves, it clearly was not enough to offset both the decline in capital inflows and the rise in external needs (see panel B). For example, the figure shows that in 1998, the injection of reserves amounted to approximately US$2 billion. This is comparable to the direct income effect of the decline in the terms of trades and the rise in interest rates, but it does not compensate for the decline in capital inflows that came with these shocks.

How severe was the mismatch between the increase in needs and the availability of external financial resources? Panel A of figure 4 has a back-of-the-envelope answer. It graphs the actual current account (light bars) and the current account with quantities fixed at 1996 levels (dark bars). At the trough, in 1999, the actual current

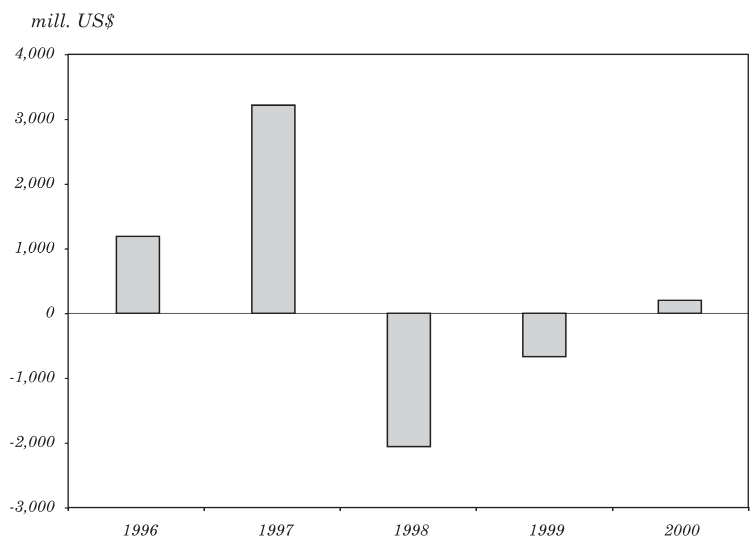
10. The price of copper has trends and cycles at different frequencies, some of which are persistent (see Marshall and Silva, 1998). The sharp decline in the price of copper in the late 1990s, however, undoubtedly resulted primarily from a transitory demand shock brought about by the Asian and Russian crises. I would argue that conditional on the information that the current shock was a transitory demand shock, the univariate process used to estimate the present value impact of the decline in the price of copper in figure 2 overestimates the extent of this decline. The lower decline in futures prices is consistent with this view. The variance of the spot price is six times the variance of fifteen-month-ahead futures prices. Moreover, the expectations computed from the autoregression process track reasonably well with the expectations implicit in futures markets, except for the very end of the sample when liquidity premium considerations may have come into play.

Figure 3. Capital Flows and Reserves

A. Capital account except reserves



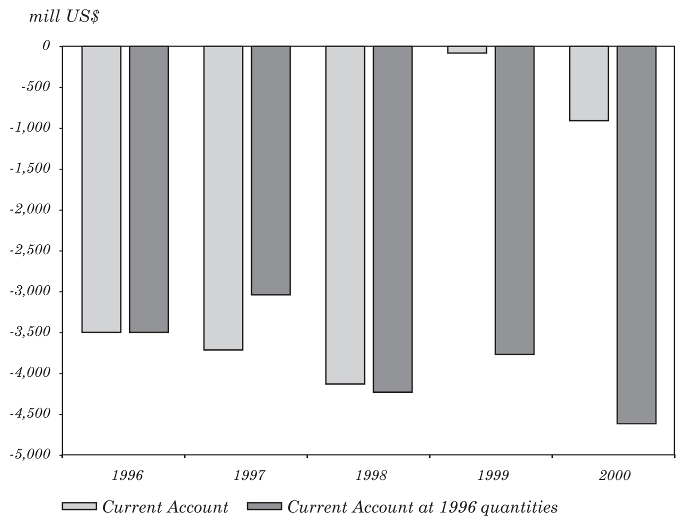
B. Balance of payments



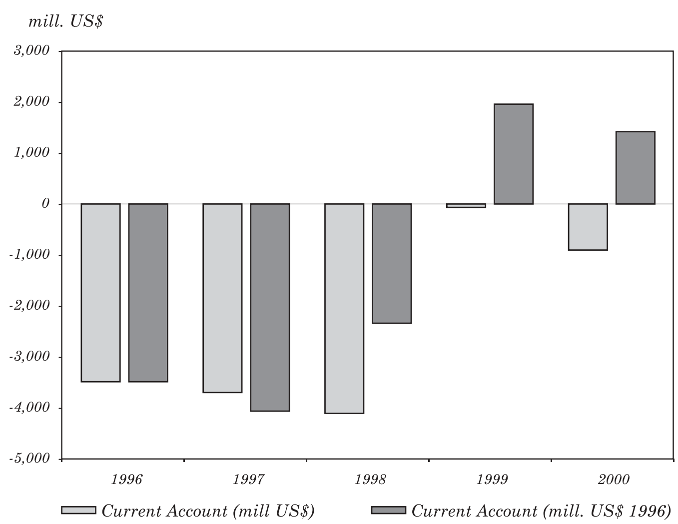
Source: Central Bank of Chile.

Figure 4. The Current Account[a]

A. Current account and current account at 1996 quantities



B. Current account (current and in 1996 prices)

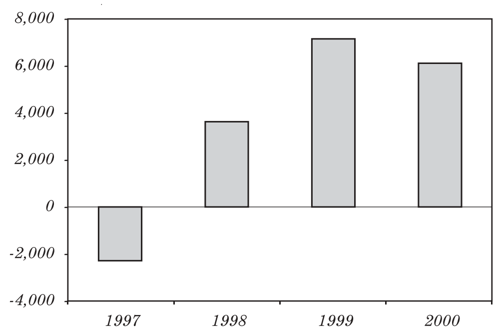


Source: Central Bank of Chile.

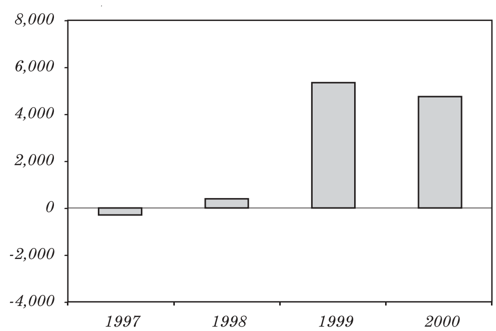
a. In panel A, the current account at 1996 quantities was computed by multiplying the 1996 quantities by each year's price indices for exports, imports, and interest payments. The other components of the current account were kept at current values. In panel B, the current account in 1996 prices was computed by multiplying the 1996 prices by each year's quantities.

Figure 5. The Increase in Potential Financial Needs[a]

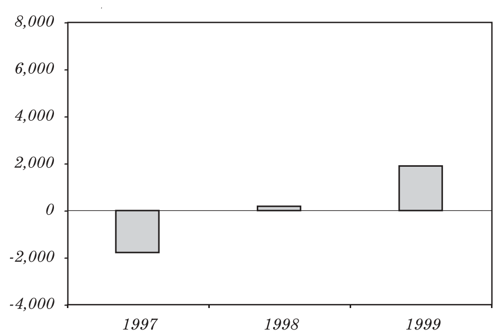
A. Comprehensive (mill. US$)



B. (A) minus reserves accummulation (mill. US$)



C. (B) minus flows to banking sector (mill. US$)



Source: Central Bank of Chile.

a. Panel A corresponds to the sum of the terms of trade effect, the interest rate effect, and the decline in capital inflows. Both the terms-of-trade and the interest rate effects are measured at 1996 quantities. The decline in capital flows corresponds to the difference of the capital account except reserves with respect to its 1996 value. Panel B subtracts from panel A the net change in Central Bank reserves. Panel C subtracts from panel B the net increase in flows to the banking sector.

account deficit was around US$4 billion less than what one would have predicted using only the actual change in terms of trade. Moreover, this dollar adjustment underestimates the quantity adjustment behind it, as the deterioration of the terms of trade typically worsens the current account deficit for any path of quantities. The importance of this price correction can be seen in panel B, which graphs the actual current account (light bars), and the current account at 1996 prices (dark bars). The latter clearly shows a significantly larger adjustment than the former.

Figure 5 reinforces the mismatch conclusion by reporting increasingly conservative estimates of the shortage of external financial resources by the nonbanking sector. Panel A describes the path of the change in potential financial needs stemming from the decline in the terms of trade and capital inflows, and the increase in spreads. Panel B subtracts from panel A the injection of reserves by the Central Bank, while panel C subtracts from panel B the decline in capital inflows to the banking sector. The increase in financial needs for 1999 ranges from about US$2 billion to just above US$7 billion. Regardless of the method used, the mismatch is large, which creates a potentially large surge in the demand for resources from the domestic financial system. The difference between panels b and c shows that the domestic financial sector not only did not accommodate this increase in demand, but also exacerbated the financial crunch.

Figure 6 illustrates additional dimensions that could have smoothed the demand for resources from resident banks, although they did not do so. Panels a and b carry the relatively good news. The former shows that issues of new equity and corporate bonds did not decline very sharply, although they hide the fact that the required return on these instruments rose significantly. The latter panel illustrates that while the pension funds increased their allocation of funds to foreign assets during the period, this portfolio shift occurred mostly against public instruments. However, this decline probably translated into a large placement of public bonds on some other market or institution that competes with the private sector, like banks (see the discussion below). Panel C, on the other hand, indicates that retained earnings, which are a significant source of investment financing to Chilean firms, declined significantly over the period.[11] Finally, panel D illustrates that

11. Before the crises, in 1996, the stock of retained earnings represented 20 percent of total assets for the median firm. The difference between profits and dividend payments (a measure of the flow of retained earnings) represented around 50 percent of total capital expenditures for the median firm in 1996.

workers did not help accommodate the financial bottleneck either, as the labor share rose steadily throughout the period.

The bottom line of this section is clear: during external crunches, firms need substantial additional financial resources from resident banks.

1.3 The (Supply) Response by Resident Banks

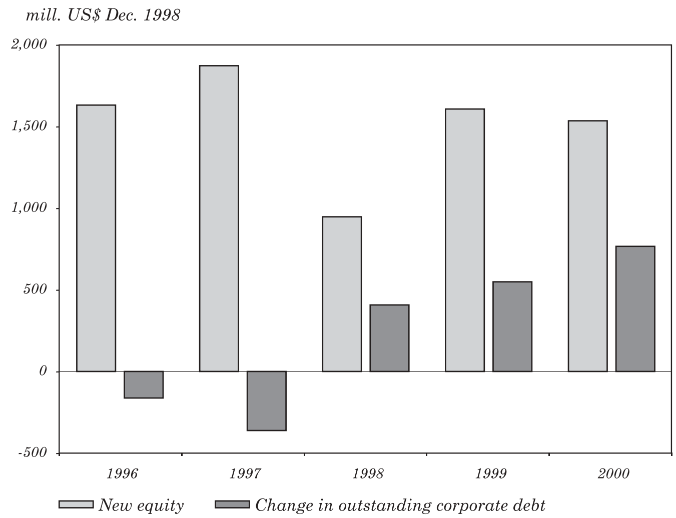
How did resident banks respond to increased demand? The short answer is that they exacerbated rather than smooth the external shock. Panel A in figure 7 shows that domestic loan growth actually slowed sharply in the late 1990s, even as deposits kept growing. This tightening can also be seen in prices, through the sharp rise in the loan-deposit spread during the early phase of the recent crisis (see panel B). While spreads started to fall by 1999, the strong substitution toward prime firms makes it difficult to interpret this decline as a loosening in credit standards.

The main substitutes for loans in banks' portfolios are public debt and external assets (see figure 8, panel A). Banks clearly moved their assets toward external assets. Interestingly, the Central Bank policy of fighting capital outflows with high domestic interest rates was only temporarily successful, as evidenced by the reversal in the last quarter of 1998. The rise in interest rates during the Russian phase of the crisis seems to have succeeded mostly in slowing down the decline in banks' investment in public instruments, and it encouraged substitution away from loans. Banks exacerbated—rather than smoothed—the loss of external funding by becoming part of the capital outflows. In fact, while the banking sector also experienced a large capital outflow during this episode (see panel B), much of the net outflow was not due to a decline in their international credit lines or inflows, but rather to an outflow toward foreign deposits and securities (panel C).

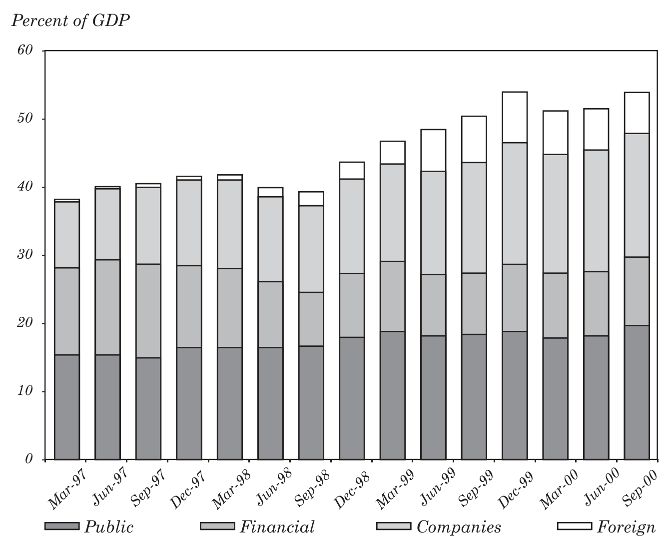
Most resident banks exhibited this pattern to some degree, but resident foreign banks had the most pronounced portfolio shift toward foreign assets. This is apparent in panels a and b of figure 9, which present the investment in domestic and foreign assets by foreign and domestic (private) banks, respectively. While all banks increased their positions in foreign assets, the trend was substantially more pronounced among foreign banks. Moreover, domestic banks "financed" a larger fraction of their portfolio shift by reducing investments other than loans. This conclusion is confirmed in panel C, which shows the paths of the

Figure 6. Additional Factors[a]

A. Change in the stock of corporate debt and new equity



B. AFP holdings as fraction of GDP

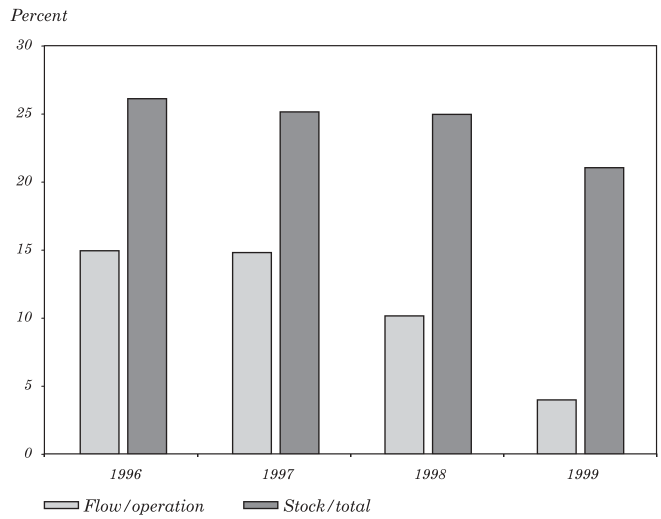


Source: Central Bank of Chile; Santiago Stock Exchange; Superintendencia de AFP; Superintendencia de Valores y Seguros.

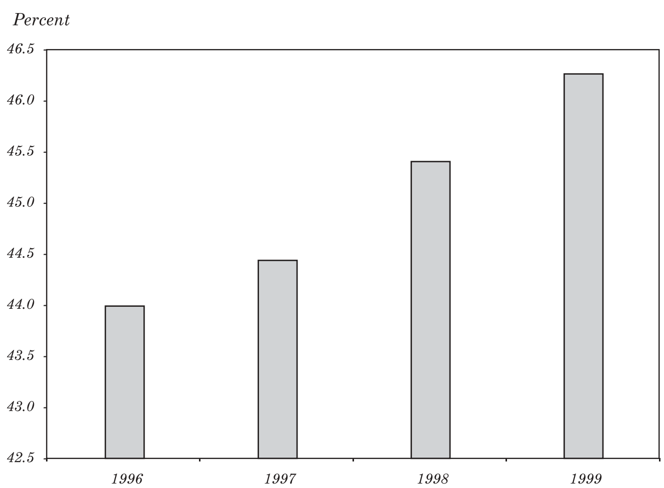
In panel A, new equity is valued at issuance price and deflated using the consumer price index (CPI). The stock of corporate debt outstanding was also deflated by the CPI. The December 1998 exchange rate was 432 pesos per

Figure 6. (continued)

C. Retained earnings



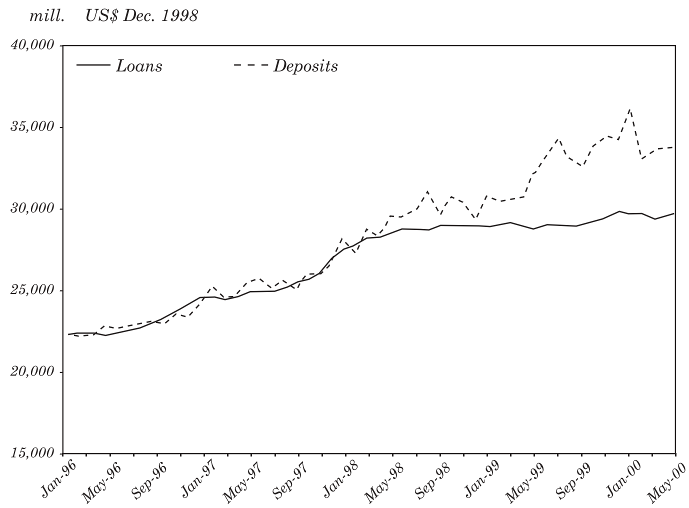
D. Labor share



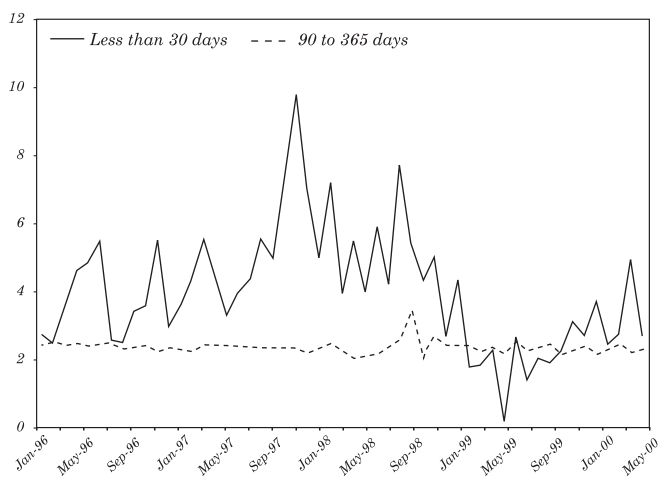
US dollar. In panel B, the values are expressed as a fraction of the year's GDP. In panel C, the data on retained earnings correspond to the stocks of retained earning reported in the balance sheets of all the companies traded in that exchange. They exclude investment firms, pension funds, and insurance companies. The flow value was computed as the difference in the (deflated) stocks at time t and $t - 1$.

Figure 7. The Credit Crunch[a]

A. Loans and deposits of the banking system



B. Interest rate spreads (annual %)

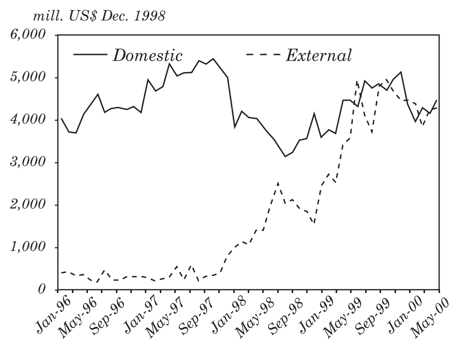


Source: Central Bank of Chile; Superintendencia de Valores y Seguros.

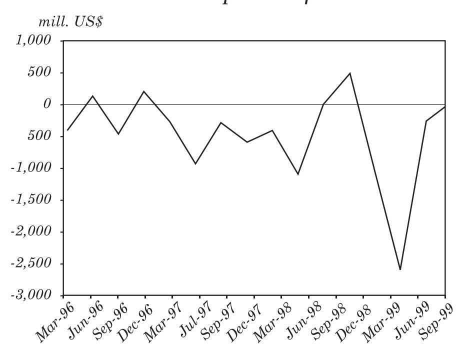
a. In panel A, loans include commercial, consumption, and trade loans and mortgages. Deposits include sight deposits and time deposits. The values are expressed in December 1998 dollars, using the average December 1998 exchange rate (472 pesos/dollar). In panel B, the thirty-day interest rates are nominal, while the ninety-day and one-year rates are real (to a first order, this distinction should not matter for spread calculations).

Figure 8. Capital Flows of the Banking System[a]

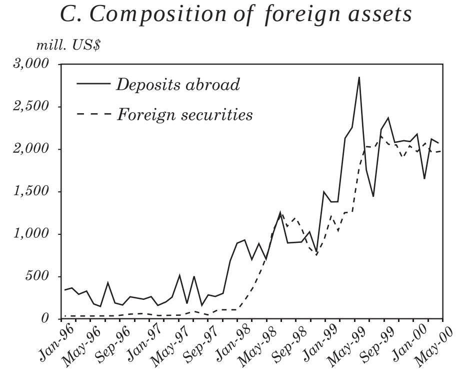
A. Investment in domestic and external assets



B. Net capital inflows



C. Composition of foreign assets

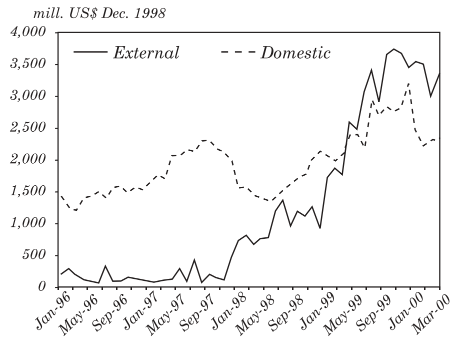


Source: Central Bank of Chile; Superintendencia de Bancos e Instituciones Financieras.

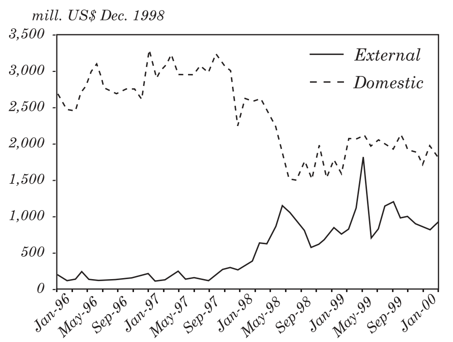
a. Domestic assets include Central Bank securities with secondary market and intermediated securities. External assets are the sum of deposits abroad and foreign securities. Deposits abroad are mostly sight deposits in foreign (nonresident) banks. Foreign securities are mostly foreign bonds.

Figure 9. Comparing Foreign and Domestic Bank Behavior[a]

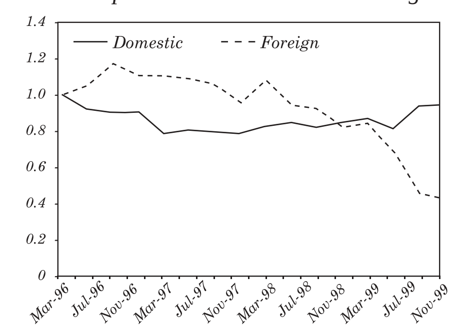
A. Investment in domestic and external assets of foreign banks



B. Investment in domestic and external assets of domestic banks



C. Loans over deposits of domestic and foreign banks except BHIF and Banco Santiago



Source: Santiago Securities Exchange.

a. Domestic banks do not include Banco del Estado. Banco BHIF and Banco Santiago, which changed from domestic to foreign ownership during the period, were excluded from the sample. All constant 1998-peso series were converted to US dollars using the average exchange rate in December 1998 (472 pesos/dollar). Deposits include sight and time deposits. Loans include commercial, consumption, and trade loans, and mortgages. In panels A and B, domestic assets include Central Bank securities with secondary market and intermediated securities; external assets are the sum of deposits abroad and foreign securities. In panel C, loan-to-deposit ratios are normalized to one in March 1996.

loans-to-deposit ratios of foreign (dashes) and domestic (solid) banks.[12]

The question arises whether factors other than nationality (such as the banks' risk characteristics) determined the differential response. While this is certainly a theme to be explored more thoroughly, the evidence in figure 10 suggests that this is not the case. Panel A shows that foreign banks did not experience a rise in net foreign currency liabilities that could account for additional hedging. They did not experience a significantly sharper rise in nonperforming loans than did domestic banks (panel B), and they were not affected by a tighter capital-adequacy constraint (panel C).

Foreign banks generally play many useful roles in emerging economies, but they do not seem to help smooth external shocks (at least in the most recent crisis). The credit and risk strategies of these banks are probably dictated from abroad, and there is no particular reason to expect them to behave too differently from other foreign investors during these times.

In summary, in 1999—perhaps the worst full year of the crisis—banks reduced loan growth by approximately US$2 billion.[13] The increase in financial needs by the nonbanking private sector was about US$2 billion, as well (see figure 5, panel C). Although these simple calculations ignore many general equilibrium issues, it is probably not too far-fetched to conclude that the financial crunch was extremely large, perhaps around US$4 billion (about 5 to 6 percent of GDP) in that single year.

2. The Costs

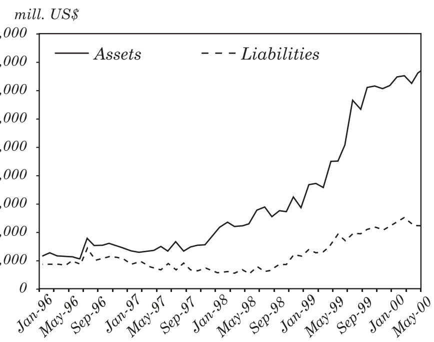
The impact of the financial crunch on the economy is correspondingly large, especially on small and medium-sized firms.

12. This figure excludes two banks (Banco BHIF and Banco Santiago) that changed from domestic to foreign ownership during the period. The change in statistical classification took place in November 1998 for Banco BHIF and in July 1999 for Banco Santiago. In the case of Banco Santiago, the takeover operation by Banco Santander (the largest foreign bank in Chile) actually took place in May 1999. The Chilean bank regulatory agency (Superintendencia de Bancos) assumed that the two banks were going to merge and therefore ordered Banco Santiago to reduce its market presence. (The two banks had a joint presence equivalent to 29 percent of total loans.) The banks finally decided not to merge, and their joint market presence has remained unaltered thus far. The confusion created by the potential participation limits probably did not help the severe credit crunch that Chile was experiencing at the time.

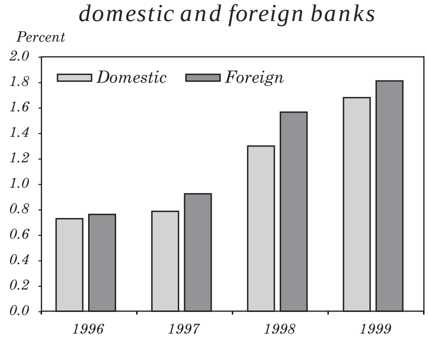
13. A number close to US$2 billion is obtained from the difference between the flow of loans during 1999 (computed as the change in the stock of loans between December 1999 and December 1998) and the flow of loans in 1996 (computed in a similar manner).

Figure 10. Risk Characteristics of Foreign and Domestic Banks[a]

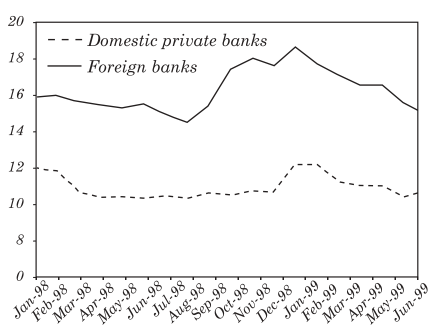
A. Foreign currency assets and liabilities: foreign banks



B. Non performing loans as percentage of total loans: domestic and foreign banks



C. Capital adequacy ratio



Source: Superintendencia de Bancos e Instituciones Financieras.

a. In panel A, foreign assets include foreign loans, deposits abroad, and foreign securities. Foreign liabilities include funds borrowed from abroad and deposits in foreign currency. In panel B, ROE is the ratio of total profits over capital and reserves (as a percentage). Domestic private banks do not include Banco del Estado.

2.1 The Aggregates

Figure 2 summarized the first-order impact of the financial mechanism, with a domestic business cycle that is many times more volatile than it would be if financial markets were perfect. This excess volatility was particularly pronounced in the recent slowdown, as illustrated by panel A in figure 11. National income and domestic demand not only appear to move together, but the latter adjusts more than the former, implying that the largely transitory terms-of-trade shock is not being smoothed over time. Panel B illustrates a sharp rise in the unemployment rate that has yet to be reversed.

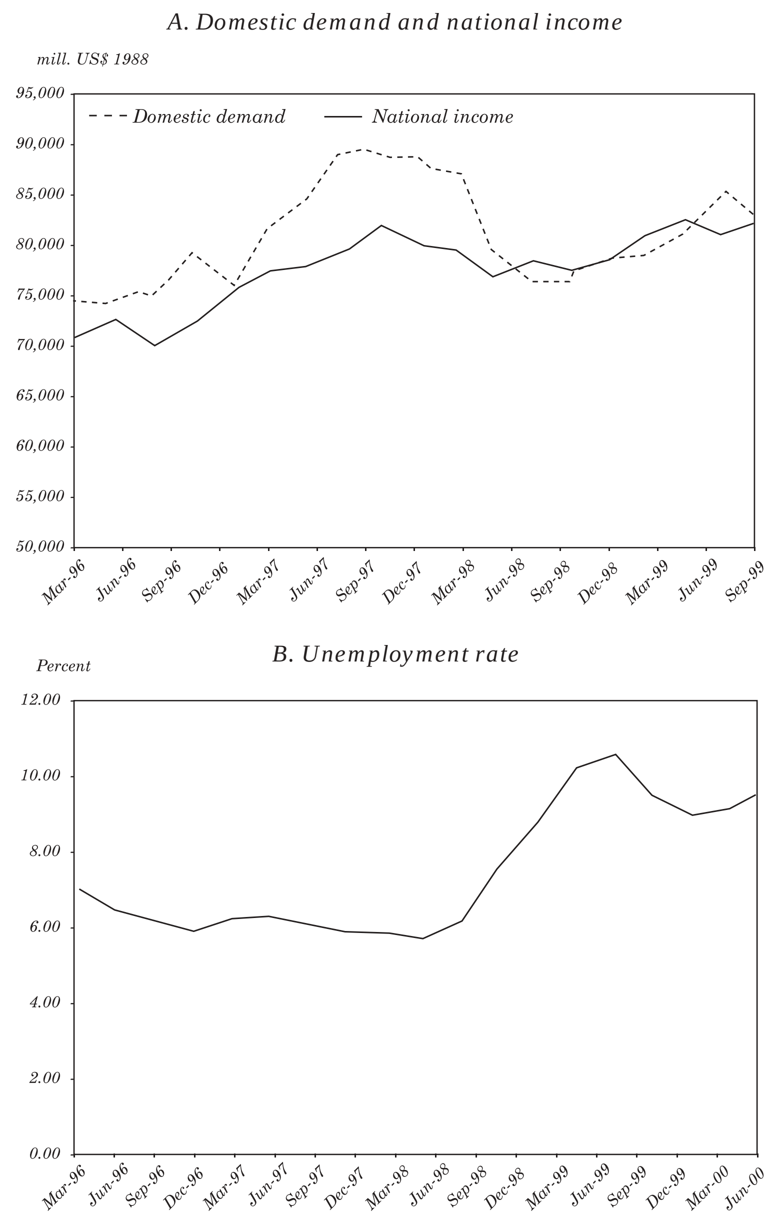
Aside from the direct negative impact of the slowdown and any additional uncertainty that may have been created by the untimely discussion of a new labor code, the buildup in unemployment and its persistence can be linked to two aspects of the financial mechanism described above. First, in the presence of an external financial constraint, the real exchange rate needs a larger adjustment for any given decline in the terms of trade.[14] Consequently, a big share of the adjustment falls on the labor-intensive nontradables sector, as illustrated in panel A of figure 12. Second, going beyond the crisis and into the recovery, the lack of financial resources hampers job creation, a phenomenon that is particularly acute among SMEs. While I do not have data on job creation, panel B shows that investment suffered a deeper and more prolonged recession than the rest of domestic aggregate demand. This is important beyond its impact on unemployment, as it also hints at the slowdown of one of the main engines of productivity growth: the restructuring process. If the United States is any indication of the costs associated with this slowdown in restructuring—possibly a very optimistic lower bound for the Chilean costs—this mechanism may add a significant productivity loss amounting to over 30 percent of the employment cost of the recession.[15]

As the external constraint tightens, all domestic assets that are not part of international liquidity must lose value sharply to offer significant excess returns to the few agents with the will and liquidity to buy them. Panel A of figure 13 shows a clear trace of this V-pattern in the Chilean stock market. Panel B is perhaps more interesting, as it illustrates that foreign direct investment (FDI) increased by almost

14. The larger real exchange rate adjustment corresponds to the dual of the financial constraint. See Caballero and Krishnamurthy (2001c).

15. See Caballero and Hammour (1998).

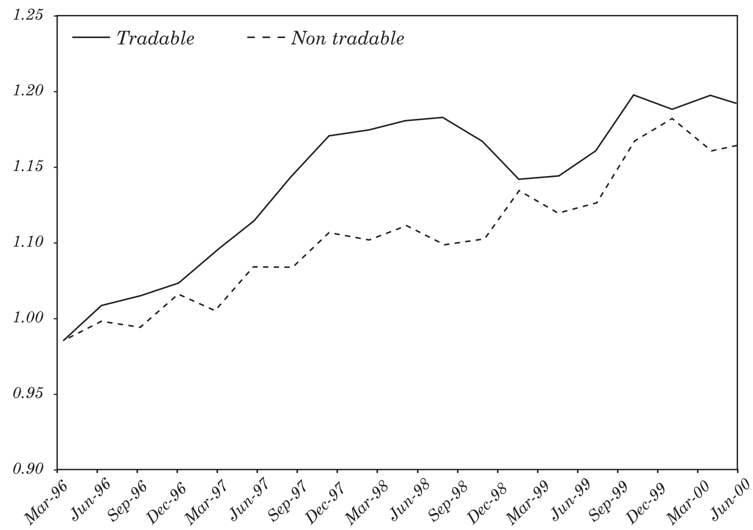
Figure 11. Output, Demand, and Unemployment[a]



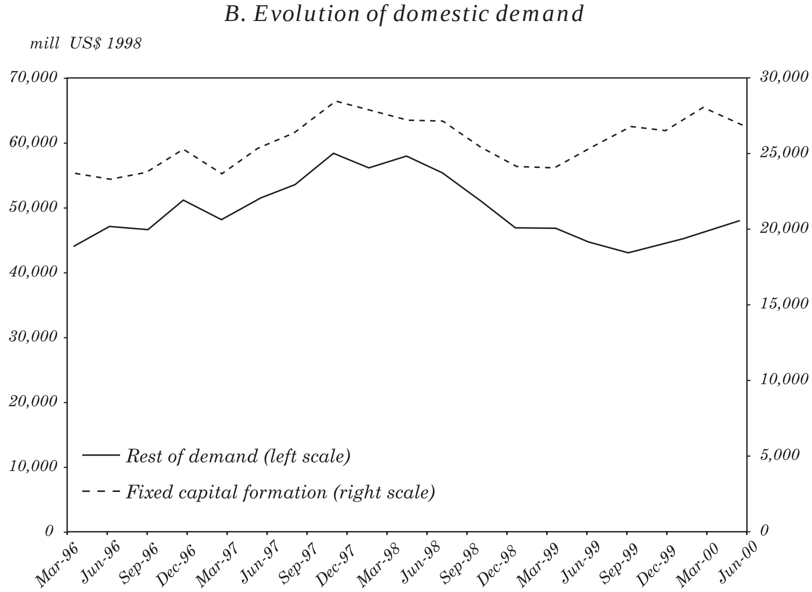
Source: Central Bank of Chile; National Bureau of Statistics (INE).
a. Series are seasonally adjusted and annualized.

Figure 12. Forced and Depressed Restructuring[a]

A. GDP tradable and non-tradable



B. Evolution of domestic demand



Source: Central Bank of Chile.

a. Series are seasonally adjusted and normalized to one in March 1996. The tradables sector includes agriculture, fishing, mining, and manufacturing; the nontradables sector includes electricity, gas and water, construction, commerce, transport and telecommunications, and other services.

US$4.5 billion in 1999 and created a bottom to the fire sale of domestic assets. However, while FDI is very useful in that it provides external resources when they are most scarce, its presence during the crisis also reflects the severe costs of the external financial constraint, as valuable assets are sold at heavy discounts.

2.2 The Asymmetries

The real consequences of the external shocks and the financial amplification mechanism are felt differently across firms of different sizes. Large firms are directly affected by the external shock, but they can substitute their financial needs domestically. They are affected primarily by price and demand factors. SMEs, on the other hand, are crowded out of domestic financial markets and thus become severely constrained financially. They are the residual claimants of the financial dimension of the mechanism described above, as are indebted consumers to a lesser extent.

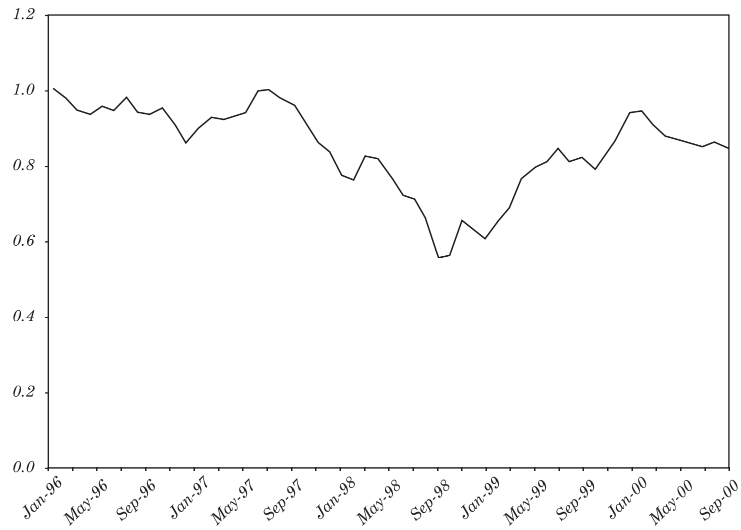
Figure 14 illustrates some aspects of this asymmetry. First, panel A shows the path of the share of large loans as an imperfect proxy for resident bank loans going to large firms. Next, panel B, shows a sharp increase in the relative size of large loans. The two trends together hint at a substantial reallocation of domestic loans toward relatively large firms. In the policy section below, I argue that some of this reallocation is likely to be socially inefficient.

The next figure looks at relatively large, publicly traded firms.[16] The figure points to important differences between the largest of them and the medium-sized ones. A comparison of the paths of medium-sized and large firms' bank liabilities (normalized by initial assets) during the recent slowdown indicates that larger firms fared better than medium-sized companies, which saw their level of loans frozen throughout 1999. Perhaps more importantly, since the sum of loans to medium-sized and large firms rose while total loans declined throughout the crisis, the contraction must have been particularly significant among smaller firms (not shown in the figure).

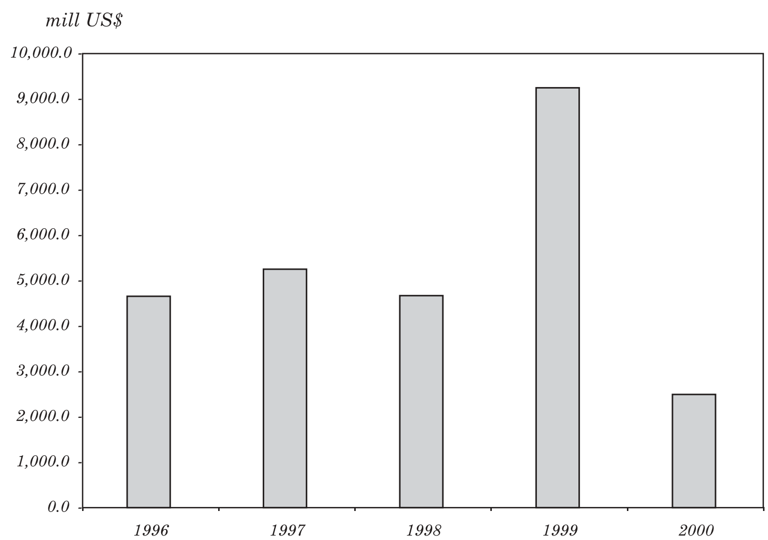
16. The firms included in Figure 15 are drawn from the Ficha Estadística Codificada Uniforme *(*FECU), which is the standardized balance sheet that every public firm in Chile is required to file quarterly with the supervisory authority (the Superintendencia de Valores y Seguros). The database contains information on those standardized balance sheets for every public firm reporting to the authority between the first quarter of 1996 and the first quarter of 2000.

Figure 13. Fire Sales

A. Value of Chilean stocks (IGPA index)[a]



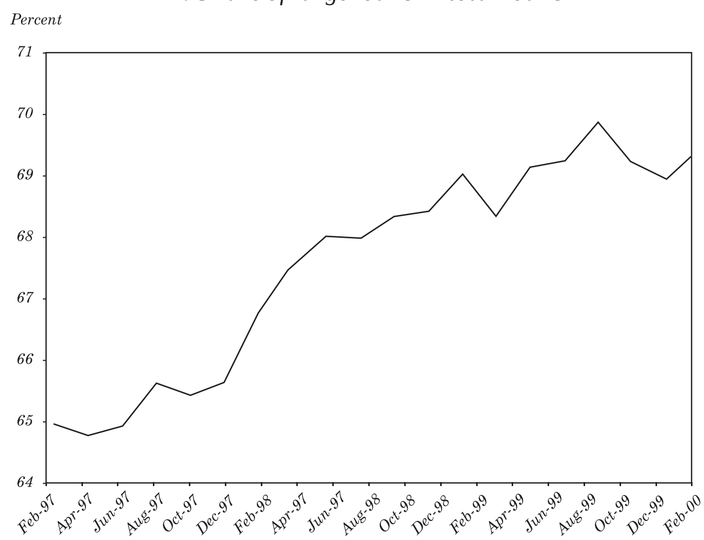
B. Foreign direct investment (FDI)



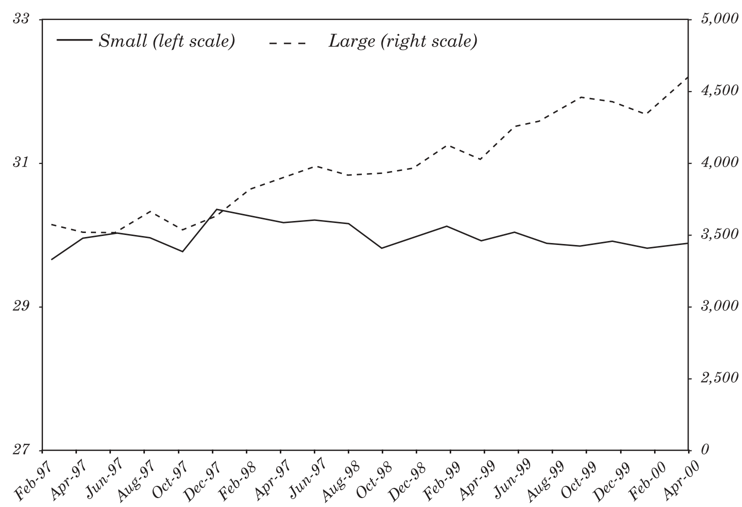
Sources: Central Bank of Chile and Bloomberg.
a. The IGPA is the general stock price index of the Santiago Stock Exchange.

Figure 14. Flight to Quality[a]

A. Share of large loans in total loans



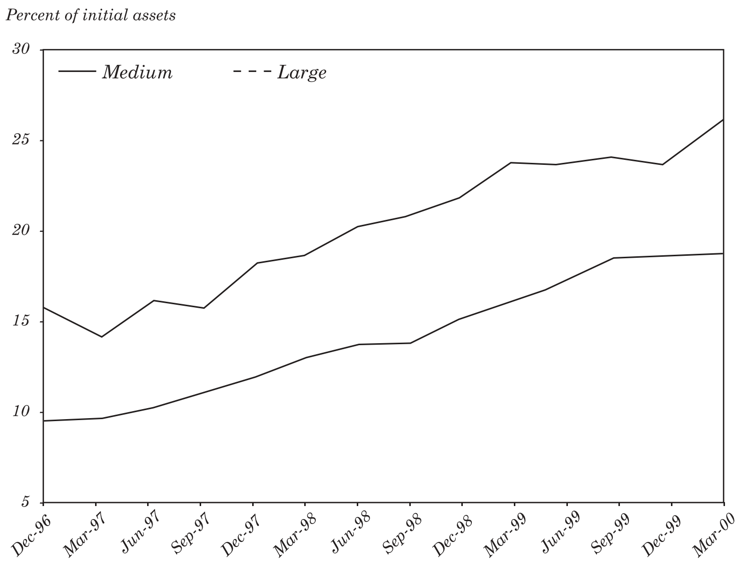
B. Average size of small and large loans



Source: Superintendencia de Bancos e Instituciones Financieras.
a. Large loans: over 50,000 UF (about US$1.4 million in 1999 dollars); small loans: between 400 UF (US$11,000) and 10,000 UF (US$280,000) . In panel B, the average size corresponds to the stock of loans in each class divided by the number of debtors.

Figure 15. Bank Debt of Publicly Traded Firms, By Size[a]

A. Bank liabilities of medium and large firms



Source: Author's calculations, based on data from the standard form *Ficha Estadistica Codificada Uniforme* (FECU), Superintendence of Securities and Insurance.

a. The sample includes all firms that continuously reported information between December 1996 and March 2000. Within this sample, the medium-sized firms (thus termed since they are larger than firms outside the sample) are those with total assets below the median level of total assets in December 1996. The series correspond to the total stock of bank liabilities at all maturities expressed in 1996 pesos, divided by the total level of assets in December 1996. The nominal values were deflated using the CPI. The total level of assets in December 1996 was US$788 million for the group of medium-sized firms and US$59.3 billion for the group of large firms.

The Chilean economy is thus still very vulnerable to external shocks despite significant institutional development over the last two decades. The main reason for this vulnerability appears to be a double-edged financial mechanism, which includes a sharp tightening of Chile's access to international financial markets and a significant reallocation of resources from the domestic financial system toward larger corporations, public bonds, and, most significantly, foreign assets.

3. Policy Considerations and a Proposal

The previous diagnostic points at the occasional tightening of an external financial constraint—especially when the terms of trade deteriorate—as the trigger for the costly financial mechanism.

3.1 General Policy Considerations

If the above assessment is correct, it calls for a structural solution based on two building blocks: measures aimed at improving Chile's integration to international financial markets and the development of domestic financial markets, and measures aimed at improving the allocation of financial resources in times of external distress and across states of nature. The first set of measures is already broadly understood, at least as an objective, and Chile is making significant progress along this dimension through its capital markets reform program. I therefore focus on the second group as the guiding principle of the policy discussion below. That is, I focus primarily on the international liquidity management problem raised by the above analysis.[17]

International liquidity management is primarily an insurance problem with respect to those (aggregate) shocks that trigger external crises. Solutions to this problem must have a contingent nature. The first step is to identify a set of shocks that captures a large share of the triggers to the mechanism described above. In the case of Chile, the terms of trade, J.P. Morgan Latin American Emerging Markets Bond Index Plus (Latin EMBI+), and weather variables represent a good starting point. The particular index chosen, however, is a central aspect of the design, and it needs to be extensively explored before it is implemented.

The second step is to identify desirable ex post transfers (perhaps temporary loans rather than outright transfers). Broadly speaking, these are simply transfers from foreign to domestic agents and from less constrained domestic agents to more constrained ones. In practice, however, the needs and availability of agents are greatly heterogeneous, which raises information requirements considerably. It is thus highly desirable to let the private sector take over the bulk of the solution, which begs the question of why this sector is not already doing as much as is needed. The answer to this question should identify the policy goals with the highest returns.

The most likely explanations can be grouped into two categories: supply and demand factors. At least three supply factors figure prominently.

Coordination problems. These arise from the absence of a well-defined benchmark around which the market can be organized.

17. See Caballero (1999, 2001) for general policy recommendations for the Chilean economy, including recommendations on the first set of measures. My objective in the current paper is instead to focus on and deepen the discussion of a subset of those policies and to add an implementation dimension.

Limited insurance capital. This situation may stem from either structural shortages or a financial constraint (in the sense that what is missing is assets that can be credibly pledged by the "insurer," rather than actual funds during a crisis). A closely related problem, but with coordination aspects as well, is that the liquidity and collateral risks faced by the insurers increase when the market encompasses an insufficient number of participants.

Sovereign (dual-agency) problems. Although contracts are signed by private parties, government actions affect the payoffs of these contracts.[18]

Demand factors, in turn, also account for at least three sources of underinsurance.

Financial underdevelopment. This leads to a private undervaluation of insurance with respect to aggregate shocks, which depresses effective competition for domestically available external liquidity at times of crises and reduces the private (but not the social) valuation of international liquidity.[19]

Sovereign problems. The government may provide explicit or implicit insurance to the private sector.

Behavioral problems. Overly optimistic market participants undervalue the need for insurance.

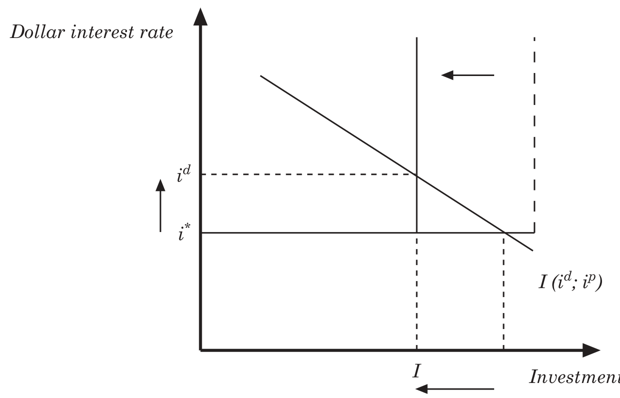
Domestic financial underdevelopment is still a problem in Chile. The solution to this problem should be pursued primarily through financial market reform. In the meantime, however, an adequate use of monetary and reserves management policy may remedy some of the underinsurance implications of this deficiency. I briefly discuss the general features of this policy in the next section. A more extensive discussion can be found in Caballero and Krishnamurthy (2001a).

At the same time, behavioral problems seem to be a pervasive human phenomenon (see, for example, Shiller, 1993). The macroeconomic implications of this factor can partly be remedied through the same mechanisms designed to address financial underdevelopment. Great care must be taken, however, not to generate a sizeable sovereign-insurance problem, which is otherwise not likely to be present in any significant amount in the case of Chile (and nor are dual-agency problems).

This process of elimination leaves coordination problems as the main focus of my policy proposal, which is discussed extensively in section 3.3.

18. See, for example, Tirole (2000).
19. See Caballero and Krishnamurthy (2001b, 2001c).

Figure 16. External Crisis



3.2 Monetary Policy as a Solution to the Underinsurance Problem

Figure 16 provides a stylized characterization of an external crises of the sort described above. The main problem during an emerging market crisis is well captured by the presence of a vertical external constraint. That is, external crises occur when it becomes very difficult, at the margin, for most domestic agents to gain access to international financial markets at any price. Consequently, international liquidity becomes scarce, and domestic competition for these resources bid up the dollar cost of capital, i^d, over the international interest rate faced by prime (international) Chilean assets, i^*. The dual of this crunch is a sharp fall in investment.

A few aspects of this perspective of a crisis have caused some confusion in the past. First, particularly in the case of Chile, the rise in the sovereign (or prime firms') spread is not a measure of the rise in the domestic (shadow or observed) rate, i^d; rather, it represents the rise in i^*, which in turn may tighten the vertical constraint.

Second, the country does not need to literally run out of international liquidity for the vertical constraint to bind for small and less-than-prime firms. In fact, total scarcity is seldom the case in Chile. If prime firms, banks, and the government perceive that there is a significant chance of a severe external crisis in the future, they may decide to hoard international liquidity rather than lend it domestically, even when the current domestic spread ($i^d - i^*$) is positive.

Finally, the constraint is seldom completely vertical in practice. The logic of the analysis that follows must therefore be blended with a standard Mundell-Fleming analysis. The interesting new insight, however, is still that which is related to the nonflat aspect of the supply of funds.[20]

Ex Post Optimal Monetary and Reserves Policy during a Crisis

Before discussing optimal policy from an insurance perspective, it is worth highlighting the incentives that a central bank faces during an external crisis. The main shortage experienced by the country is one of international liquidity (or collateral, broadly understood). Thus, an injection of international reserves into the market is a very powerful tool: it directly relaxes the vertical constraint on investment in figure 16, and it stabilizes the exchange rate. During an external crisis, international arbitrage does not hold because there is an external credit constraint. Domestic arbitrage, on the other hand, must hold. Peso and dollar instruments backed by domestic collateral must yield the same expected return (risk aversion aside). The domestic arbitrage condition is thus

$$i^d = i^p + \left(e - Ee\right), \tag{1}$$

where i^p denotes the peso interest rate, e the (logarithm of the) current exchange rate, and Ee the expected interest rate for the next period. In what follows, I take the latter as given, although interesting interactions arise when this expectation is affected by policy (see Caballero and Krishnamurthy 2001a).

Rearranging equation 1 yields an expression for the exchange rate:

$$e - Ee = i^d - i^p, \tag{2}$$

which shows that as i^d falls with the injection of reserves, the exchange rate appreciates for any given peso interest rate.

20. Part of the explanation of the diagonal shape, in practice, is that the currency depreciates as i^d rises. If exports are an important dimension of the country's international liquidity, then a depreciation increases international collateral.

The effectiveness of reserve injections in boosting investment and protecting the exchange rate contrasts sharply with the impact of an expansionary monetary policy. The main problem during an external crisis is the lack of international—rather than domestic—liquidity. Domestic liquidity facilitates domestic loans; hence the role of i^p in the investment function in figure 16 (given i^d, lower peso interest rates raise investment demand). Domestic liquidity does not, however, relax the binding international financial constraint, to a first order. Consequently, an expansionary monetary policy is not effective in boosting real investment in equilibrium. Its main impact is, instead, to raise domestic competition for the limited international liquidity; hence i^d. By equation 2, this means that the exchange rate depreciates sharply, as it must not only offset the reduction in i^p (the standard channel), but also absorb the rise in i^d.

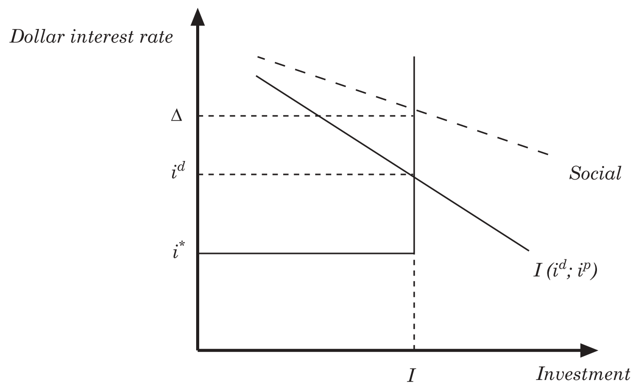
A central bank that has an inflation target and that is concerned with the impact of the exchange rate on that target will thus prefer to tighten monetary policy. Doing otherwise does not have much real benefit during a crisis, and it can lead to a sharp exchange rate depreciation.

Ex Ante Optimal Monetary and Reserves Policy during Crisis

If the central bank could commit to a monetary policy ex ante, would it still choose to tighten during a crisis? The answer is no. The primary problem is the private sector's underinsurance with respect to aggregate external shocks. The amount of international liquidity that the country has during an external crisis may be exogenous at the time of the crisis, but it is not exogenous ex ante. It depends on several factors, including how much international borrowing occurred during the boom years, the maturity structure and denomination of that debt, the contingent credit lines contracted, and the sectoral allocation of investment. Underinsurance means that these decisions did not fully internalize the social cost of sacrificing a unit of international liquidity. Figure 17 captures this gap by adding a social valuation curve to figure 16. The gap $\Delta - i^d$ captures the undervaluation problem. In other words, if the private sector's expected value of a unit of liquidity had been Δ as opposed to i^d, then private investors would have hoarded more international liquidity and the vertical constraint during the crisis would have shifted to the right.

Thus, while an expansionary monetary policy during a crisis is unable to boost investment, the anticipation thereof is. If private agents

Figure 17. Underinsurance



anticipate such a policy, they will expect a higher i^d and hence will make ex ante decision more in line with those of the social planner. In this context, the main role of monetary policy is one of incentives rather than one of liquidity provision.

What about international reserve injections? They are still optimal ex ante, but the fall in i^d they bring about has a perverse incentive effect that also needs to be offset by the expansionary monetary policy.

Before concluding this section, I mention two caveats. First, a related but distinct type of monetary policy ineffectiveness arises during the recovery phase of an external crunch. While international liquidity may no longer be the binding constraint in this phase, a new constraint arises in the form of the lack of domestic collateral among SMEs—lost during the international crunch. An expansionary monetary policy in this case injects resources into the banking system, but it does not reach SMEs, since the binding constraint is not the availability of loanable funds.

Second, I have taken *Ee* as given throughout. If this is not warranted, in the sense that the commitment to a post-crisis inflation target is not sufficiently credible and is seriously compromised by policies during the external crunch, then monetary policy may not be an available incentive mechanism. Having lost the latter, the authorities may have to resort to much costlier incentive mechanisms such as capital controls. This is not the case in Chile today.

3.3 Creating a Market: Issuing a Benchmark-Contingent Instrument

As mentioned above, another key factor behind underinsurance is simply a coordination problem. While there are many ways to hedge and to hoard international liquidity, they tend to be cumbersome and costly for most, especially when the goal is to obtain long-term insurance. The basic proposal here is extremely simple: the Central Bank or, preferably, one of the international financial institutions should issue a financial instrument—a bond, for now—that is contingent on the shocks identified in step one in section 3.1. Ideally, this bond should be free of other risks and thus should be underwritten by a reputable first issuer. The issue should be significant enough to attract the participation of international institutional investors, which would generate its liquidity. Some of the desired insurance will be achieved directly by this bond, but its main purpose is simply to create the market. With the basic contingency well priced, the private sector will find it substantially simpler to engineer its own contingent instruments.

The contingency generated via this mechanism addresses only the expected differential impact of the aggregate shocks contained in the index. Individual agents will generate heterogeneity in their effective hedging through their net positions rather than through a change in the specific contingency.[21] Other, more idiosyncratic underinsurance problems are also welfare reducing, but they are less connected with aggregate stabilization, which is the concern of this paper.[22]

In principle, the question of how responsive the contingency should be to the underlying insurance factors or indexes is irrelevant, since the private sector should be able to develop the derivative markets that can generate any slope they may need. In practice, however, financial constraints and liquidity considerations suggest otherwise. The bond contingency should therefore be very steep, so as to minimize the leverage and derivative instruments required to generate an appropriate amount of insurance for large crises. The counterpart will probably be

21. See Shiller's (1993) seminal work on promoting the creation of macromarkets as a mechanism for insuring microeconomic risks. While much of his reasoning also applies in the context I discuss, my ultimate focus is on the equilibrium (macroeconomic) benefits of microeconomic insurance with respect to macroeconomic shocks, rather than on the direct microeconomic welfare-enhancing features of such insurance.

22. Insurance against aggregate shocks is also more likely to support a market instrument as its solution, as opposed to more expensive (less liquid) individually tailored insurance contracts.

a very limited insurance against small and intermediate shocks, which should be fine since these shocks seldom trigger the financial amplification mechanism highlighted in this paper.

How much insurance does a country need? This question is not easy to answer because it involves many general equilibrium considerations. Even so, a very conservative answer for a full-insurance upper bound should not be very far from the partial equilibrium answer. Crises deep enough to trigger the complex scenarios recently experienced by Chile are probably once-in-a-decade events; the estimates presented earlier on the shortfall of resources indicate that they probably involve about US$5 billion a year and last for at most two years. (Longer recessions probably stem from the damage created by the lack of insurance, rather than the direct effect of the external shocks.) The required insurance is only a fraction of this shortfall, however, since these resources need only be lent, not transferred. If I conservatively assume that the average (shadow, not sovereign) spread on Chilean external debt rises by 600 basis points, then the required insurance is effectively US$300 million per crisis year (with the loan commitment or credit line). Combining all these factors puts the fair price of full insurance at around US$60 million a year. Of course, prices for this type of insurance are never fair, but the point of this back-of-the-envelope calculation is that the amounts involved are not large.

Mapping the above onto the size of the contingent bond issues required depends on the slope of the contingency, the amount of insurance required (full insurance is highly unlikely to be optimal), and other design issues. The benchmark bond should represent only a small fraction of the total amount, since the private sector should follow suit. The issue cannot be too small, however, since it needs to be liquid enough from the outset.

The above discussion refers to the insurance between foreign and domestic agents, but a substantial amount of domestic insurance is also needed. Large corporations with better access to international financial markets should be able to profit from arbitraging their access to smaller domestic firms, rather than moving inward to borrow in the domestic markets during time of distress, as happened in the recent episode. The domestic banking system is probably the natural institution for administering this side of the contingent strategy, which would probably require regulatory changes to accommodate this new role without causing undesirable domestic credit crunches as the index moves around.

The question arises of whether the development of such contingency has any obvious advantage over the admittedly simpler strategy of internationalizing the peso—that is, of placing abroad bonds denominated in Chilean pesos. The Central Bank is currently pursuing this strategy with the support of a recent World Bank issuance of US$105 million in peso-denominated bonds.[23] These bonds serve a role similar to that of the contingent instruments I propose in that the shocks indexing the contingency will in all likelihood put pressure on the exchange rate, but they have a clear disadvantage: because the Chilean authorities largely control the value of the peso, this contingency is unlikely to appeal to the insurers (or bond holders) as much as an exogenous contingency would. Moreover, and somewhat paradoxically, a peso-denominated bond may not only be subject to a higher premium owing to the risk of the Central Bank's manipulation of the exchange rate, but it may also prove to be a not very effective insurance mechanism if, for example, the authorities decide to dampen an exchange rate depreciation that is putting an inflation target at risk.[24]

The disadvantage of the contingent bond, on the other hand, is that it is more difficult to implement, and the risk of not finding a market for it is thus nonnegligible. It will require careful planning to design an instrument that it is not difficult to comprehend and whose contingencies are fully transparent. The experiences of previous placements of commodity-indexed bonds should be studied carefully. Although bonds with warrants on the issuer's shares have become fairly common financial instruments, bonds embedded with options on commodity prices are still relatively rare. These commodity-indexed bonds have generally been attractive to investors who would like to participate in commodity options but cannot purchase directly for regulatory or other reasons. While these instruments can be quite complex, they can always be broken down (and thus valued) as the sum of fairly standard securities.

In 1986, for example, Standard Oil of Ohio created an issue of oil-indexed notes, in which the principal payment was a function of oil prices at maturity. The holder of a 1990 note received—in addition to a guaranteed principal amount—the value of 170 barrels of Light Sweet

23. The bond was floated on 31 May 2000 for 55 billion Chilean pesos. The bonds have a five-year maturity (to be repaid on 4 June 2005) and a coupon of 6.6 percent, and they are indexed to Chilean inflation. Most of the issue was acquired by Chilean institutional investors (75 percent), while the rest was placed among international investors. Chase Manhattan International Ltd. of New York acted as the director bank.

24. This is the so-called fear of floating (Calvo and Reinhart, 2002). In principle, one could think of an optimal amount of external peso debt at which the moral hazard problem is exactly offset by the fear-of-floating effect. In practice, such a mechanism may introduce significant policy uncertainty among investors.

Oklahoma Crude Oil, with a price floor of $25 and price ceiling of $40. Investors essentially held a standard four-year bond that included a long call option with an exercise price of $25 and a short call option with an exercise price of $40.

The recent securitization of catastrophe insurance contracts in the United States similarly offers several important lessons.[25] The first placements of these instruments faced numerous obstacles, ranging from investors' lack of understanding of their contingencies to the legal obstacles stemming from, for example, the great confusion on whether to classify these instruments as bonds or as insurance and hence on which institution should regulate them. Another lesson from the catastrophe risk experience is that these bonds will probably pay a significant premium early on, but this premium should come down rapidly.[26] Since this declining path creates a natural incentive for a war of attrition in the private placement of these bonds, it reinforces the conclusion that the process needs to be started by the Chilean authorities or an international financial institution.[27]

4. Final Remarks

There is no reason to stop at financial markets. Once the contingent index has been created, contracts indexed to it can naturally arise. Chile's financial market already operates with an inflation index (the unidad de fomento, or UF), which has removed much of the uncertainty that microeconomic agents once experienced as a result of high, unstable inflation. The new contingency may be institutionalized to perform a similar role with regard to the uncertainty generated by financially amplified external shocks. For example, labor markets, such as minimum wages and temporary contracts, could be indexed to the contingent index to ease firms' financial difficulties during external crises. The structural fiscal surplus could also be indexed to free up financial resources to the private sector during those times.

Finally, regional interactions are also important. It may be worth giving up some of the benefits of specifically tailoring the instrument to Chilean needs in exchange for a much more liquid contingent bond

25. See Froot (1999).

26. The first catastrophe (or CAT) bonds, which were placed in 1997, initially paid a premium over nine times the expected loss. By 1999, that premium had steadily declined by nearly forty percent.

27. There is also some evidence that CAT options paid a lower initial excess premium than CAT bonds. See Cummins, Lalonde, and Phillips (2000).

that includes other advanced emerging economies of the region, such as Argentina, Brazil, and Mexico. It may even prove advantageous to search for co-issuers beyond Latin America, with contingency needs not too distant from those of Chile.

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The Golden Period for Growth in Chile: Explanations and Forecasts

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Chile registered a remarkable economic growth performance between 1985 and 1998, when the country's growth rate was in the top four worldwide. Equally remarkable is the fact that this high rate resulted from a sharp turnaround in economic growth. In fact, the *change* in Chile's per capita gross domestic product (GDP) growth rate between 1985–1998 and the previous fifteen years was, by far, the highest in the world. This paper follows a macroeconomic perspective to study Chile's economic growth performance in the last four decades, using regional and world trends as benchmarks for comparison. The first objective of the paper is to consider a series of questions and hypotheses to explain Chile's growth improvement. Explaining economic growth in Chile is important not only for academic reasons, but also because it could shed light on the sustainability of high growth rates in the country. Thus, a second objective of the empirical analysis is to assess what can be expected for Chile's growth rate in the future—and to identify the pre-conditions for continued growth.

Chile's outstanding macroeconomic performance in the late 1980s and 1990s has been portrayed as an example of successful market-oriented policies. As such, it has been the subject of numerous studies,

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including, for instance, Bosworth, Dornbusch and Labán (1994); Corbo, Lüders, and Spiller (1997); Perry and Leipziger (1999); and Solimano (1999). There is a large empirical literature that attempts to explain the determinants of Chile's growth achievement. We classify these articles into four categories, based on their methodology. The first group takes a time-series econometric approach. Examples include Coeymans (1999); Jadresic and Zahler (2000); and Rojas, López, and Jiménez (1997). The second group uses growth accounting to identify the relative contribution of production factors and total factor productivity (TFP). In this group are Chumacero and Fuentes (2001); Corbo, Lüders, and Spiller (1997); De Gregorio (1997); Marfán and Bosworth (1994); Meller, O'Ryan, and Solimano (1996); Roldós (1997); and Contreras and García (2002). The third category uses calibrated analytical models to study economic growth in Chile. Here we find Bergoeing and others (2001); Braun and Braun (1999); and Schmidt-Hebbel (1999). Finally, the fourth category—the one most related to this paper—uses cross-country evidence to study the Chilean experience. The most recent of these papers are Barro (1999); De Gregorio and Lee (2000); and Lefort (1997).

Most studies find that TFP played an important role in the period of high growth and the corresponding improvement over previous periods. The majority of the studies agree that external conditions, such as favorable terms of trade and greater availability of foreign capital, also contributed to the economy's improved growth performance. Some papers point to the beneficial impact of the market-friendly reforms implemented in Chile since the mid-1970s, arguing that these reforms explain the remarkable increase in total factor productivity and that they prepared Chile to make the best of the international conditions it faced.[1]

This paper belongs in the group of cross-country growth studies, which we extend along the following lines. First, we update previous cross-country research by expanding the sample period up to 1998. Second, we explicitly consider in the regression analysis the periods before and after 1985, which allows for direct evaluation of the factors behind the jump to high growth. Third, we expand the traditional empirical framework to include nonstandard variables that help explain the marked growth improvement in the last 15 years. Fourth, we present a series of stylized facts regarding the pattern, composition, and sources

1. With different emphases, of course. For example while Rojas, López, and Jiménez (1997) and Coeymans (1999) highlight trade openness, Bergoeing and others (2002) stress the role of financial reform and new bankruptcy laws.

of growth in the country relative to the Latin America region and the world, with an eye to motivating further study of growth in Chile.

Most papers based on cross-country regressions underpredict the Chilean performance during the period of high growth. For example, Barro's (1999) regression model projects a per capita growth rate of 3.4 percent per year in 1985–1995, while the actual rate was 5.0 percent. This underestimation may contaminate future projections if the Chilean residual is a feature of long-run growth, rather than a transitory phenomenon. We study this issue by including an expanded set of growth determinants in our empirical analysis.

Although we still underestimate the growth improvement in the golden period in Chile, our expanded empirical model of cross-country growth is able to explain a large fraction of this improvement (about 73 percent). Apart from the direct effect of the standard growth determinants (better education and health, deeper financial markets, less government-induced distortions, and more favorable international conditions), indicators of the quality of the political system and governance, the comprehensiveness and complementarity of policy reforms, and the availability of public services and infrastructure appear to play important roles. According to our estimates, a country that jointly implements a series of growth-promoting measures (which we call policy complementarities) gains an additional bonus of more than 1 percentage point in its growth rate, even after controlling for the isolated effect of those measures. This factor appears to be important not only in the case of Chile but also in other high-performing countries such as Ireland, Korea, the Netherlands, and Thailand.

Maintaining the high growth rates of the last fifteen years will be challenging for Chile. The strong convergence effect that results from decreasing marginal returns to capital indicates that, ceteris paribus, Chile's growth rate should start to decline. Therefore, an important task is to find new and continuing sources of growth for the country. The last part of the paper initiates the evaluation of possible growth sources by, first, projecting Chile's growth rate for the next ten years under various assumptions and, second, proposing some areas with potentially large returns, including improvements in the quality of schooling, infrastructure, technology adoption, and government efficiency.

The outline of the paper is the following. Section 1 describes the main stylized facts of growth in Chile from four different macroeconomic perspectives. We first review the long-run growth trends in the country, in Latin America, and in the world by decades from the 1960s through the 1990s. We then examine the sectoral composition of growth in Chile to determine the extent of its structural transformation. Next, we carry out a decomposition of growth in Chile into its sources related to capital accumulation, expansion of the labor force, and total factor productivity growth. Finally, we study the dynamic relationship between saving, investment, and growth, using a vector autoregression (VAR) methodology applied previously by Attanasio, Picci, and Scorcu (2000) in a cross-country panel setting.

In section 2, we attempt to explain the economic growth performance in Chile from a cross-country perspective. We follow the approach in Barro and Lee (1994) and Easterly, Loayza, and Montiel (1997), which consists of linking aggregate economic, political, and social variables to growth rates in per capita GDP for a large sample of countries. The estimated model is then used to forecast changes in the growth rate in the country and examine whether its growth performance has been close to expected values. Since our basic model is not able to fully account for the change of the growth rate in Chile, we then extend the model to incorporate a group of variables recently proposed in the endogenous growth literature.

Section 3 presents some projections for Chile's future growth based on the cross-country empirical results and using a variety of assumptions. In this connection, we also start an evaluation of further sources for growth in the country. Section 4 concludes.

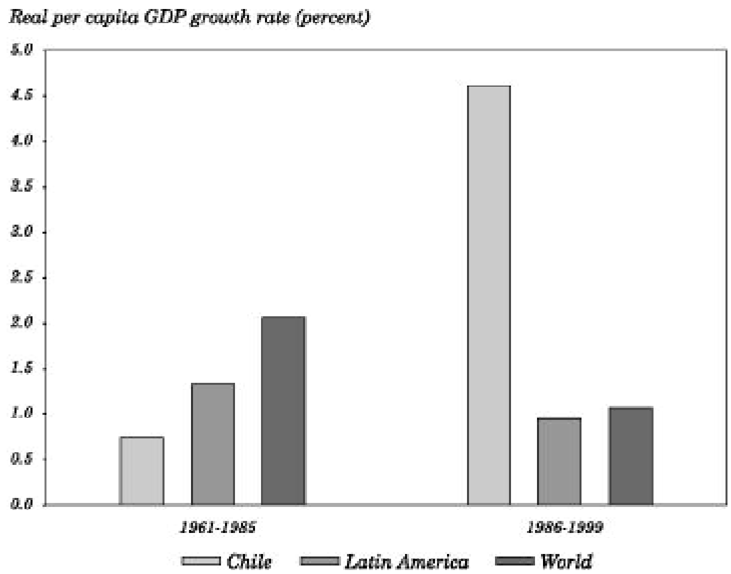
1. STYLIZED FACTS

This section describes the main characteristics of economic growth in Chile over the last four decades. We first review the long-run growth trends in the country and the world. We then examine the sectoral composition of growth in Chile and conduct an analysis of the sources of growth via Solow growth accounting. Finally, we study the dynamic relationship between saving, investment, and growth, using vector autoregressions.

1.1 Long-Run Growth Trends in Chile, Latin America, and the World

Figure 1 presents the real per capita GDP growth rate in Chile before and after 1985. For comparison purposes, it also presents the growth rates of the median countries in Latin America and the Caribbean and the world, respectively. While Chile lagged behind the typical countries in these groups in 1961–1985, its growth rate of per capita

Figure 1. Economic Growth in Chile, Latin America and the Caribbean, and the World, 1961-99



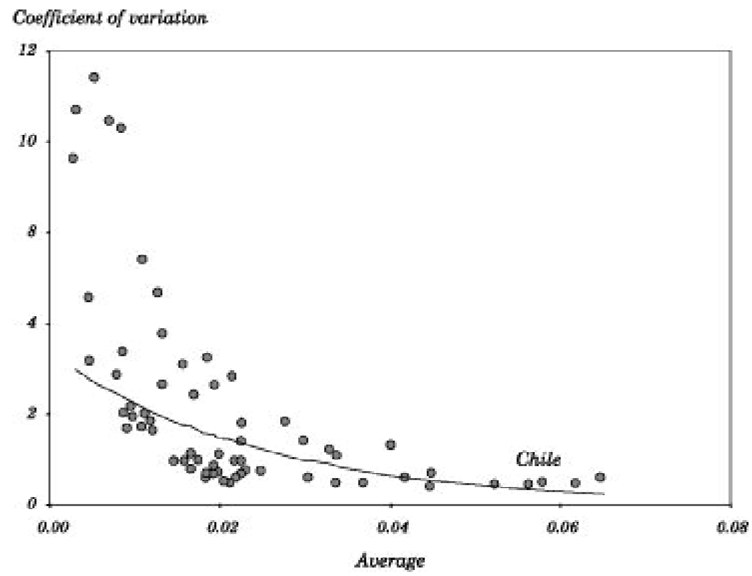
GDP soared to above 4.5 percent in 1986–1999, far surpassing the regional and world medians. Of course, Chile experienced periods of high growth prior to 1985, most notably between 1976 and 1981. Such periods were usually short-lived, however, and they were preceded and followed by sharp recessions. The golden period for growth in Chile is remarkable for its extension and stability.

In contrast to other Latin American countries, the 1980s was not a lost decade for Chile. Even though Chile's GDP fell drastically in the aftermath of the regional debt crisis and its own banking crisis, it fully recovered in the second half of the 1980s and continued to grow throughout most of the 1990s. Not only did Chile experience high growth rates, on average, after 1985, but the volatility of its growth rate was small compared with a worldwide sample of countries (see figure 2).[2]

Chile experienced a slowdown in 1998, after thirteen years of sustained high growth rates. While it is uncertain whether this represents a decrease in Chile's trend growth or a prolonged cyclical downturn,

2. The line in figure 2 demonstrates that higher growth is negatively correlated with the variability of growth rates. This point is analyzed in more detail in Fatás (this volume).

Figure 2. Average Level and Variability of the Growth Rate, 1986-1999



Chile's growth prospects for the future continue to lead the Latin America region and most emerging countries.

The increase in Chile's growth rate—not only in terms of its past performance, but also in comparison with other countries—is an important stylized fact, and as such, it must be analyzed. We do this in section 2, where we take a cross-country-regression approach to explain the changes in growth rates before and after 1985. For this, we consider the effect of various domestic and international conditions, whether policy determined or not.

1.2 Sectoral Composition of Output Growth

Table 1 presents the average output growth rates of primary, industry, and service sectors before and after 1985 in Chile. We also present growth rates by further disaggregated sectors. The increase in the growth rate after 1985 is a phenomenon shared by all major productive areas of the economy. In fact, the primary, industry, and service sectors have more than doubled their growth rates in the last fifteen years (see figure 3).

Table 1. Sectoral Output Growth in Chile, 1961–2000
Percent

Sector	*1961–2000*	*1961–1985*	*1986–2000*
Primary	4.1	2.8	6.2
Agriculture and livestock	3.2	2.0	5.1
Fishing	8.0	6.8	10.0
Mining and quarrying	4.4	3.2	6.3
Industry	3.5	2.2	5.6
Manufacturing	3.4	2.3	5.3
Construction	5.5	4.9	6.5
Gas, electricity, and water	3.0	1.0	6.4
Services	4.2	3.0	6.2
Wholesale and retail trade	4.3	2.3	7.8
Transport and communications	5.8	3.7	9.5
Banking	7.1	6.8	7.6
Public administration	2.3	1.6	3.5
Other services	2.3	2.5	1.9
GDP	4.1	2.5	6.6
Sectoral dispersion of growth rates[a]	0.43	0.59	0.38

Source: Central Bank of Chile (2001).
a. The sectoral dispersion of growth rates is measured as the coefficient of variation of the sectoral growth rates in each period.

Among the disaggregated sectors, the growth jump is particularly noticeable in the areas directly affected by the privatization of public enterprises, namely, the utilities (gas, electricity, and water) and transport and communications. However, other sectors also achieved remarkable growth. For example, banking, commerce, and construction grew by more than 6 percent per year after 1985, as did the primary activities of fishing and mining. In addition, the dispersion of growth rates by sectors declined with respect to the previous period.

Contrary to the experience of other developing countries, the primary sector in Chile did not shrink as the economy grew. In fact, in the last forty years, industry lagged behind the other sectors, albeit by a small margin. This produced a slight gain in the primary and service shares of value added at the expense of industry (see figure 4). All in all, however, economic growth in Chile has been balanced across most productive sectors, particularly in the period of high growth after 1985. This suggests that the Chilean economy is internally integrated and diversified, despite its small size.

Figure 3. Sectoral Economic Growth in Chile, 1961-2000

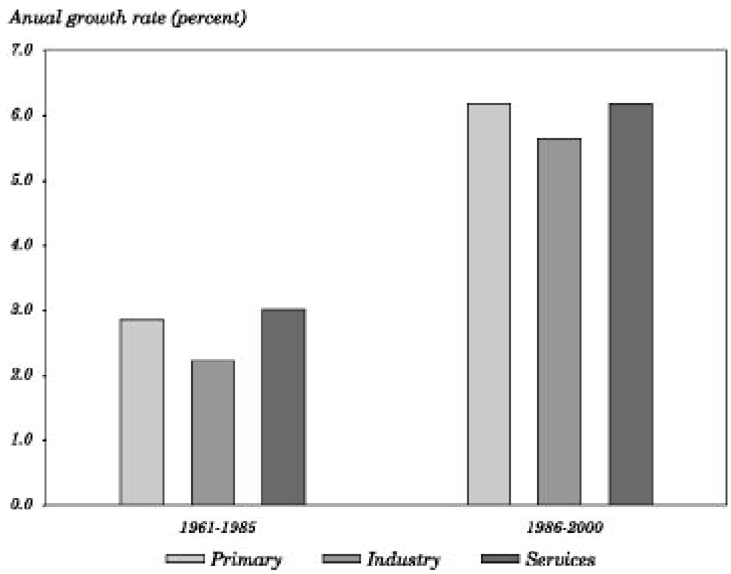
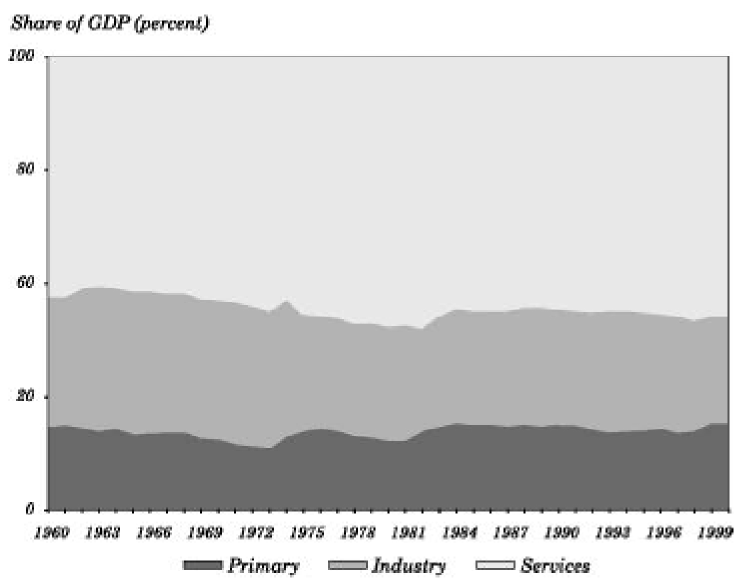


Figure 4. Composition of Chile's GDP by Sector, 1960-2000



1.3 Growth Accounting and Trends in TFP

The next stylized fact stems from a Solow-style decomposition of output growth into the contributions of capital, labor, and productivity growth. We use two methods to derive the Solow decomposition. In both, the contribution of total factor productivity is obtained as a residual once the contributions of capital and labor on output growth are imputed. The difference between the two methods is that the second adjusts for the utilization of capital and labor and adds human capital as a factor of production.

Consider a neoclassical production function that depends on physical capital, K; labor, L; and the level of total factor productivity, A. Assuming, for simplicity, a Cobb-Douglas production function, we have

$$Y = AK^{\alpha}L^{1-\alpha}.$$

To solve for the growth rate of productivity, we take logs and time derivatives. We follow the international study by Bernanke and Gurkaynak (2001) and the study on Chile by Coeymans (1999) in assuming a capital share (α) of 0.4. This yields our first Solow decomposition,

$$\text{TFP1} = \text{GDPGROWTH} - 0.4 * \text{CAPGROWTH} - 0.6 * \text{LABORGROWTH},$$

in which capital growth consists simply of investment net of depreciation, and labor growth comprises only the expansion of the working-age population.

Our second Solow decomposition involves two adjustments. First, we incorporate human capital as a factor of production, H, in the aggregate production function. Second, we control for the rate of utilization or employment of capital and labor. Following Bernanke and Gurkaynak (2001), we consider the following human-capital-augmented variation of the previous production function:

$$Y = AK^{\alpha}(HL)^{1-\alpha},$$

where H is an index of the quality of the labor force, based on its educational attainment. Following Collins and Bosworth (1996) and Bernanke and Gurkaynak (2001), for each country i we construct H_i as a weighted average of the population shares, E_{ij}, that attained educational level j.

$$H_i = \sum_j W_j E_{ij}$$

The weights W_j are based on the social returns to schooling for each educational level. Our estimates for W_j are based on Psacharopoulos (1994) for the primary, secondary, and tertiary levels of education. The data on educational attainment are from Barro and Lee (2000).

Next, we control for the extent of capital and labor employment. We adjust for the degree of capacity utilization of the capital stock by using, as a proxy, the rate of labor employment. With regard to labor, we adjust for employment by deducting from the working-age population the number of inactive and unemployed people and adjusting for the number of hours actually worked (from the Occupation and Employment Surveys carried out by the University of Chile for 1960–2000).

As before, we assume that $\alpha = 0.4$. We then solve for the second measure of growth in TFP (TFP2):

$$\begin{aligned} \text{TFP2} = {} & \text{GDPGROWTH} - 0.4 * \text{CAPGROWTHADJ} \\ & - 0.6 * (\text{LABORGROWTHADJ} + \text{HUMCAPGROWTH}), \end{aligned}$$

where CAPGROWTHADJ is the utilization-adjusted growth rate of physical capital, LABORGROWTHADJ is the employment-adjusted growth rate of labor, and HUMCAPGROWTH is the growth rate of the human capital index.

Table 2 presents the growth accounting results. The main purpose of the table is to show the differences in the sources of growth for the periods before and after 1985. Similarly, panels A and B of figure 5 present, respectively, the simple and the adjusted growth decompositions before and after 1985.

According to the simple decomposition, the increase in the GDP growth rate after 1985 was due primarily to a very large expansion of total factor productivity and secondarily to an increase in the contribution of physical capital. Whereas total factor productivity was barely a source of growth in the period 1961–1985, it became the dominant source in 1986–2000. Before 1985 labor was the most important factor behind economic growth in Chile, but its contribution fell in the more recent period in both absolute and relative terms.

Adjusting for human capital and employment considerably increases the contribution of labor to growth, particularly in the period after 1985. The working-age population increased less after 1985 than in the previous period; however, the strong increase in the employment rate and human capital after 1985 more than compensated for the weaker popula-

Table 2. Growth Accounting in Chile, 1961–2000
Percent

				Total factor productivity[a]	
Decomposition and period	*Output*	*Physical capital*	*Labor*	*TFP1*	*TFP2*
Traditional Solow residual					
Annual growth rates					
1961–1985	2.54	2.68	2.34	—	—
1986–2000	6.64	6.02	1.74	—	—
Contribution to output growth					
1961–1985	2.54	1.07	1.40	0.07	—
1986–2000	6.64	2.41	1.04	3.19	—
Solow residual with adjustments for input utilization and human capital					
Annual growth rates					
1961–1985	2.54	2.38	2.95	—	—
1986–2000	6.64	6.16	3.70	—	—
Contribution to output growth					
1961–1985	2.54	0.95	1.77	—	–0.18
1986–2000	6.64	2.46	2.22	—	1.95

a. TFP1 = Solow residual. TFP2 = Solow residual after controlling for input utilization and human capital.

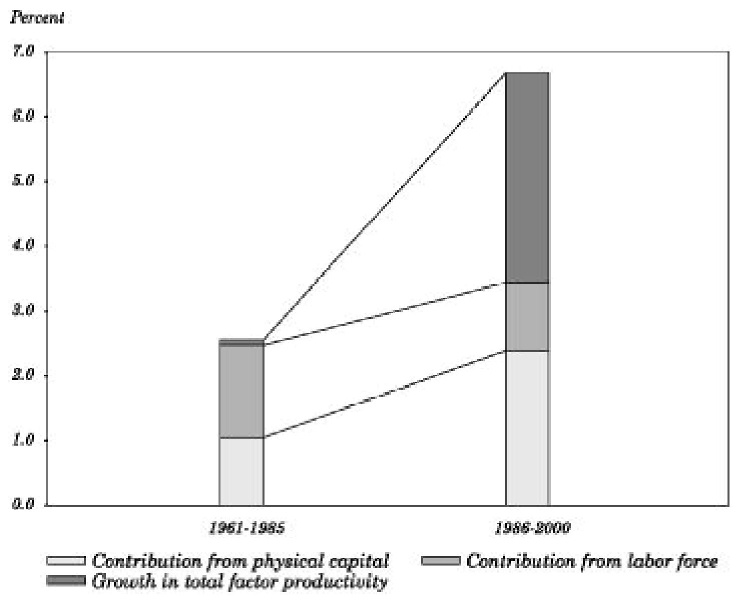
tion increase.[3] Likewise, the adjustment for capacity utilization raises the contribution of physical capital in the second period, but only slightly. After 1985 the stock of physical capital (particularly machinery and equipment) grew by more than 6 percent a year, and the rate of capital utilization expanded (rather than shrank, as happened before 1985). Correspondingly, the contribution of total factor productivity after 1985 appears to be more modest when the adjustments are taken into account than otherwise. Indeed, the three sources of growth appear to contribute similar shares after 1985. Even so, while the contribution of labor and, specially, physical capital expanded considerably from the first to the second period, the contribution of total factor productivity increased the most after 1985.

The main conclusion emerging from the growth accounting exercise is that the large increase in the growth rate between 1961–1985 and 1985–2000 was due primarily to an expansion of total factor

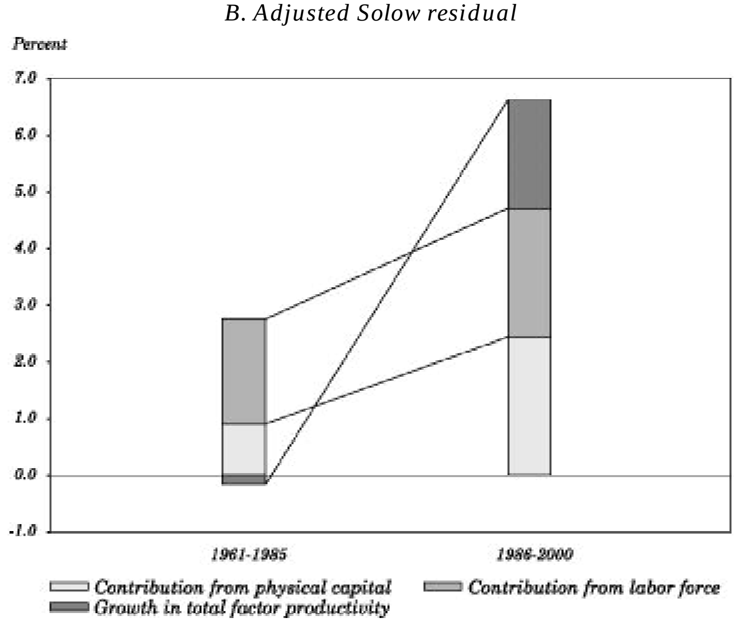
3. Improvements in input utilization and human capital from 1961–1985 to 1986–2000 are seen in the growth rates of physical capital utilization (–0.29 versus 0.14); the human-capital index (0.20 to 0.81); employment (1.59 versus 3.08); and hours worked (–0.19 versus –0.07). The unemployment rate also underwent an important change, as it increased by 7.04 percentage points in the earlier period and decreased by 1.77 percentage points in the later one.

Figure 5. Growth Accounting in Chile, 1961-2000

A. Solow residual



B. Adjusted Solow residual



productivity. Before rejecting capital fundamentalism altogether, however, we should highlight the second conclusion—namely, that after 1985, labor, capital, and TFP provide a balanced contribution as sources of growth in Chile. Physical capital, human capital, and the labor force are still the predominant factors accounting for growth in the country.

1.4 Growth, Saving, and Investment

We now explore the dynamic relationship between the growth rate and the saving and investment ratios. Following Attanasio, Picci, and Scorcu (2000), we study these relationships by running VAR systems on annual data. We consider three bivariate systems, namely, investment and growth; national saving and growth; and external saving and growth. The VARs include one lag of each variable[4]

Table 3 presents the results. The dynamic relationship between investment and growth at annual frequencies reveals that investment has a high degree of inertia and is significantly predicted by past growth. The latter result can be explained by considering that past growth creates incentives to new investment by making future growth more likely. Growth also exhibits some inertia, but surprisingly, it is not significantly predicted by past investment. Judging only by the sign of the coefficient, lagged investment appears to have a negative link with growth. This result may seem to contradict the cross-country evidence, which finds a positive effect of investment on growth. The two results are not necessarily contradictory, however, given that the dynamic relationship estimated here considers effects over relatively short horizons (a few years) while the cross-country analysis focuses on long periods. Attanasio, Picci, and Scorcu (2000) and Blomstrom, Lipsey, and Zejan (1996) find a negative (short-run) link between past investment and current growth. They offer two explanations for this result: either investment is limited by saving, which anticipates growth negatively, or growth behaves cyclically, with high growth and investment preceding low growth.

The dynamic relationship between national saving and growth in Chile is not significant at short horizons according to our estimated VARs. Both saving and growth are predicted by their respective past values, and the degree of inertia is higher in the case of saving. It is surprising that growth does not Granger-cause saving and vice versa,

4. Further lags do not enter significantly in the regressions and are thus excluded in the final estimated system.

Table 3. Investment, Domestic and Foreign Saving, and Growth in Chile[a]

	VAR (1)		VAR (2)		VAR (3)	
Explanatory variable	*Investment*	*Growth*	*Domestic saving*	*Growth*	*Foreign saving*	*Growth*
Growth (–1)	0.1580**	0.3302*	–0.1200	0.3113*	0.2525**	0.3058*
	(0.0730)	(0.1724)	(0.1553)	(0.1789)	(0.1124)	(0.1630)
Investment (–1)	0.8269**	–0.0359				
	(0.0808)	(0.1908)				
Saving (–1)			0.7747**	0.0105		
			(0.1287)	(0.1482)		
Foreign saving (–1)					0.5573**	–0.0563
					(0.1350)	(0.1958)
Summary statistics						
R^2	0.8076	0.1013	0.5359	0.1005	0.3416	0.1025
No. observations	39	39	39	39	39	39

* Significant at the 10 percent level.
** Significant at the 5 percent level.
a. VAR estimations, using annual data for 1961–2000. Savings and investment expressed as ratios to GDP. Growth rate is the real per capita GDP growth rate. Standard errors are in parentheses.

although Gallego, Morandé, and Soto (2001) find a similar result for Chile. This may indicate that cyclical effects are transmitted within the same year or that long-run relationships take horizons of substantially more than a few years to materialize (especially in a context of underdeveloped financial markets, as was the case in Chile until the 1990s).

The dynamic relationship between foreign saving and growth is more interesting. Again, both variables show significant inertia, which is higher in the case of foreign saving. Whereas foreign saving does not help predict economic growth, an increase in growth is significantly associated with a rise in foreign saving. While this result is not inconsistent with a long-run positive effect of foreign saving on domestic growth, it does indicate that in short horizons, international capital flows are driven by higher domestic returns, rather than the other way around.

The conclusion that we draw from the dynamic analysis at annual frequencies is that output growth is not Granger-caused by investment, national saving, or foreign saving, although it helps predict investment and foreign saving.

To summarize, the main stylized facts on growth in Chile are, first, that the rate of output growth became significantly higher and more stable after 1985 than in the past; second, that this high growth was not limited to a few sectors, but was shared by most of the economy; third, that the jump in economic growth after 1985 reflected mostly a large and new improvement in total factor productivity; and fourth, that changes in output growth are not preceded by changes in investment, national saving, or foreign saving. Taken together, these stylized facts suggest that the jump in growth that occurred in Chile after 1985 was driven by policies and macroeconomic conditions that affected the economy's overall productivity.

2. Determinants of Growth

This section uses cross-country comparative analysis to identify and quantify the factors behind Chile's growth improvement. We follow the approach in Barro and Lee (1994) and Easterly, Loayza, and Montiel (1997), which consists of linking aggregate economic, political, and social variables to growth rates in per capita GDP for a large sample of countries. The estimated model is then used to project the change of the growth rate in the country and examine whether its performance has been close to expected values.

The regression equation to be estimated is the following:

$$y_{it} - y_{it-1} = \alpha y_{it-1} + \beta' X_{it} + \mu_t + \eta_i + \varepsilon_{it}, \tag{1}$$

where y is (log of) per capita output, X is a set variables postulated as growth determinants, μ_t is a period-specific effect, and η_i represents unobserved country-specific factors, and ε is the regression residual. The subscripts i and t refer to country and time period, respectively.

The sample consists of a balanced panel of forty-six countries for three periods over the years 1960–1998. To smooth out transitory fluctuations, we work with averages and use periods of longer than a decade, specifically, 1960–1970, 1971–1985, 1986–1998. This partition allows us to compare growth before and after 1985, while maintaining the minimum number of consecutive observations per country (that is, three periods) required to run the instrumental variable procedure outlined below. Our sample is determined by the availability of data on relevant variables, and not by arbitrary selection. It includes twenty-two developed and twenty-four developing countries (see appendix A for a complete list). Latin America and the Caribbean is overrepresented in the sample.

The growth regression specified in equation 1 is dynamic, in the sense that it can be rewritten as a lagged dependent variable model. The inclusion of the initial level of per capita output, y_{it-1}, follows from the neoclassical growth model and captures the transitional convergence effect.[5] The time-specific effect, μ_t, allows us to control for international conditions that change over time and affect the growth performance of countries in the sample. The term η_i accounts for unobserved country-specific factors that both drive growth and are potentially correlated with the explanatory variables.

There is a large variety of economic and social variables that can be proposed as growth determinants, X. We use the variables that are most popular in the empirical growth literature given both their quality as indicators of development in specific areas and their data availability. The list of explanatory variables is as follows (see appendix B for details on definitions and sources):

—Initial level of per capita GDP, to capture transitional convergence;

—The initial average years of schooling of the adult population, to proxy for human capital in the working force;

—Life expectancy, to proxy for human capital;

—The ratio of domestic credit in the private sector to GDP, to measure financial development;

—The ratio of the trade volume (real imports plus exports) to real GDP, to measure trade orientation and dependence on international markets;

—The ratio of government consumption to GDP, to measure the burden of government size and taxation on private activity;

—The black market premium on foreign exchange, to proxy for relative price distortions and government intervention in external markets; and

—Terms-of-trade shocks, to account for the effect of international conditions on the country's trade markets.

These variables make up our basic regression model. Figure 6 shows the values of the explanatory variables in the basic model for Chile and the typical (median) country in the world before and after 1985. The basic regression cannot fully explain the change in Chile's growth rate before and after 1985. We thus augment the model by including variables related to the political system, public infrastructure, and policy complementarities. Figure 7 shows the values of these additional explanatory variables for Chile and the world median over the periods in question.

The proposed growth regression poses a couple of challenges for estimation. The first is the presence of unobserved period- and country-specific effects. While the inclusion of period-specific dummy variables

5. Transitional convergence is also possible within endogenous growth models; see Turnovsky (2000) for a review.

Figure 6. Basic Growth Determinants. 1971–1985 versus 1986–1998

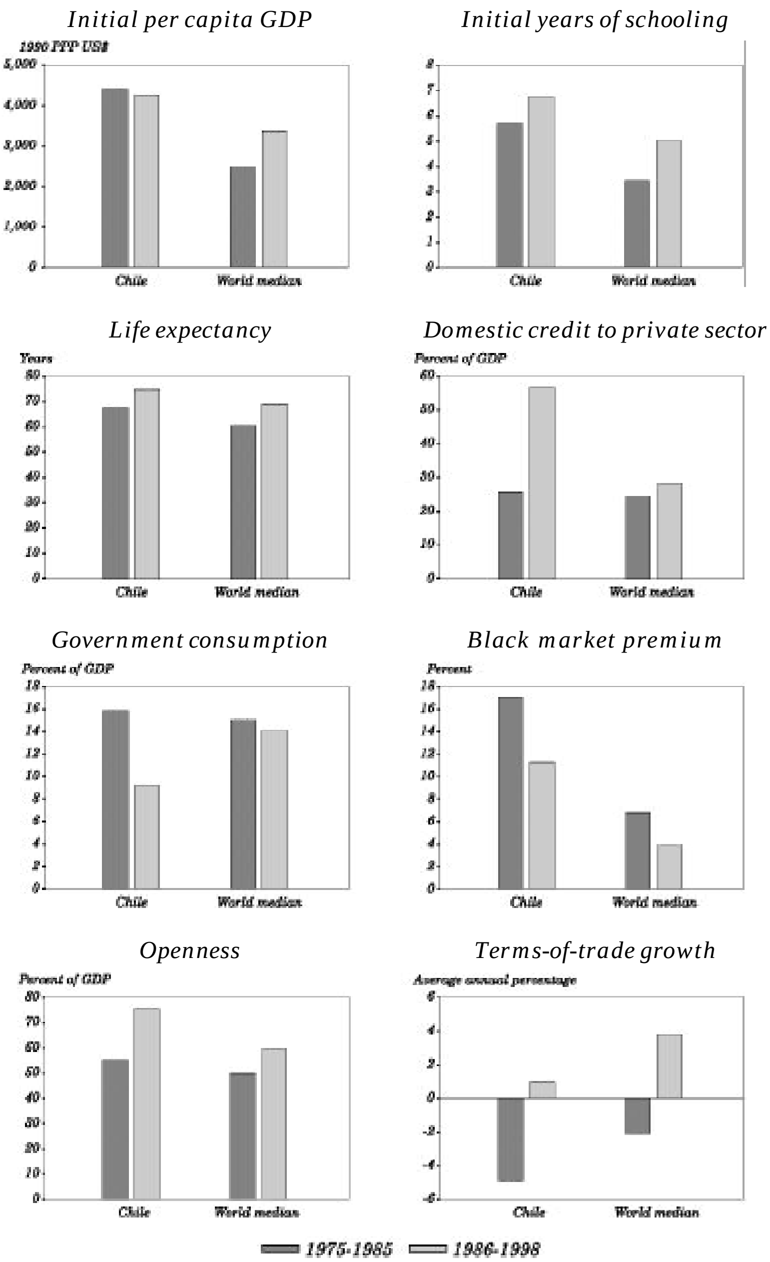
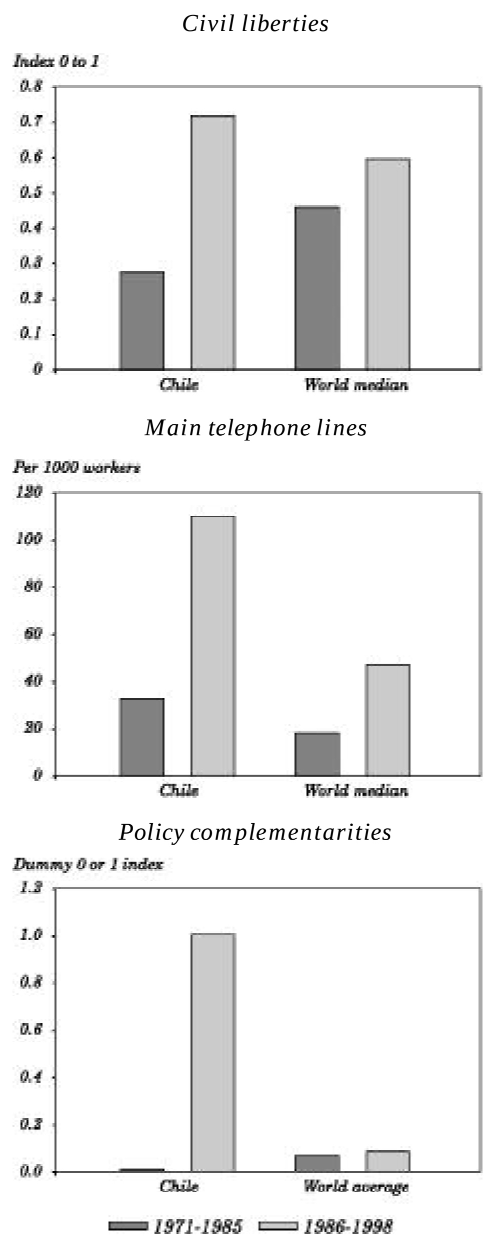


Figure 7. Additional Growth Determinants, 1971–1985 versus 1986–1998



can account for the time effects, the common methods of dealing with country-specific effects ("within" or differences estimators) are inappropriate given the dynamic nature of the regression. The second challenge is that most explanatory variables are likely to be jointly endogenous with economic growth. That is, we need to control for the biases resulting from simultaneous or reverse causation. In the following paragraphs we outline the econometric methodology we use to control for country-specific effects and joint endogeneity in a dynamic model of panel data.

2.1 Econometric Methodology

We use the generalized method of moments (GMM) estimators developed for dynamic models of panel data that were introduced by Holtz-Eakin, Newey, and Rosen (1990), Arellano and Bond (1991), and Arellano and Bover (1995). Taking advantage of the data's panel nature, these estimators are based on, first, differencing regressions or instruments to control for unobserved effects (or both), and, second, the use of previous observations of the explanatory variables as instruments (called internal instruments).

After accounting for the time-specific effects, we can rewrite equation 1 as follows:

$$y_{it} = \alpha\, y_{it-1} + \beta' X_{it} + \eta_i + \varepsilon_{it}. \tag{2}$$

We then eliminate the country-specific effect by taking first-differences of equation 2:

$$y_{it} - y_{it-1} = \alpha\left(y_{it-1} - y_{it-2}\right) + \beta'\left(X_{it} - X_{it-1}\right) + \left(\varepsilon_{it} - \varepsilon_{it-1}\right). \tag{3}$$

The use of instruments is required to deal with both the likely endogeneity of the explanatory variables and the problem that, by construction, the new error term, $\varepsilon_{it} - \varepsilon_{it-1}$, is correlated with the lagged dependent variable, $y_{it-1} - y_{it-2}$. The instruments consist of previous observations of the explanatory and lagged dependent variables. Given that it relies on past values as instruments, this method only allows current and future values of the explanatory variables to be affected by the error term. Therefore, while relaxing the common assumption of strict exogeneity, our instrumental-variable method does not allow the X variables to be fully endogenous.

Under the assumptions that the error term, ε, is not serially correlated and that the explanatory variables, X, are weakly exogenous (that is, the explanatory variables are assumed to be uncorrelated with future realizations of the error term), the GMM dynamic panel estimator uses the following moment conditions:

$$E\left[y_{it-s}\cdot\left(\varepsilon_{it}-\varepsilon_{it-1}\right)\right] = 0 \text{ for } s \geq 2;\ \text{t} = 3,\ldots,\text{T and} \tag{4}$$

$$E\left[X_{it-s}\cdot\left(\varepsilon_{it}-\varepsilon_{it-1}\right)\right] = 0 \text{ for } s \geq 2;\ t = 3,\ldots,T. \tag{5}$$

The GMM estimator based on these conditions is known as the difference estimator. Notwithstanding its advantages with respect to simpler panel data estimators, the difference estimator has important statistical shortcomings. Alonso-Borrego and Arellano (1996) and Blundell and Bond (1997) show that when the explanatory variables are persistent over time, lagged levels of these variables are weak instruments for the regression equation in differences. Instrument weakness influences the asymptotic and small-sample performance of the difference estimator. Asymptotically, the variance of the coefficients rises. In small samples, Monte Carlo experiments show that the weakness of the instruments can produce biased coefficients[6]

To reduce the potential biases and imprecision associated with the usual difference estimator, we use a new estimator that combines in a system the regression in differences with the regression in levels (developed in Arellano and Bover, 1995; Blundell and Bond, 1997). The instruments for the regression in differences are the same as above; the instruments for the regression in levels are the lagged differences of the corresponding variables. These are appropriate instruments under the following additional assumption: although the levels of the right-hand-side variables may be correlated with the country-specific effect in equation 2, there is no correlation between the differences of these variables and the country-specific effect. This assumption results from the following stationarity property:

$$E\left[y_{it+p}\cdot\eta_i\right]=E\left[y_{it+q}\cdot\eta_i\right] \text{ and} \tag{6}$$

6. An additional problem with the simple difference estimator relates to measurement error: differencing may exacerbate the bias stemming from errors in variables by decreasing the signal-to-noise ratio (see Griliches and Hausman, 1986).

$E\left[X_{it+p}\cdot\eta_i\right]=E\left[X_{it+q}\cdot\eta_i\right]$ for all p and q.

The additional moment conditions for the second part of the system (the regression in levels) are[7]

$$E\left[\left(y_{it-1}-y_{it-2}\right)\cdot\left(\eta_i+\varepsilon_{it}\right)\right] = 0 \text{ and} \tag{7}$$

$$E\left[\left(X_{it-1}-X_{it-2}\right)\cdot\left(\eta_i+\varepsilon_{it}\right)\right] = 0. \tag{8}$$

We use the moment conditions presented in equations 4, 5, 7, and 8 to employ a GMM procedure to generate consistent estimates of the parameters of interest and their asymptotic variance-covariance (Arellano and Bond, 1991; Arellano and Bover, 1995). These are given by the following formulas:

$$\hat{\theta}=\left(\bar{\mathbf{X}}'\mathbf{Z}\hat{\Omega}^{-1}\mathbf{Z}'\bar{\mathbf{X}}\right)^{-1}\bar{\mathbf{X}}'\mathbf{Z}\hat{\Omega}^{-1}\mathbf{Z}'\bar{\mathbf{y}} \text{ and} \tag{9}$$

$$\text{avar}(\hat{\theta})=\left(\bar{\mathbf{X}}'\mathbf{Z}\hat{\Omega}^{-1}\mathbf{Z}'\bar{\mathbf{X}}\right)^{-1}, \tag{10}$$

where θ is the vector of parameters of interest (α, β), $\bar{\mathbf{y}}$ is the dependent variable stacked first in differences and then in levels, $\bar{\mathbf{X}}$ is the explanatory-variable matrix including the lagged dependent variable (y_{t-1}, X) stacked first in differences and then in levels, $\mathbf{Z}$ is the matrix of instruments derived from the moment conditions, and $\hat{\Omega}$ is a consistent estimate of the variance-covariance matrix of the moment conditions.[8]

Consistency of the GMM estimator depends on the validity of the instruments. To address this issue, we consider a Sargan-type specification

7. Given that lagged levels are used as instruments in the differences specification, only the most recent difference is used as an instrument in the levels specification. Using other lagged differences would result in redundant moment conditions (see Arellano and Bover, 1995).

8. Arellano and Bond (1991) suggest the following two-step procedure to obtain consistent and efficient GMM estimates. First, assume that the residuals, e_{it}, are independent and homoskedastic both across countries and over time. This assumption corresponds to a specific weighting matrix that is used to produce first-step coefficient estimates. Second, construct a consistent estimate of the variance-covariance matrix of the moment conditions with the residuals obtained in the first step, and use this matrix to reestimate the parameters of interest (that is, second-step estimates). Asymptotically, the second-step estimates are superior to the first-step ones in so far as efficiency is concerned.

test. This test of overidentifying restrictions examines the overall validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation process.

2.2 Basic Results

Table 4 presents the basic estimation results. The Sargan test cannot reject the null hypothesis of correct specification of our model. The estimated coefficients on most explanatory variables have the expected sign and are statistically significant. First, economic growth is affected by economic characteristics of development. The growth rate thus rises with a lower initial level of output (relative convergence effect), better education and health of the population, and deeper financial markets. Although openness to international trade has a positive estimated coefficient, it is not statistically significant in the basic regression, although it becomes so in the expanded model. Second, economic growth is shaped by the country's type of government. Consequently, the growth rate rises with smaller government size and a lower black market premium (less relative price distortions). Third, current international conditions also determine economic growth, such that the growth rate is higher in countries that face positive terms-of-trade shocks. The negative and significant coefficient on the period dummy variable indicates that the period 1985–1998 was less propitious for growth throughout the world than the previous fifteen years.

Our regression model can be used to explain the changes over time in economic growth for any country in the sample. We cannot, however, explain the levels of growth, given that we do not estimate the unobserved country-specific effects (although we control for them). We are interested in assessing the extent to which our model can account for the different growth performance before and after 1985. We use the regression point estimates and the actual changes in the explanatory variables to construct the regression projections.

Our projection results for Chile and a few other Latin American countries are presented in table 5. The accuracy of the projection is not satisfactory in most cases. Only for Colombia and Mexico does the projected growth difference closely approximate its actual value. Brazil and Ecuador performed considerably below what the regression projected, while Argentina, Peru, and especially Chile performed beyond their projections.

The actual improvement in Chile's growth rate after 1985 relative to the previous fifteen years was 4.74 percentage points. Our

Table 4. Determinants of Economic Growth, Basic Regression[a]

Explanatory variable	*Coefficient*	*Standard error*
Constant	0.1405	0.1543
Initial GDP per capita (in logs)	–0.0206**	0.0059
Initial average years of schooling (in logs)	0.0226**	0.0068
Life expectancy (in logs)	0.0653 *	0.0417
Domestic credit to private sector (as ratio to GDP, in logs)	0.0089 *	0.0049
Government consumption (as ratio to GDP, in logs)	–0.0772 *	0.4797
Black market premium (in log of 1 + bmp)	–0.0620**	0.0274
Openness (as ratio of exports plus imports to GDP, in logs)	0.0033	0.0063
Terms-of-trade shocks (log difference of the terms of trade)	0.1912**	1.7153
Dummy 1986–98 versus 1970–85	–0.0127**	0.0031
Summary statistics		
Sargan test (*p* value)[b]	0.152	
No. countries	46	
No. observations	138	

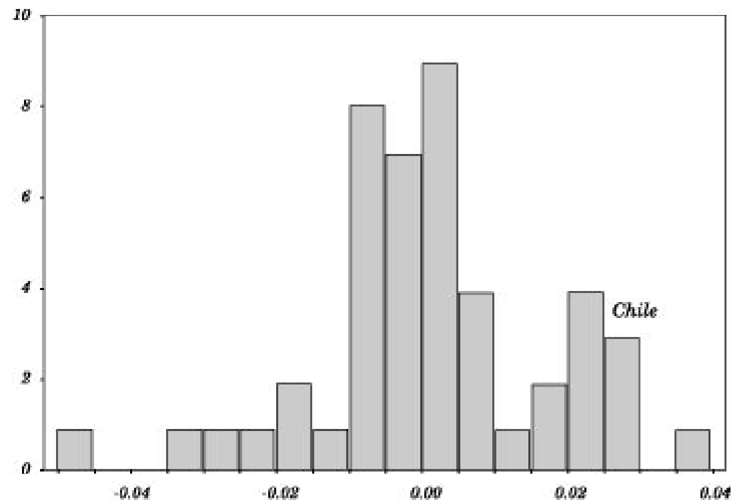
* Significant at the 10 percent level.
** Significant at the 5 percent level.
a. The dependent variable is the growth rate of per capita GDP. The estimation technique is the GMM-IV system estimator described in Arellano and Bover (1995).
b. The null hypothesis is that the instruments are valid.

Table 5. Comparison of Actual and Projected Growth Changes for Selected Latin American Countries, Basic Regression
1986–1998 versus 1970–1985
Percent

Country	*Actual*	*Projected*	*Residual[a]*
Argentina	1.98	–0.06	2.04
Brazil	–2.87	–0.85	–2.02
Chile	4.74	2.08	2.67 +
Colombia	–0.96	–0.55	–0.41
Ecuador	–3.67	0.91	–4.58 **
Mexico	–0.81	–0.96	0.16
Peru	0.76	–0.75	1.51

** indicates that the residual is different from zero at the 5 percent significance level.
+ indicates that the residual is different from zero at the 12 percent significance level.
a. The standard deviation for the residuals is 1.6478% for the 1986–1998 period.

Figure 8. Histogram of Residuals, Basic Regression



basic regression can account for only about 45 percent of the growth acceleration. The growth residual for Chile is 2.67 percentage points. This is one of the highest residuals of the sample, lying in the 12 percent upper tail of the distribution (see the histogram of residuals in figure 8.)

In the first column of table 6, we assess the contribution of each explanatory variable to the projected difference in Chile's growth rate. (The second column presents the same exercise for the expanded regressions; the results are discussed below.) The variables that represent international conditions had contrasting effects that almost cancel each other: while positive terms-of-trade shocks contributed to more than a 1 percentage-point increase in Chile's growth rate after 1985, negative international growth conditions subtracted more than 1 percentage point over the same period. The combined effect of the human capital variables (education and life expectancy) was slightly over 1 percentage point. The increased depth of Chilean financial markets contributed about 0.75 percentage points to the growth acceleration, and a similar contribution resulted from the combined effect of the reduction in the government distortion variables (government consumption and black market premium). The conditional convergence effect actually played in favor of growth after 1985, given that the initial level of per capita income in this period was slightly lower than in the early 1970s.

Table 6. Sources of Growth: Change in Contribution to per Capita Growth Rate, 1986–1998 versus 1971–1985
Percent

Source of growth	*Basic regression*	*Expanded regression*
Actual change in growth	4.74	4.74
Projected change in growth	2.08	3.47
Initial per capita income	0.07	0.14
Initial average years of schooling	0.38	0.37
Life expectancy	0.63	1.08
Domestic credit to private sector	0.72	0.15
Government consumption	0.50	0.70
Black market premium	0.32	0.45
Openness	0.11	0.39
Terms-of-trade shocks	1.13	0.91
Time dummies	–1.27	–2.34
Civil liberties	—	0.70
Main telephone lines	—	0.53
Policy complementarities	—	1.26
Residual	2.67	1.27
Residual for Chile, alternative regressions	*Residual*	*P value*
Simple (table 4)	2.67	0.120
Civil liberties (table 7, col. 1)	2.34	0.354
Main telephone lines (table 7, col. 2)	2.43	0.263
Policy complementarities (table 7, col. 4)	1.78	0.333
All (table 7, col. 5)	1.49	0.544

2.3 Expanded Regression Model

Given that the basic model could not explain more than half of the growth improvement in Chile after 1985, we now expand the regression model, still following a cross-national approach. We consider three aspects of economic reform and development that have received considerable attention in the recent literature. The first area concerns the political system and governance. This large area comprises several aspects of the institutional quality of government, including respect for civil and political rights, bureaucratic efficiency, absence of corruption, enforcement of contractual agreements, and prevalence of law and order. After the seminal work by Mauro (1995) and Knack and Keefer (1995), the political system and governance have received increasing attention as a key determinant of economic growth; see, for instance, Barro (1996), Kaufmann, Kraay, and Zoido-Lobatón (1999b), and the survey in Przeworski and Limongi (1993). The recent empirical growth literature uses various subjective indices to measure different aspects of the political system and governance and compare them across countries and over time. In general, these indices are highly mutually correlated, which suggests that the underlying processes they measure are very interdependent. We use the popular Gastil's civil liberties index from Freedom House as representative of all measures of political system and governance. In robustness exercises, we also consider the indices produced by Business Environmental Risk Intelligence (BERI) and by Political Risk Services in their publication, *International Country Risk Guide* (ICRG). The correlation coefficients between Gastil's index and the BERI and ICRG indices are 0.69 and 0.78, respectively, and the correlation between any of the three variables and their first principal component is at least 0.90.

The second area involves the availability of public services and infrastructure. The importance of productive public services in generating long-run growth has been highlighted in the theoretical work of Barro (1990) and Barro and Sala-i-Martin (1992), among others. Such studies use a variety of strategies to model the role of public services. Some treat government services as classic public goods, while others consider that they may be subject to congestion. In some models, public services and infrastructure enter directly as inputs of the production function, while in others they serve to improve total factor productivity, and in still others public services affect the expected rate of return on investment by protecting property rights. In any case, their theoretical importance has been well established. Empirical studies confirm this conclusion. The work by Loayza (1996) and Calderón, Easterly, and Servén (2001) provides evidence on the positive role of public services and infrastructure in promoting economic growth.

There are a few alternative measures of public services and infrastructure. Among them, the variables with the largest cross-country and time-series coverage focus on the provision of infrastructure. We choose to work with telecommunications capacity, measured by the number of main telephone lines per capita. In robustness exercises, we consider alternative aspects of public infrastructure, namely, energy generation capacity (as megawatts of electricity produced per capita) and transport facilities (as kilometers of paved roads per capita). The correlation coefficient between telephone lines and electricity generated and paved roads are 0.80 and 0.72, respectively. The correlation between any of the three variables and their first principal component is at least 0.90.

The third area deals with the comprehensiveness and complementarity of policy reforms. The main idea is that joint progress in the determinants of growth carries a premium over and above the sum of their independent effects on growth. This premium is derived from the positive interactions and synergies that occur among the factors that promote economic growth. The early theoretical work by Hirschman (1958) shows how stronger linkages among various productive sectors can lead to higher economic growth. Levine and Renelt (1992) emphasize the growth impact of groups of policies working jointly. More recently, Ortiz (2001) and Acemoglu and Zilibotti (2001) underscore the interaction between human capital and technological adoption in producing productivity improvements. Dollar and Burnside (2000) stress the connection between institutional development and external aid in the growth process of poor economies, while Aziz and Wescott (1997) empirically measure the premium derived from joint progress in several areas and its importance in explaining growth differences across countries. These are only a few examples of a rich literature that stresses the interactions among various factors such as foreign direct investment, education, institutional development, and financial depth in generating a growth premium.

As a proxy for the joint progress in policy-related growth determinants (that is, policy complementarities), we use a dummy variable that takes the value of 1 in countries where all measures of a set of policy indicators have values better than the corresponding world median, and 0 otherwise. These indicators are taken from the basic model's explanatory variables, and they are related to openness, the black market premium, government consumption, financial development, life expectancy, and education. In the last period (1986–1998), the countries with a value of 1 in the policy complementarities dummy variable are Belgium, Chile, Ireland, Korea, the Netherlands, the Philippines, and Thailand.[9]

As shown in Figure 7, Chile's improvement in civil liberties, the number of telephone lines per capita, and the policy complementarities binary indicator in the periods 1970-85 and 1986-1998 is nothing short of remarkable.

Table 7 presents the results of the expanded regressions. In the first three columns, each of the additional explanatory variables is included in turn. The fourth column includes all of them jointly. Civil liberties, telephone lines per capita, and the dummy variable for policy

9. In 1960–1970, they are Belgium, Japan, and Norway; in 1971–1985, they are Greece, Ireland, Israel, Japan, the Netherlands, and Spain.

Table 7. Determinants of Economic Growth, Expanded Regression[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*
Constant	0.1465	–0.0438	0.1942	0.2284
	(0.1385)	(0.1397)	(0.1553)	(0.1589)
Initial per capita GDP	–0.0182**	–0.0534**	–0.0191**	–0.0427**
(in logs)	(0.0065)	(0.0079)	(0.0039)	(0.0064)
Initial average years of schooling	0.0181**	0.021248**	0.0222**	0.0219**
(in logs)	(0.0088)	–0.00657	(0.0069)	(0.0058)
Life expectancy	0.0418	0.1890**	0.1961**	0.1126**
(in logs)	(0.0453)	(0.0305)	(0.0576)	(0.0293)
Domestic credit to private sector	0.0086*	0.0080*	0.0037	0.0019
(as ratio to GDP, in logs)	(0.0048)	(0.0050)	(0.0035)	(0.0051)
Government consumption	–0.0682	–0.1136**	–0.0531*	–0.1072**
(as ratio to GDP, in logs)	(0.0463)	(0.0488)	(0.0332)	(0.0342)
Black market premium	–0.0443*	–0.0841**	–0.0696**	–0.0857**
(in log of 1 + bmp)	(0.0232)	(0.0225)	(0.0267)	(0.0177)
Openness (as ratio of exports	–0.0015	0.0150**	–0.0031	0.0120**
plus imports to GDP, in logs)	(0.0056)	(0.0046)	(0.0050)	(0.0029)
Terms-of-trade shocks	0.1613**	0.1799**	0.1961**	0.1540**
(log difference of the terms of trade)	(0.0497)	(0.0365)	(0.0576)	(0.0300)
Dummy 1986–1998 vs. 1970–1985	–0.0098**	–0.0272**	–0.0122**	–0.0216**
	(0.0032)	(0.0034)	(0.0023)	(0.0025)
Civil liberties (Gastil)	0.0182**	—	—	0.0161**
	(0.0084)	—	—	(0.0080)
Main telephone lines	—	0.0820**	—	0.0690**
(as lines per 1000 workers)	—	(0.0150)	—	(0.0130)
Policy complementarities	—	—	0.0147*	0.0126**
	—	—	(0.0084)	(0.0052)
Summary statistics				
Sargan test (*p* value)[b]	0.126	0.668	0.248	0.858
No. countries	46	46	46	46
No. observations	138	138	138	138

* Significant at the 10 percent level.
** Significant at the 5 percent level.
a. The dependent variable is the growth rate of per capita GDP. The estimation technique is the GMM-IV system estimator described in Arellano and Bover (1995). Standard errors are in parentheses.
b. The null hypothesis is that the instruments are valid.

complementarities enter significantly in their respective regressions and with a positive sign that denotes a growth-improving effect. The sign and significance of their growth effects are maintained when the three variables are jointly included in the regression, although the point estimates are somewhat reduced. The estimated coefficients on the other variables have the same sign as in the basic model, but their size and significance changes in a couple of cases. The coefficient on openness increases in size and becomes statistically significant, while the opposite occurs with the ratio of private domestic credit to GDP.

We also conduct robustness exercises on the additional variables of the expanded model.[10] For the political system and governance, we replace the civil liberties index with, in turn, the ICRG index, the BERI index, and the first principal component of the three indices. In each case, the estimated coefficient is positive and statistically significant. For public services and infrastructure, we replace the number of telephones per capita with, in turn, the measures of paved roads and electricity generation, as well as the first principal component of the three infrastructure indicators. The corresponding estimated coefficient is positive in all cases, but it is statistically significant only when the number of telephone lines and the first principal component are used. Finally, for the policy complementarities indicator, we run the regression excluding Chile from the sample to dispel fears that it may be simply representing a Chile-specific dummy variable. The results are basically unchanged, and the estimated coefficient on policy complementarities remains significantly positive and even increases in absolute value.

With the additional explanatory variables, we reassess the regression's ability to account for Chile's growth improvement after 1985 relative to the previous fifteen years. The corresponding results are presented in the second column of table 6. By including the variables on the political system and governance, public services and infrastructure, and policy complementarities, we can account for 73 percent of the growth improvement. The contribution of public infrastructure to the growth acceleration in Chile is similar to the contribution of the increase in openness, the expansion of education, or the diminution of the black market premium. The contribution of civil liberties is even higher, on the level of the reduction in government consumption. The most remarkable result in the expanded regression is the large contribution of policy complementarities, which at 1.26 percentage points surpasses that of larger positive terms-of-trade shocks and enhanced

10. The results of these exercises are available on request.

life expectancy. This indicates that a comprehensive reform strategy that targets all policy fronts carries an important premium over the positive, independent effect of isolated policy improvements. It appears to be an important growth determinant in other high-performing countries, such as Ireland, Korea, the Netherlands, and Thailand.

Although the additional variables have improved the regression's explanatory power, we still fail to account for about 27 percent of the actual increase in the Chilean growth rate after 1985. A cross-country approach is unlikely to advance any further in this regard. We have already included the most relevant variables for this type of econometric exercise, and other variables are likely to be highly correlated with those already present in the model. Still, one possibility is that we have left out some important variables that are difficult to measure and that relate specifically to Chilean economic development. A more likely explanation, however, is that some of the growth gains after 1985 do not reflect long-run developments, but rather represent a cyclical recovery from the recessionary periods of the early 1970s and early 1980s.[11]

3. Growth in the Future

What can Chile expect in the way of economic growth in the future? Put differently, what is Chile's growth potential? A proper answer to these questions calls for a comprehensive, multifaceted approach. Here, we address the issue of Chile's future growth from the perspective of cross-national empirical results. We use the estimates obtained in our cross-country, panel regressions to forecast economic growth in Chile in the next ten years, working under alternative assumptions for the behavior of the variables that drive growth.

We begin by projecting growth under the assumption that the explanatory variables continue their past trends into the next decade. First, we estimate a linear, logarithmic, or quadratic trend—whichever provides the best fit—to each explanatory variable. The exceptions are initial per capita income and average years of educational attainment, for which we simply take a value at the start of the forecasting period (specifically, an average of the years surrounding 2000). A third exception concerns the black market premium on foreign exchange; in this case we assume that the current exchange rate policies (free-floating system

11. Another potential explanation has to do with error of measurement in GDP. Preliminary estimates show that in 1997–1998, the old National Accounts overestimated GDP growth by roughly 0.75 percent per year.

with a liberal capital account) remain unchanged into the next decade. Second, we use the estimated regression coefficients to project the contribution of each variable to growth in the next decade. The results are presented in the first panel of table 8. The first column shows the values of the explanatory variables corresponding to the period 1986–1998, and the second column shows their respective values used in the growth projection for the next decade. The last two columns present the growth forecast under the simple and expanded models, respectively. The main conclusion from this exercise is that if the evolution of growth determinants follows the same trends as in the past, the per capita GDP growth rate in the next decade will be between one-half and three-quarters of a percentage point less than it was during 1986–1998.

Under this "continuing trend" assumption, therefore, we project a slight decrease in Chile's growth rate. The fall in the growth rate occurs despite an improvement in most explanatory variables. The only variable that is projected to reduce growth is the terms of trade, which are expected to present less favorable shocks in the future. Improvements in human capital, government efficiency, the financial market, and particularly public infrastructure are projected to have a beneficial impact on economic growth. However, this combined positive effect is not large enough to overcome the forces of conditional convergence stemming from decreasing marginal returns. The fact that the initial income in 2001 is more than twice as large as the initial income in 1986 weighs heavily against growth in the next decade.

Our second projection for Chilean growth in the next decade is based on the assumption that Chile is able to jump to at least the ninetieth percentile of the world distribution for each variable that drives growth in our model. This sharp progress is admittedly unrealistic because improvements in human capital, government efficiency, infrastructure, financial depth, and governance take a long time to materialize and are usually accompanied by increases in income, which in turn lead to lower growth. The exercise may be valuable, however, because it helps establish some upper bounds for what can be expected for growth in Chile under a strong process of development and economic reforms.

The second panel of table 8 presents the results of the second projection. According to the basic model, by accessing the top 10 percent in growth determinants, Chile would obtain 0.24 percentage points higher growth than in the past fifteen years. This growth acceleration would mainly be due to improvements in schooling, financial intermediation, and reductions in price distortions (represented by the black market premium). The expanded model is even more optimistic, as it predicts

Table 8. Growth Forecasts under Different Scenarios[a]
Change in per capita growth rate

Assumption and source of growth	*Actual and projected values*		*Projected change in growth (percentage points)*	
A. Continuing trend	*Actual 1986–1998*	*Projected 2001–2010*	*Basic regression*	*Expanded regression*
Growth rate of GDP per capita (percent)	4.52		-0.45	–0.70
Initial per capita income[b]	4,236	9,702	–1.71	–3.54
Initial average years of schooling[b]	6.87	7.55	0.21	0.21
Life expectancy	74.29	77.15	0.25	0.43
Domestic credit to private sector (percent)	56.5	87.70	0.39	0.08
Government consumption (percent)	9.20	7.30	0.18	0.21
Black market premium (percent)	11.10	0.00	0.65	0.90
Openness (percent)	75.50	93.90	0.07	0.22
Terms-of-trade shocks (percent)	0.89	–1.72	–0.50	–0.40
Civil liberties	0.71	0.83	—	0.20
Main telephone lines	109.09	253.07	—	0.99
Policy complementarities	1.00	1.00	—	0.00
B. Sharp progress	*Actual 1986–1998*	*Projected 2001–2010*	*Basic regression*	*Expanded regression*
Growth rate of GDP per capita (percent)	4.52		0.24	2.04
Initial per capita income[b]	4,236	9,702	–1.71	–3.54
Initial average years of schooling[b]	6.87	9.27	0.68	0.66
Life expectancy	74.29	77.15	0.25	0.43
Domestic credit to private sector (percent)	56.50	103.40	0.54	0.11
Government consumption (percent)	9.20	7.30	0.18	0.21
Black market premium (percent)	11.10	0.00	0.65	0.90
Openness (percent)	75.50	119.7	0.15	0.55
Terms-of-trade shocks (percent)	0.89	–1.72	–0.50	–0.40
Civil liberties	0.71	1.00	—	0.46
Main telephone lines	109.09	494.79	—	2.66
Policy complementarities	1.00	1.00	—	0.00
C. Sharp progress in three new areas	*Actual 1986–1998*	*Projected 2001–2010*	*Additional regression*	
Quality of education	–0.96	0.60	1.48	
Microeconomic restrictions	12.00	5.00	0.74	
Technology adoption	15.37	191.15	1.09	

a. The variables are defined as in the cross-country regressions. Panel A (continuous trend) projects growth under the assumption that the explanatory variables continue their past trends into the next decade. Panels B and C (sharp progress) are based on the assumption that Chile is able to jump to at least the ninetieth percentile of the world distribution for each variable that drives growth in the model.
b. Values for these variables correspond to the start of the relevant period.
c. Additional regressions (see table 9).

an increase in the growth rate of 2.04 percentage points. In this case, the main contributors are improvements in schooling, openness, price distortions, and, most importantly, public infrastructure.

Our search for factors that explain the remarkable growth acceleration in Chile after 1985 concentrated on those variables for which we have data for the various periods under consideration. This may have excluded some relevant variables for which only cross-country data are available. Given that our focus in this section is on the prospects for growth in Chile, we can go back to the question of what drives growth and consider variables for which we only have cross-sectional information. We thus consider three new areas. The first is the quality of education. As Barro (2001) and Hanushek and Kimko (2000) point out, the average number of years of schooling is only a rough proxy for human capital in the educational dimension. It needs to be complemented by measures of educational quality, such as those derived from standardized test scores. We use the series in Barro and Lee (2000) and Hanushek and Kimko (2000), complemented by the TIMSS international test scores, to construct an index of the quality of education for a sample of forty-two countries (see appendix B for details).

The second new area concerns microeconomic restrictions—or more precisely, the regulatory obstacles to the establishment of new enterprises. As de Soto, Ghersi, and Ghibellini (1986) vividly illustrate in their study on red tape in Peru, entry restrictions for new enterprises can be a serious obstacle to economic development. Following de Soto's ideas, Djankov and others (2000) recently constructed a measure of entry restrictions for a large sample of countries. We include this measure in our growth regressions.

Finally, the third area is related to technological adoption. Whether a country develops or copies new technologies, its capacity and willingness to assimilate new methods of production are bound to affect its growth potential (see, for instance, Young, 1989, chap. 6; Romer, 1992; Beaudry and Green, 2001; Keller, 2001). In a recent paper, Caselli and Coleman (2001) use the number of imported computers as a proxy for technological adoption in a sample of countries. We follow their example in using this measure in our growth regressions.

Our purpose here is to obtain an estimate of the beneficial growth impact of Chile's advancing in the areas of educational quality, microeconomic restrictions, and technological adoption. We first need an estimate of the effect of each of these variables on growth, which we obtain by adding each variable to our basic model, one by one. The results are presented in table 9. The estimated coefficients are significant,

Table 9. Determinants of Economic Growth, Additional Factors[a]

Explanatory variable	*(1)*	*(2)*	*(3)*
Constant	0.3889	–0.1845	0.0903
	(0.1883)	(0.1419)	(0.1661)
Initial per capita GDP	–0.0091	–0.0126**	–0.0280**
(in logs)	(0.0057)	(0.0054)	(0.0062)
Initial average years of schooling	–0.0148*	–0.0115	0.0187**
(in logs)	(0.0080)	(0.0090)	(0.0074)
Life expectancy	0.0375	0.1598**	0.1108**
(in logs)	(0.0394)	(0.0246)	(0.0393)
Domestic credit to private sector	0.0012	–0.0059	0.0048
(as ratio to GDP, in logs)	(0.0025)	(0.0041)	(0.0036)
Government consumption	0.0614**	–0.0799**	–0.0408
(as ratio to GDP, in logs)	(0.0216)	(0.0287)	(0.0312)
Black market premium	–0.0933**	–0.0752**	–0.0748**
(in log of 1 + bmp)	(0.0123)	(0.0270)	(0.0229)
Openness (as ratio of exports	–0.0007	0.0145**	0.0025
plus imports to GDP, in logs)	(0.0043)	(0.0044)	(0.0048)
Terms-of-trade shocks	0.1156**	0.1813**	0.1708**
(log difference of the terms of trade)	(0.0482)	(0.0700)	(0.0497)
Dummy 1986–1998 vs. 1970–1985	–0.0028	–0.0137**	–0.0178**
	(0.0028)	(0.0022)	(0.0027)
Quality of education	0.0095**	—	—
(as a normalized index)	(0.0049)	—	—
Microeconomic restrictions	—	–0.0011**	—
(no. procedures to open a firm)	—	(0.0005)	—
Technology adoption	—	—	0.0001**
(imported computers per worker)	—	—	(0.0000)
Summary statistics			
Sargan test (p value)[b]	0.146	0.261	0.236
No. countries	42	37	44
No. observations	126	111	132

* Significant at the 10 percent level.

** Significant at the 5 percent level.

a. The dependent variable is the growth rate of per capita GDP. The estimation technique is the GMM-IV system estimator described in Arellano and Bover (1995). Standard errors are in parentheses.

b. The null hypothesis is that the instruments are valid.

carry the expected sign, and appear to be economically important, as discussed below.[12] We should note, however, that since these coefficients are estimated considering only the basic model, part of their effect might be captured by the variables of the expanded model or the variables representing the other new areas.

Following our "sharp progress" assumptions, we measure the growth impact that the economy would experience if Chile were to jump to the top 10 percent of the world in the three new areas over the next decade. The results are presented in the third panel of table 8. A comparison of the second and first columns shows that Chile is still far behind the best countries in all three areas, particularly technological adoption. This large gap, coupled with the size of the regression coefficients, implies that Chile can make potentially large gains from advancing in the three areas, especially the quality of education. Improvements in microeconomic restrictions would increase growth by three-quarters of a percentage point; in technological adoption, by a little over one percent; and in educational quality, by close to one and a half percentage point (see column 3).

4. Conclusions

Economic growth in Chile since the mid-1980s has been remarkable for its high level and persistence. The country, however, has not been immune to the wave of international crises in the late 1990s, and many people now wonder whether the golden period of growth in Chile is a thing of the past. This paper examines the factors behind the high growth rates of the last fifteen years and analyzes the extent to which they can be sustained in the future.

To this end, we present a set of stylized facts on economic growth in Chile, which allows us to identify the issues that deserve further investigation. First, Chile's growth performance in the last fifteen years has been substantially higher and less volatile than in the typical country in Latin America and the world. For Chile, the 1980s did not represent a lost decade, as it did in most of Latin America. Second, an analysis of sectoral value added shows that high growth in Chile was balanced across sectors, which suggests that growth was prompted by suitable

12. It is interesting to note that when the quality-of-education variable is added to the basic regression, the coefficient on average years of schooling becomes negative. This could support the view that the quality of education is more important for economic growth than the quantity.

general macroeconomic conditions. Third, growth accounting exercises indicate that the expansion of growth in the latter period is driven by a combination of capital accumulation, labor expansion, and, particularly, a significant increase in TFP. Finally, dynamic analysis suggests that Chile's high growth followed—rather than preceded—domestic investment and external financing. Taken together, these stylized facts suggest that the jump in growth was driven by policies and macroeconomic conditions that affected the economy's overall productivity.

Given these stylized facts, our first analytic objective is to explain the sharp change in the growth rate in Chile after 1985. There are several potential ways to address this issue; given our comparative advantage, we chose an international perspective. On considering the large body of recent empirical growth literature, we examine the extent to which a cross-country approach can explain Chile's growth performance. We formulate a basic regression model that contains the most popular variables in the growth literature and estimate it using techniques suited for dynamic models of panel data. Our basic model allows us to explain about 45 percent of the change in the growth rate between 1970–1985 and 1986–1998, which was 4.74 percentage points. We find that the variables that represent international conditions had contrasting effects that nearly cancel each other out. The combined effect of human capital variables was slightly over 1 percentage point. The increased depth of Chilean financial markets contributed about 0.75 percentage points to the growth acceleration, and a similar contribution resulted from the combined effect of the reduction in the variables that accounted for government-induced distortions.

We then extend the basic model in a quest to explain a higher fraction of the growth acceleration. We include variables that have recently received attention in the growth literature. The expanded model explains about 73 percent of the increase in the growth rate after 1985. Improvements in the political system and public infrastructure contribute a little more than one-half of a percentage point each, while a binary indicator that served as a proxy for the comprehensiveness of policy reforms accounts for more than one percentage point of the increase in the growth rate. The last result is particularly interesting as it signals the existence of a growth premium for advancing the policy reform agenda on several fronts at the same time.

The last section of the paper assesses what can be expected with regard to growth in Chile over the next decade. Continuing with the cross-country empirical approach, we estimate that if the variables that drive growth continue their past trends into the future, the growth rate of per capita GDP in the next decade will decrease by one-half to three-quarters of a percentage point relative to the rate in 1986–1998. The growth rate would fall despite projected improvements in human capital, government efficiency, financial market, and public infrastructure because their combined positive effect is not large enough to offset the forces of conditional convergence. This fall in the growth rate could be prevented if the country follows an admittedly difficult path of sharp progress in economic reform.

Finally, we search for new sources of economic growth for a country, like Chile, that has already advanced in the basic determinants of growth. After combining the results from these rather tentative exercises with those from our basic and expanded models, we conclude that Chile can increase its future growth by focusing on the provision of public infrastructure and the enhancement of the quantity and quality of education. Improving governance, eliminating excessive regulatory restrictions, and encouraging technology adoption also appear to be promising avenues for increasing economic growth.

APPENDIX A

Sample of Countries by Region

Our sample consists of a balanced panel of forty-six countries, which we selected based on the availability of data on relevant variables and not by arbitrary selection. It includes twenty-two developed and twenty-four developing countries, with fifteen from Latin America and the Caribbean. The complete list is as follows:

- *East Asia and the Pacific (four countries)*: Indonesia, Korea, the Philippines, and Thailand.
- *High-income economies (twenty-two countries)*: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Jamaica, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States.
- *Latin America and the Caribbean (fifteen countries)*: Argentina, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Paraguay, Peru, Trinidad and Tobago, and Uruguay.
- *South Asia (one country)*: Pakistan.
- *Sub-Saharan Africa (four countries)*: Ghana, Niger, Senegal, and South Africa.

Appendix B
Variables and Sources

Variable	Definition and construction	Source
Output		
Real per capita GDP (in 1990 PPP US$)	Ratio of total GDP to total population. GDP is in 1990 US$ and is corrected to make it internationally comparable using PPP.	Summers and Heston (1991); World Bank (2000)
Real GDP (in 1986 Chilean pesos)	Constructed by splicing GDP in 1977 pesos (from National Accounts, 1960–1985) and GDP in 1986 pesos (from National Accounts, 1985–2000).	Central Bank of Chile (2001); authors' elaboration
Sectoral shares in total value added (percent of total value added)	Constructed as percentage of total value added by splicing GDP by economic sector in 1977 pesos (from National Accounts, 1960–1985) and GDP by economic sector in 1986 pesos (from National Accounts. 1985–2000)	Central Bank of Chile (2001); authors' construction
Physical and human capital		
Domestic capital stock (in 1986 Chilean pesos)	Constructed using the perpetual inventory method. Depreciation rate is 4 percent a year. We assumed a ratio of capital to GDP of 2.5 in 1940. Series of gross capital formation are taken from Bennett, Schmidt-Hebbel, and Soto (2000).	Authors' construction using Chilean National Accounts and Bennett, Schmidt-Hebbel, and Soto (2000)
Investment (percent of GDP)	Ratio of gross domestic investment (in 1986 pesos) to GDP (in 1986 pesos).	Bennett, Schmidt-Hebbel, and Soto (2000); Central Bank of Chile (2001)
National and foreign saving (percent of GDP)	Ratio of gross national (foreign) saving (in 1986 pesos) to GDP (in 1986 pesos).	Bennett, Schmidt-Hebbel, and Soto (2000); Central Bank of Chile (2001)
Labor force, total	Working-age population, taken from several surveys.	Central Bank of Chile (2001); authors' construction
Employment, total	Number of people actually working, taken from several labor surveys.	Central Bank of Chile (2001); authors' construction
Average hours worked	Average number of hours actually worked, per worker.	Occupation and Employment Surveys of University of Chile
Average years of schooling	Average number of years of schooling in the population.	Barro and Lee (2000)

Appendix B (continued)

Variable	*Definition and construction*	*Source*
Average years of secondary schooling	Average number of years of secondary schooling in the population.	Barro and Lee (2000)
Life expectancy at birth (years)	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.	World Bank (2000)
Labor force quality (index)	Normalized index constructed by combining measures of standardized test scores taken from several sources. To make it comparable each observation was normalized by subtracting each test's average and dividing by each test's standard deviation. Hence a value of *n* means the observation is *n* standard deviations distant from the test average.	Authors' construction, based on Barro and Lee (2000), Hanushek and Kimko (2000), and TIMSS (2000)
External sector		
Terms-of-trade shocks	Log difference of the terms of trade. Terms of trade are defined as customary.	World Bank (2000)
Openness (percent of GDP)	Ratio of the sum of real exports and real imports to real GDP.	Summers and Heston (1991); World Bank (2000)
Finance		
Domestic credit to the private sector (percent of GDP)	Ratio of the stock of domestic credit to the private sector to GDP.	Beck, Demirgüç-Kunt, and Levine (2000)
Government-induced distortions		
Black market premium (BMP)	Calculated as (parallel exchange rate/ official exchange rate)–1. Values for industrial countries are added as 0.	Wood (1988); *International Currency Analysis* (various issues)
Democracy and governance		
Civil liberties (index)	Defined as rights to free expression, to organize or demonstrate, and to a degree of autonomy such as is provided by freedom of religion, education, travel, and other personal rights. Countries are classified into seven categories. The original ranking from one to seven was converted here to a scale of 0 to 1, where 0 corresponds to the fewest rights (rank seven) and 1 to the most rights (rank one).	Freedom House

APPENDIX B (continued)

Variable	*Definition and construction*	*Source*
Law and order (index)	A subjective index related to the overall maintenance of the law and the legal tradition of a country. The index goes from 0 to 6, where 0 indicates the poorest maintenance of the rule of law and 6 the best.	*International Country Risk Guide* (ICRG)
Governance (index)	The simple average of the following subindexes: bureaucratic delay, contract enforceability, nationalization risk, and infrastructure quality. Each component is measured on a scale of 0 to 4.	Business Environmental Risk Intelligence
Microeconomic distortions (number)	Measure of the number of different bureaucratic procedures necessary to open a new business. It goes from 2 (the lowest value, Canada) to 20 (the highest value, Bolivia).	Djankov and others (2000)
Policy complementarities (dummy variable)	Dummy variable that takes the value of 1 if a country is above the world median in secondary years of schooling, life expectancy, domestic credit to private sector, and openness; and below the world median in government consumption and black market premium. Otherwise, the variable equals 0.	Authors' construction
Infrastructure		
Main telephone lines per 1000 workers	Telephone mainlines are telephone lines connecting a customer's equipment to the public switched telephone network. Data are presented per 1,000 workers for the entire country.	Canning (1998), International Telecommunications Union
Energy generation capacity	Electricity production is measured at the terminals of all alternator sets in a station. In addition to hydropower, coal, oil, gas, and nuclear power generation, it covers generation by geothermal, solar, wind, and tide and wave energy, as well as that from combustible renewables and waste. Production includes the output of electricity plants that are designed to produce electricity only, as well as that of combined heat and power plants. Sources of electricity refer to the inputs used to generate	Canning (1998), United Nations

APPENDIX B (continued)

Variable	Definition and construction	Source
	electricity: hydropower, coal, oil, gas, and nuclear power. Hydropower refers to electricity produced by hydroelectric power plants, oil refers to crude oil and petroleum products, gas refers to natural gas but excludes natural gas liquids, and nuclear refers to electricity produced by nuclear power plants. Data are presents as megawatts per 1000 people.	
Paved roads	Paved roads are roads that have been sealed with asphalt or similar road-building materials. Data are presented in kilometers per 1,000 people.	Canning (1998), International Road Federation
Imported computers per worker	Computer imports in US$ per worker. Computers are defined as imports of assembled computers, as well as imports of key components, such as central processing units, memory chips, storage devices, and peripherals.	Caselli and Coleman (2001)
Government		
Government consumption (percent GDP)	The ratio of government consumption to GDP.	Summers and Heston (1991); World Bank (2000)

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Growth and Adjustment in Chile: A Look at the 1990s

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In the mid-1970s, Chile was the first country in Latin America to start moving away from a model based on pervasive government intervention to one in which the market plays a central role in resource allocation and in production and consumption decisions. This move toward a market economy was accompanied by a restoration of order in the public finances in an attempt to reduce inflation to single digit levels and to put the macroeconomic situation under control. The changes accomplished since then have been dramatic. At the time the shift was instituted, the Chilean economy was highly distorted as a result of the cumulative effects of forty years of interventionist policies and disregard for the macroeconomic fundamentals. It was dominated by a very large and intrusive public sector, with severe macroeconomic unbalances that had their roots in a high public sector deficit, which reached 25 percent of gross domestic product (GDP) in 1973. Price controls and rationing were widespread, and the financial sector was repressed through the use of controls on nominal interest rates at levels that were far below inflation.

The Chilean economy went through a major political and economic crisis in the early 1970s. A deep recession in 1975 was then followed by a period of recovery and rapid growth that lasted until 1981, when a new crisis developed. After a costly adjustment effort, growth resumed

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again in 1984. The average growth rate between 1985 and 1997 was 7.4 percent, with 1997 growth at 7.4 percent. This period of high growth was interrupted in the late 1990s as a result of severe external shocks (namely, reduced capital inflows, worsening terms-of-trade, and contagion of the Asian, Russian, Brazilian, and Argentine crises) and the domestic policy response to these shocks.[1] Table 1 presents Chile's main economic indicators in the 1974-2000 period.

The post-1997 growth slowdown does not have a single cause. Several hypotheses have been put forth to explain the situation. One cites the bad luck resulting from a series of external shocks: terms-of-trade losses and a slowdown in capital inflows following the Asian crisis. Another blames the slowdown on the policy responses to the deterioration in the external environment. In particular, the inability to achieve a more balanced mix of monetary and fiscal policy during the 1997–1998 period put all the weight of reducing expenditures on monetary policy, with detrimental effects on sectors that are heavily dependent on the interest rate cost (namely, small and medium-sized enterprises and the construction sector). A related hypothesis is that the staunch defense of the exchange rate band resulted in high interest rates, with similar costs on the most exposed sectors. A final explanation is that the slowdown resulted from the completion of a high growth cycle associated with the structural reforms introduced in the 1985–1995 period. According to this last hypothesis, the favorable supply shock linked to the structural reforms of the previous twenty years unleashed a period of high productivity growth that was completed by the second half of the 1990s.

This paper evaluates Chile's macroeconomic performance in the second half of the 1990s, concentrating on the role played by each of these competing hypotheses, with a special emphasis on the first two. The rest of the paper is organized in five sections. Section 1 uses a Solow's growth accounting framework to identify the factors contributing to growth from 1951 to 1997, just before the slowdown. Section 2 reviews the main developments in policies and macroeconomic development in the 1990s to set the stage for the analysis carried out in the next two sections. Section 3 uses a framework based on nonstructural vector autoregressive (VAR) models to look at the main factors accounting for the post-1997 slowdown of the economy. Section 4 uses a small macroeconomic structural model to assess the economic consequences of some of the actions undertaken in 1997–1998. Finally, section 5 presents our main conclusions.

1. For a review of the period at different stages and from different points of view, see the papers in Bosworth, Dornbusch, and Labán (1994) and Larraín and Vergara (2000b).

Table 1. Chile: Macroeconomic Indicators, 1974-2000

	Real GDP growth (%)	Domestic expenditure growth (Real,%)	Trade balance (% GDP)	Current account balance (% GDP)	Public sector balance (% GDP)	Real price of copper (1990=1)	Real price of oil (1990=1)	Inflation rate (% Dec-Dec)	Unempl. rate national (%)	Real exchange rate (1986=100)	Real interest rate (% annual)	Terms of trade (1986=1)
1974					-5.4	1.678	1.185	369.2				2.077
1975	-13.3	-21.1	1.0	-6.8	-2.0	0.921	0.966	343.3	14.9			1.261
1976	3.2	-0.5	6.5	1.5	4.0	1.001	1.055	197.9	12.7			1.387
1977	8.3	12.9	0.3	-4.1	0.4	0.879	1.082	84.2	11.8	57.1		1.254
1978	7.8	9.7	-2.8	-7.1	1.6	0.851	1.001	37.2	14.2	68.1		1.207
1979	7.1	10.4	-1.7	-5.7	4.8	1.098	2.001	38.9	13.6	70.2	22.9	1.444
1980	7.7	10.5	-2.8	-7.1	6.1	1.062	2.070	31.2	10.4	60.8	13.4	1.343
1981	6.7	12.4	-8.1	-14.3	0.8	0.775	1.836	9.5	11.3	52.9	14.7	1.169
1982	-13.4	-23.8	0.3	-9.8	-3.4	0.645	1.639	20.7	19.6	59.0	15.5	1.066
1983	-3.5	-8.6	5.1	-5.7	-3.0	0.686	144.2	23.1	14.6	70.8	11.1	1.161
1984	6.1	8.7	1.9	-10.9	-4.3	0.579	1.359	23.0	13.9	74.0	9.2	1.077
1985	3.5	-2.4	5.4	-8.6	-2.6	0.599	1.312	26.4	12.0	90.9	9.1	1.032
1986	5.6	4.9	6.2	-6.7	-2.1	0.598	0.706	17.4	10.4	100.0	7.6	1.000
1987	6.6	9.8	6.3	-3.6	-0.2	0.759	0.880	21.5	9.6	104.3	7.2	1.147
1988	7.3	7.7	9.1	-1.0	0.2	1.061	0.687	12.7	8.0	111.2	7.4	1.552
1989	10.6	13.3	5.4	-2.5	1.3	1.107	0.798	21.4	7.1	108.6	8.9	1.575
1990	3.7	2.9	4.2	-1.6	3.6	1.000	1.000	27.3	7.4	112.7	12.7	1.382
1991	8.0	6.2	4.3	-0.3	2.4	0.876	0.841	18.7	7.1	106.4	8.3	1.283
1992	12.3	15.0	1.7	-2.3	2.9	0.850	0.812	12.7	6.2	97.6	8.3	1.273
1993	7.0	10.8	-2.2	-5.7	2.1	0.702	0.701	12.2	6.4	96.9	9.3	1.255
1994	5.7	5.5	1.4	-3.1	2.3	0.838	0.645	8.9	7.8	94.2	9.3	1.423
1995	10.6	16.2	2.1	-2.1	3.8	1.027	0.671	8.2	6.6	88.9	8.5	1.573
1996	7.4	7.9	-1.6	-5.1	2.0	0.783	0.786	6.6	5.4	84.7	8.8	1.376
1997	7.4	9.1	-2.1	-5.0	1.0	0.778	0.735	6.0	5.3	78.2	8.4	1.418
1998	3.9	3.9	-3.4	-5.7	-1.2	0.580	0.502	4.7	7.2	78.0	10.9	1.259
1999	-1.1	-10.0	2.5	-0.1	-2.3	0.547	0.692	2.3	8.9	82.3	8.2	1.203
2000	5.4	6.6	2.1	-1.4	-0.6	0.597	1.046	4.5	8.3	86.0	7.4	1.228

Source: see appendix A.

1. Growth Accounting: Explaining GDP Trends

Chile's favorable growth record in 1985–1997 has attracted the attention of researchers and policymakers interested in learning from the successful transformation of a Latin American country. The Chilean model is relevant beyond Latin America as it provides a clear contrast with the East Asian model, by relying on a private market economy guided more by rules than by discretion. Consequently, the country requires a smaller government than the East Asian model, and it therefore economizes on human capital and government capacity. The model might thus be more suitable for the typical developing country. Given that Chile is rich in natural resources, however, it is natural to question whether the success is due to the results of the economic policy implemented or whether it is only a consequence of a period of good luck in the commodity lottery.[2]

To answer this question, we study the factors contributing to the Chilean growth record in this period. Much work has been done in this field in recent years, extending the standard Solow model of the 1950s. It is mostly of the cross-sectional variety and is based on the now fairly standard new growth theory framework (Barro and Sala-i-Martin, 1995; Fischer, 1993). Within this framework, a sudden jump in the growth rate, such as that observed in 1985–1997 in Chile, has to be attributed to a change in the growth rate of capital accumulation, a temporal increase in the growth rate of employment above the growth rate of the labor force, a jump in the growth rate of total factor productivity (TFP), or a combination of these three factors. Of course, the rate of increase in capital accumulation can be affected by changes in the prices of export commodities.

Lefort and Solimano (1994) and Meller, O'Ryan, and Solimano (1996) use this type of framework for the case of Chile. The latter paper shows that in the prereform period (1951–1973 in the study), TFP growth was small relative to GDP growth, while in 1984–1989 (which the authors define as a period of recovery and reconsolidation of reforms), TFP growth was 0.79 percent per year, and growth in the labor input was the main factor contributing to growth. In contrast, in 1989–1993 (here defined as a period of sustained growth), the growth of TFP was 2.39 percent per year and accounted for one-third of the GDP growth rate. The contribution of capital accumulation alone in this period was close to one-half of the GDP growth rate—3.5 percent compared with 7.1 percent.

2. Bulmer-Thomas (1994).

Table 2. Factors Accounting for Growth

Period	*Labor*	*Capital*	*TFP*	*Total*
1951-1960	0.99	1.33	0.64	2.96
1961-1970	0.74	1.61	1.39	3.74
1971-1980	0.40	0.79	0.09	1.28
1981-1985	0.74	0.50	-2.95	-1.71
1986-1995	0.87	1.56	3.97	6.4
1995-1997	0.69	4.80	3.01	8.5

Source: Authors' own calculations.

Lefort and Solimano (1994) follow the work of Fischer (1993) in endogenizing the growth rate of factor inputs and TFP. They relate the growth rate of these variables to macroeconomic factors, economic reforms, and external shocks. They find that macroeconomic instability, measured by the inflation rate and the standard deviation of the inflation rate, has a negative effect on the growth rate of factor inputs and the rate of change of TFP.[3] They also find that the volatility of the real exchange rate, measured by its standard deviation, has a negative effect on the rate of change of TFP, whereas trade liberalization and financial deepening have a positive effect on the rate of change of TFP. Indeed, financial deepening "is the most important factor in explaining the change in total factor productivity growth, both in the whole sample and in the period 1974–1989" (Lefort and Solimano, 1994, p. 25).

The same study finds that rate of change in the terms of trade has a positive effect on the rate of capital accumulation for the period 1974–1989. After testing the robustness of their findings, the authors conclude that macroeconomic factors and TFP growth chiefly affect capital formation.

To further examine the factors accounting for Chile's growth record, we re-estimate Lefort and Solimano's extended production function framework, extending the sample up to 1997. We then use the estimated equation to compute the factors contributing to growth in six subperiods (1951–1960, 1961–1970, 1971–1980, 1981–1985, 1986–1995, and 1995–1997). Table 2 reports the results. We find that the acceleration of growth during the high growth periods, 1986–1995 and 1995–1997, is largely due to a quantum jump in the growth rate of

3. Lefort and Solimano (1994) also find that the response of the rate of change of factor inputs and of TFP to inflation is nonlinear, with a higher response to high inflations.

total factor productivity, which alone accounts for more than half of the GDP growth rate, on average. This result is higher than that reported by Meller, O'Ryan, and Solimano (1996) just for the period 1989–1993. The second most important factor is capital accumulation, which contributes more than 40 percent of the total.

This raises the question of the extent to which the growth reported above really reflects sustained growth, rather than recovery. There is no way to answer this question short of developing a full general equilibrium model for the period. One point is clear, however. As the economy was approaching full employment toward the end of 1997, sustaining the growth process would have required maintaining a high growth rate of capital formation; continuing to improve the allocation of resources and the incentives for firms to increase efficiency; and increasing the contribution of human capital accumulation. Instead, Chile suffered another string of external shocks and some important slippages in economic policy: a string of large increases in the minimum wage starting in May 1998, an expansionary fiscal policy just when the current account deficit had to be reduced, and a hard monetary policy response to exchange rate pressure. This combination of factors derailed the economy from its previous high growth path.

2. Macroeconomic Policies and Developments in the 1990s: An Overview

By the end of the 1980s, the transition to a democratically elected government was in process, and the Chilean economy was enjoying a solid economic performance backed by strong macroeconomic fundamentals and sound microeconomic policies that promoted integration into the world economy and competition. On the macroeconomic side, the public sector debt was manageable, there was a fiscal surplus, and monetary policy was geared toward avoiding an acceleration of inflation and—with the help of the fiscal surplus—maintaining a competitive real exchange rate. In 1989, growth was 10.6 percent, the unemployment rate was 7.1 percent (down from 12 percent in 1985), inflation reached 21.4 percent, and the current account deficit was 2.5 percent of GDP.[4]

The new coalition government that took power in March 1990 made a strategic decision to embrace the market-oriented, open-economy policies of the past administration. Early on, the government implemented a stabilization program to slow down an economy that was clearly over-

4. For a description of monetary policy in this period see Fontaine (1991).

heating by the late 1980s, with accelerating inflation. The recently installed Board of the Central Bank had the responsibility of bringing inflation under control. The newly independent Central Bank was created in October 1989 and began operating in December 1989, only three months before the Presidency was transferred from Pinochet to Aylwin. It undertook as its main task the gradual reduction of inflation. The focus on gradualism was based on the concern that a rapid reduction of inflation would introduce serious distortions in relative prices in an economy characterized by widespread indexation of key prices to past inflation. Although the Central Bank's main objectives are to achieve price stability and to ensure the proper functioning of the domestic and external payment systems, the existence of a robust financial system and solid external accounts allowed the Central Bank to focus on the inflation rate objective. In terms of the current literature on central bank independence, the Central Bank of Chile is modeled on Rogoff's conservative central banker (1985)[5]. Chilean law gives the Central Bank independence to set its own targets, as well as to choose the instruments it deems appropriate for achieving those targets[6]. In contrast to other independent Central Banks created recently, the Central Bank of Chile is also responsible for the exchange rate system and for exchange rate policy.

The Central Bank initially set itself the objective of gradually reducing inflation. That objective was later modified to achieving inflation rates similar to those observed in industrial countries, while maintaining current account deficits that would not jeopardize the stability of the external payment system[7]. Whenever the two objectives entered into conflict, as was the case in 1996, the inflation target was given priority.

The inflation objective for the coming year is chosen by the Central Bank and then announced to the Congress and the country during the first fifteen days of September of each year. At first, that objective was

5. In this model, the Central Bank Board behaves as if minimizing a quadratic loss function. The arguments of the function are the departure of the inflation rate from its target and the departure of the current account deficit from its target (or the unemployment rate from its target in Rogoff's model). De facto, the Central Bank has been assigning the greatest weight to the inflation term, resulting in conduct similar to that observed for what Rogoff describes ad the conservative central banker.

6. This is by omission more than by commission, since the Central Bank's charter spells out its objective of achieving price stability but does not specify who sets the inflation target.

7. Massad (1998) defines this level as 4 percent of GDP when the current account is measured using normal terms-of-trade levels. Unfortunately, normal is not defined in the same paper. Morandé (2001b) states that the current account objective was 2 to 4 percent up to 1995 and between 4 percent and 5 percent between 1996 and 1998.

stated in terms of a range for the consumer price index (CPI) inflation rate for the period December to December of the coming year. In September 1994, the Central Bank moved toward setting a point estimate for the inflation objective. Finally, in September 1999, it announced that the objective was now to maintain an inflation rate in the range of 2 percent to 4 percent, allowing only for temporary deviations from these bounds. At the same time, the Bank replaced the exchange rate band system with a floating rate. In the initial years, the target was announced without an explicit declaration of how policy was going to be conducted. The system has since converged to a full-fledged inflation-targeting regime. The inflation target is the ultimate objective of policy, while a publicly announced inflation forecast is the intermediate objective; the interest rate is the main instrument for achieving those objectives.[8]

When the independent Central Bank started to operate in late 1989, it inherited a passive crawling peg exchange rate band system that had been in operation since the mid-1980s. In that system, the mean point of the band was adjusted by the differential between domestic and foreign inflation in a sort of constant central parity for the real exchange rate. The width of the band at the time was 5 percent in each direction of the central parity. As the Central Bank pursued its objective of achieving a target inflation rate, the secondary objective of also targeting a level for the real exchange rate became increasingly problematic, given that the combination of favorable external factors and perceived good domestic policies in Chile resulted in a quantum jump in capital inflows. Consequently, a conflict between the inflation target and the real exchange rate objective surfaced repeatedly in the 1990s. The inflation objective was given priority, but the Central Bank also struggled to avoid an excessive real appreciation. Throughout most of this period, it actively intervened in the foreign exchange rate market, implementing an aggressive and costly policy of foreign reserve accumulation, accompanied by the sterilization of the monetary effects of this accumulation. At other times, the Bank accommodated a real appreciation with a downward adjustment of the central parity and reduced the slope of the central parity by introducing a discount related to the growth rate of productivity[9]. It was during this period

8. For reviews and descriptions of monetary policy in this period- see Corbo and Fischer (1994); Corbo (1998); Budnevich and Pérez (1995); Massad (1998); Zahler (1998). A review of the international experience with inflation targeting in the same period can be found in Bernanke and others (1999).

9. The discount was estimated to be a 2 percent annual appreciation, based on a Harrod-Balassa-Samuelson effect. More recent estimations obtain values of 0.7 percent (see Délano and Valdés, 1998).

of high capital inflows that the Central Bank introduced an unremunerated reserve requirement for capital inflows.

The problem inherent in the simultaneous pursuit of inflation and exchange rate targets is well known. Within the exchange rate system, as long as the observed value of the exchange rate is well within the band, the uncovered interest rate parity condition provides a link between the interest rate and the exchange rate, such that any adjustment of the domestic interest rate results in a movement of the nominal exchange rate. For all practical purposes, therefore, exchange rate policy cannot be independent[10]. The Central Bank of Chile also ran into conflicts with the Ministry of Finance whenever an increase in domestic interest rates caused a sharp nominal and real exchange rate appreciation, since such an appreciation could lead to a deterioration in the profitability of exports and eventually damage the long-term sustainability of the export-led growth process.

Chile did not suffer the effects of either the tequila crisis itself or its extension to Argentina, thanks to continuous access to foreign financing and very favorable terms of trade. The economy was by then delivering growth above 7 percent per year, the unemployment rate was falling rapidly, and annual inflation decrease continuously throughout the period. Public support for the economic policies thus began to increase. Difficulties on the macroeconomic front only began to emerge in early 1998, when the authorities were unable to articulate a coordinated monetary and fiscal policy response to a series of severe external shocks. In addition, several speculative attacks on the currency initiated a period of very high interest rates, which ultimately resulted in a sharp slowdown.

Various factors were behind the slowdown in growth, but one of the key processes was the deterioration in the external environment, including a drop in the terms of trade and reduced financial inflows owing to contagion from the series of emerging market crises. The terms of trade fell 15.2 percent between 1997 and 1999. But this was not all. On the eve of the Asian crisis, 33.1 percent of Chilean exports went to

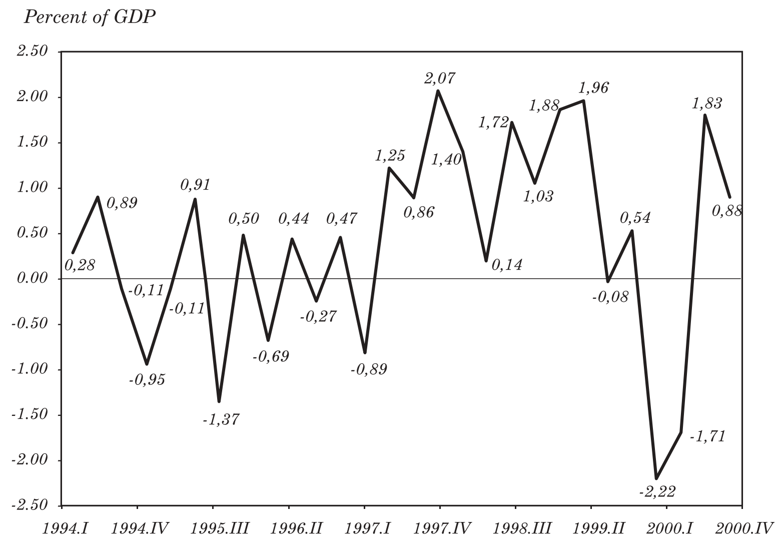
10. The exchange rate system took the form of a diagonal exchange rate band throughout most of the 1990s. The central parity of the band was adjusted passively, on a daily basis, by the difference between the domestic and international inflation. The width of the band was increased to 10 percent on both sides of central parity in January 1992. Central parity was established in terms of the value of the U.S. dollar before July 1992 and in terms of a basket of currencies thereafter. Starting in November 1995, a further 2 percent per year was subtracted from the central parity to accommodate an estimate for trend appreciation of the equilibrium real exchange rate.

Asia; these subsequently dropped by 25 percent. Furthermore, in what is a major difference with the tequila crisis of late 1994, this time the deterioration in the external environment came when the economy was already overheating. Domestic expenditure was growing at an average four-quarter rate of 14.4 percent during the last two quarters of 1997 and the first of 1998. The spending boom was fueled by a combination of a private-sector-led spending boom, overgenerous public sector wage increases, a sharp increase in the minimum wage, and another foreign-financed lending boom. In contrast with the crisis of the early 1980s, however, the financial system was quite strong thanks to a well-designed and effectively enforced supervisory and regulatory system, as well as the existence of well-capitalized banks. Even so, the overheating did take place, and, as a result, the excess of domestic spending over national disposable income—that is, the current account deficit—reached 7.4 percent of GDP in the year ending in the third quarter of 1998. The real exchange rate suffered a sharp appreciation, as is typical of an economy facing increasing demand pressures in the nontradables market.

The deterioration in the external environment coincided with a strongly expansionary economic cycle, and it set in motion several speculative attacks on the exchange rate system, this time on the exchange rate band. Although the explicit exchange rate band was a very wide 12.5 percent on each side of the central parity, and the market exchange rate was solidly on lower end of the range, the Central Bank was implicitly targeting a level of the exchange rate as an additional tool—on top of the short-term interest rate—to keep inflation within the target and to avoid an excessive exchange rate appreciation that could contribute to widening the current account deficit (Morandé, 2001a).

By the time the Asian crisis hit, the Chilean economy was overheating behind a foreign-financed boom in private domestic spending and expansionary fiscal and monetary policies. Indeed, the Central Bank initiated a series of cuts to reduce the policy interest rate from 7.5 percent to 6.5 percent, starting in February 1997. The latter level was set in October of the same year. Three arguments might be used to justify these reductions in the policy rate. First, inflation was coming down and was well within the target-band; the Central Bank could thus have been quite confident that future inflation was not a problem. Second, if the terms-of-trade shock was expected to provide enough restraint, authorities may have seen room to introduce a more expansionary policy, given that inflation was under control. Third, the high costs of sterilization may have led the Central Bank to decide to stop

Figure 1. Quarterly Fiscal Impulse



Source: Authors' calculations.

sterilizing the monetary effect of the foreign reserve accumulation. The Central Bank in fact accumulated more than US$3 billion in foreign reserves from end-January 1997 to end-October 1997. As shown in appendix B, fiscal policy was also expansionary during this period. Measures of quarterly fiscal impulse indicate that fiscal policy was expansionary during almost the whole period between 1997:2 and 1999:2 (see figure 1). The fiscal impulse for the periods before and after 1997:2 exhibit clear differences. Marcel and others (2001) use annual data to show that half of the deterioration in the fiscal accounts in 1997–1999 can be accounted for by a more expansionary fiscal policy and the other half by the cycle and the temporary deterioration in the price of copper.

When the Asian crisis emerged in the third quarter of 1997, domestic expenditure was growing at 12.0 percent and GDP at 8.7 percent (both as the four-quarter rate of change), while the current account deficit in the year up to the third quarter of 1997 had reached 4.5 percent of GDP. The deterioration in the external environment and the resulting reduction in the terms of trade raised the prospects for a further rise in the current account deficit. Under these circumstances, the appropriate response was a monetary and fiscal policy mix capable of providing appropriate restraint while facilitating the real depreciation required for switching. Given that the exchange rate was already in the lower range of the exchange rate band, the correct mix here was a restrictive fiscal policy and a monetary policy geared toward assisting a nominal and real depreciation of the currency. The budget submitted to and approved by Congress, however, was extremely expansionary, as it was built under the assumption of a 7 percent growth rate in 1998. Moreover, some additional fiscal decisions that did not directly affect the budget might have had a perverse effect on the evolution of private sector expenditure and wage arrangements. The minimum wage was raised more than 40 percent in May 1998—many months after the Asian crisis had emerged—and public sector wages were raised 6 percent in 1998. The sharp minimum wage adjustment, together with the generous increase in public sector wages in the same year, gave a bad signal to private sector workers and made switching more difficult and costly in terms of unemployment. A more conservative budget and lower wage adjustments might have helped to adjust domestic demand without having to rely exclusively on monetary policy. As it was, monetary policy was confronted with an important trade-off between the inflation target and deteriorated real activity given the deterioration of the external environment.

The first episode of an attack on the peso coincides with the development of the Asian Crisis, when the sharp increases in domestic interest rates all across Asia and the massive capital flight that was developing resulted in a major downfall in regional stock markets, including Latin America. Brazil, Argentina, and Mexico experienced record falls on Monday, 27 October. Later that week, severe pressure started to build on the Latin American currencies and stock markets, especially in Brazil, Argentina, and Mexico. By early 1998, as the plunge in the Asian currencies intensified and Indonesia's political problems increased, the contagion to Latin America accelerated through Brazil and Argentina. The observed value of the Chilean market exchange rate at this time was well within the lower half (the most appreciated part) of the band. The Central Bank was in a difficult position, however, with an expansionary fiscal policy for the year already approved in Congress and an overheating economy. It was thus reluctant to allow the exchange rate to depreciate within the band out of a fear that a high pass-through from the depreciation to inflation would jeopardize the inflation target for the following year[11]. This fear of depreciation—that is, of letting the exchange

11. Indeed all through this period the market exchange rate was well within the lower—or most appreciated—part of the band.

rate depreciate within the exchange rate band—is clearly stated in a recent paper by the then Chief Economist of the Central Bank:

> At first, in early 1998, the main fear of the Central Bank was that the rapid depreciation of the peso in progress was a serious threat to the inflation target set for the year's end. This concern was based on the high pass-through from the peso depreciation to domestic inflation when the local demand was growing at annual rates of over 12 percent, estimated then at 0.6 (Morandé, 2001a, p. 4).

The fear of depreciation was also sometimes linked to its potential balance sheet effects.[12] Given this fear of depreciation and despite the refusal of the fiscal authorities to revise the level of government expenditures for the year 1998, the Central Bank decided to lean against the wind, first selling foreign reserves and then, beginning in early January of 1998, increasing the policy interest rate. Between end-November 1997 and end-January 1998, the level of foreign reserves fell by US$2 billion, equivalent to more than 10 percent of the initial stock. This provides evidence in favor of the view that the failure to coordinate monetary and fiscal policy had its share of responsibility in the costly adjustment of the 1997–1998 period. The rise in the policy real interest rate, introduced a little later, was quite steep, from 6.5 percent in January to 8.5 percent in February—a full 200 basis points in less than two months. When the rate was raised another 150 basis points on 3 February 1998, the Central Bank also changed its operation procedures, shifting its intermediate target away from the interest rate and toward a monetary aggregate. As stated by the Central Bank Board on 3 February:

> The administration of liquidity will be oriented toward providing enough resources for the normal functioning of the financial system, with the objective that the inter-bank rate, at a minimum, be equal to the policy or reference interest rate [authors' translation].

Not surprisingly, as the expectation of a depreciation increased with the deterioration in the external environment, the market interest rate became much higher than the policy interest rate, with the latter now serving as a minimum value for the overnight interest rate. The operational procedure used for this purpose was the introduction of monetary targets. Restrictions on capital inflows were also progressively reduced in April 1998.

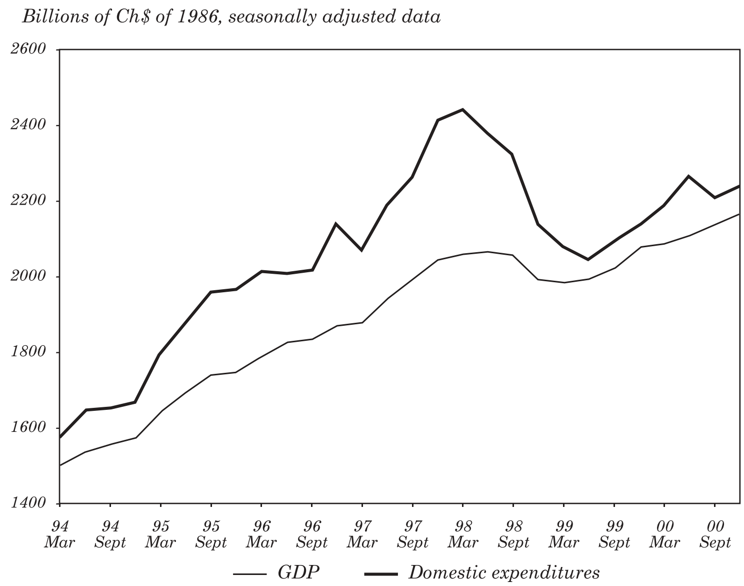
12. Public Statement of the Central Bank, 23 December 1998.

The second episode of a speculative attack took place around the last week of June 1998, when Brazil's large current account deficit (7.4 percent of GDP in the year ending in the third quarter of 1998) and contagion from the developing Russian crisis put renewed pressure on the Brazilian exchange rate system. The country's looming budget and current account deficits and upcoming presidential elections made Brazil the center of the attack.[13] When the contagion from the attack on the Brazilian currency reached Chile, the Central Bank used a battery of instruments to withstand the attack. A set of measures was announced on 25 June. First, the reserve requirement on capital inflows was reduced from 30 percent to 10 percent. Second, dollar-indexed Central Bank bonds were offered to facilitate private sector coverage of exchange rate risks and to relieve the pressure on the spot foreign exchange market. Third, in a move that took everybody by surprise, the Central Bank narrowed the exchange rate band from 12.5 percent on both sides of a central parity to an asymmetric band with a 3.5 percent lower band and a 2 percent upper band. The Central Bank statement at the time justified the move as a way of reducing the volatility in foreign exchange and financial markets. Because the market interest rate was the main instrument used to defend the narrow band, domestic interest rates increased substantially, reaching monthly levels of close to 4.5 percent in real terms. The deterioration of the situation in Russia and the continuous pressure on the Brazilian currency made the move to reduce the width of the band a very costly undertaking, in that the high interest rates required to defend the narrower band had detrimental effects on sectors sensitive to a sharp increase in interest rates.

A third attack on the peso developed after the Russian crisis of August 1998 and continued through mid-September, when the pressure on the Brazilian real was gaining renewed force. By then, however, the very high interest rates of the previous months were taking their toll on domestic spending, which was contracting sharply and thereby helping achieve a sharp reduction in the current account deficit. The four-quarter rate of change of domestic expenditures fell from 18.1 percent in the

13. The logic of this attack on the Brazilian currency can be derived from a second-generation model of currency crisis (Obstfeld, 1996; Krugman, 1996). In this model, private agents anticipate that the government faces a clear trade-off between the benefits of holding the exchange rate fixed (the exchange rate was by then the key anchor for inflation) and the costs associated with defending it through high interest rates with elections approaching in October 1998. Although the Brazilian Central Bank decided to fight the attack with high interest rates, this defense probably was not credible given the upcoming elections and the already weak public finances.

Figure 2. GDP and Domestic Expenditure Growth



Source: Authors' calculations. Seasonally adjusted using X-12 ARIMA.

first quarter of 1998 to 9.2 percent in the second quarter, 2.8 percent in the third quarter, and –11.6 percent in the fourth quarter.

Following this attack, the Central Bank decided to raise the policy interest rate and make it binding again by providing enough liquidity to an economy that was slowing down very fast.[14] Thus, the policy interest rate, which had not been relevant for the determination of the interest rate since January, was raised to 14 percent on 16 September, bringing up the market rate along with it. At the same time, the Central Bank announced that the exchange rate band was going to converge by the end of the year to a wider, symmetric band of ±5 percent around a central parity. These changes helped ease the pressure on the exchange rate, and the nominal exchange rate effectively remained close to the middle of the band for the rest of the year.

Table 3 presents the quarterly evolution of the main macroeconomic variables for the 1997–2000 period. Table 4 shows the cumulative change

14. Also on 3 September, the period considered for the computation of minimum reserve requirements was reduced from thirty to fifteen days to reduce the opportunities for banks to speculate against the peso.

Table 3. Chile: Macroeconomic Indicators: 1996.I-2000.IV

	Real GDP growth (%)	*Domestic expenditure growth (Real,%)*	*Trade balance (% GDP)*	*Current account balance (% GDP)*	*Public sector balance (% GDP)*	*Real price of copper (1990=1)*	*Real price of oil (1990=1)*	*Inflation rate (% 4^{th} qtr)*	*Unempl. rate national (%)*	*Real exchange rate (1986=100)*	*Real interest rate (% annual)*	*Terms of trade (1986=1)*
1996-I	8.9	12.6	1.4	-2.97	4.6	0.9	0.7	7.9	6.6	86.9	9.1	1.073
1996-II	7.5	7.7	2.1	-3.20	2.0	0.8	0.7	8.4	6.6	84.2	9.5	1.057
1996-III	5.5	3.0	-4.0	-3.74	1.9	0.7	0.8	6.8	6.8	83.8	9.4	0.958
1996-IV	7.7	8.7	-5.9	-5.12	0.9	0.7	0.9	6.5	5.4	83.8	9.3	0.975
1997-I	5.0	2.0	3.8	-4.09	5.0	0.8	0.8	7.0	5.8	80.5	9.1	1.046
1997-II	6.1	9.1	0.6	-4.32	0.9	0.9	0.7	5.6	6.6	79.1	8.8	1.094
1997-III	8.7	12.0	-4.8	-4.48	2.1	0.8	0.7	5.7	6.7	76.8	8.6	1.064
1997-IV	9.8	13.1	-7.4	-4.95	-0.5	0.7	0.7	6.3	5.3	76.3	8.5	0.981
1998-I	8.8	18.1	-3.5	-6.63	3.9	0.6	0.6	5.6	5.3	77.8	10.3	0.942
1998-II	6.3	9.2	-3.0	-7.29	0.6	0.6	0.5	5.4	6.1	77.6	10.6	0.951
1998-III	3.4	2.8	-5.9	-7.40	-0.3	0.6	0.5	5.1	6.8	78.4	15.2	0.926
1998-IV	-2.5	-11.6	-1.5	-5.67	-2.5	0.5	0.4	4.4	7.2	78.2	11.6	0.897
1999-I	-2.8	-14.8	3.6	-3.95	1.3	0.5	0.4	3.8	8.2	79.0	9.4	0.868
1999-II	-3.7	-14.0	3.2	-2.43	-2.2	0.5	0.6	3.9	10.8	78.7	8.4	0.871
1999-III	-1.8	-9.9	0.1	-1.00	-1.0	0.6	0.8	3.2	11.4	83.6	7.3	0.902
1999-IV	4.0	-0.3	2.9	-0.12	-3.2	0.6	0.9	2.5	8.9	87.8	7.6	0.910
2000-I	5.5	5.4	4.9	-0.02	4.4	0.6	1.0	3.2	8.2	83.1	7.6	0.917
2000-II	6.0	11.0	0.4	-0.95	0.4	0.6	1.0	3.6	9.4	83.0	7.7	0.906
2000-III	5.6	5.7	0.6	-1.04	-1.7	0.6	1.1	4.0	10.7	88.4	7.5	0.904
2000-IV	4.5	4.7	2.2	-1.41	-2.3	0.6	1.1	4.6	8.3	89.6	7.2	0.899

Source: see appendix A.

Table 4. Cumulative Changes in Selected Macroeconomic Aggregates

Panel (a): Changes from 1998.II[a]
Percent

	1998.IV	*1999.I*	*1999.II*	*1999.III*	*1999.IV*
Gross Domestic Product	-3.9	-4.0	-3.6	-2.6	-0.3
Absorption	-10.3	-12.6	-14.2	-12.1	-10.1
Total Consumption	-9.8	-11.1	-12.2	-7.9	-4.5
Fixed Investment	-11.8	-16.3	-19.2	-22.5	-24.0
Net Exports	54.9	69.6	83.4	77.5	80.8
Exports	0.6	2.6	6.4	5.4	10.1
Imports	-15.1	-17.8	-19.0	-18.0	-15.7

Panel (b): Changes from 1998.II

	1998.IV	*1999.I*	*1999.II*	*1999.III*	*1999.IV*
	Difference (percentage points)				
Unemployment Rate	0.30	2.00	3.10	4.70	4.80
Core Inflation[b]	0.187	0.44	-0.169	-1.286	-2.382
Real Interest Rate	4.18	0.63	-1.13	-2.23	-3.25
Capital Flows (GDP)[c]	10.07	7.75	-4.52	1.63	4.05
Capital Flows (GDP)[d]	-1.45	-0.18	-2.84	-2.39	-3.95
	Change (%)				
Real Money M1A	-5.8	-9.5	-8.3	-5.1	-1.4
Real Money M2	3.0	2.6	1.5	5.7	8.1
Terms of Trade	-2.7	-5.7	-8.7	-8.5	-5.2
Employment	0.1	-1.2	-2.4	-3.7	-3.4

a. Seasonally adjusted data
b. 4-quarter change
c. Quarter
d. 4-quarter moving average
Source: Authors' own calculation on base of Central Bank of Chile (2001) and *Economic and Financial Report*, various issues.

for the main macroeconomic variables with respect to their values in the second quarter of 1998; and figure 2 presents the seasonally adjusted levels of GDP and domestic expenditure. The tables and figure illustrate that after peaking in early 1998, GDP and domestic spending (private consumption, public consumption, and total investment) started to fall rapidly.

Identifying the possible sources of this slowdown is not an easy task, since many factors were present at the same time. A primary

Table 5. Decomposition of the Economic Slowdown: Annual Values
Percent

	Government consumption	*Private consumption*	*Inventory investment*	*Fixed investment*	*Exports*	*Imports*	*GDP*
1998	0.07	-2.40	-1.15	-2.71	-1.62	4.25	-3.57
1999	0.03	-9.34	-5.59	-11.65	-2.94	17.91	-11.57
2000	0.07	-11.55	-4.34	-14.19	-4.08	20.50	-13.59

Source: Authors' calculations, based on the methodology of Hall (1993).

exploration can be achieved by computing the differences between the actual values of each component of GDP and values simulated under the alternative scenario of each component growing at the average GDP growth rate of the previous fourteen years. The results of this analysis are shown in table 5, which reports the values as a percentage of the GDP value obtained under the assumption that all variables grew at the previously observed average growth. As can be observed, the major decelerations came from private consumption and fixed investment.[15]

Carrying out the same decomposition using quarterly data allows us to take a closer look at the factors behind the slowdown. Unfortunately, Chilean quarterly national accounts provide a demand decomposition with only four terms: total consumption (private and public consumption plus change in inventories); fixed investment; imports of goods and nonfactor services; and exports of goods and nonfactor services. Despite the loss of detail in the disaggregation, working with quarterly data has a big advantage in that the possible break point can be observed more closely.[16] We use the first quarter of 1998 as our break point, as it represents the peak in the level of domestic spending and thus allows us to capture possible differences among variables in the timing of the slowdown. The benchmark scenario is one in which each component grows at a rate equal to the average quarter-to-quarter growth rate of GDP during the previous fourteen years. In line with the previous results, the major deceleration during 1998 came from total consumption and fixed investment. The slowdown of real imports was also very severe, but in our analysis this means a positive contribution to GDP growth (see table 6).

15. The import figure is positive because from an accounting perspective, a lower imports value implies a higher GDP value.

16. We use seasonally adjusted data.

Table 6. Decomposition of the Economic Slowdown: Quarterly Values
Percent

	GDP	*Total consumption*	*Fixed investment*	*Net exports*	*Exports*	*Imports*
Mar-98	-1.09	-0.90	-0.08	-0.11	-1.78	1.68
Jun-98	-2.68	-4.87	-1.16	3.35	-1.11	4.46
Sep-98	-4.71	-7.63	-3.12	6.04	-1.76	7.81
Dic-98	-9.61	-15.41	-6.02	11.81	-2.35	14.16
Mar-99	-11.69	-17.79	-7.92	14.02	-2.31	16.33
Jun-99	-13.10	-19.83	-9.29	16.02	-1.67	17.69
Sep-99	-13.43	-17.98	-10.70	15.25	-2.73	17.99
Dic-99	-12.66	-16.83	-11.59	15.76	-1.86	17.62
Mar-00	-13.95	-17.21	-10.93	14.19	-1.63	15.82
Jun-00	-14.70	-15.94	-10.75	11.98	-3.07	15.05
Sep-00	-15.25	-19.95	-10.80	15.49	-2.14	17.63
Dic-00	-15.69	-20.45	-10.71	15.47	-2.66	18.13

Source: Authors' calculations, based on the methodology of Hall (1993).

This analysis does not allow us to separate the deceleration between exogenous innovations in the variable and changes caused by endogenous responses to shocks in other variables. To recognize the causes of the slowdown it is necessary to take a closer look at those exogenous innovations. As an approximation of these effects, we follow the analysis that Blanchard (1993) uses to identify shocks to GDP components during the 1990–1991 recession in the United States.[17] We estimate a quarterly VAR model including three components of GDP: total consumption, fixed investment, and net exports.[18] The first two variables are expressed as four-quarter rate of change and the third as percentage of trend GDP, which is measured as an exponential trend of seasonally adjusted GDP. An additional variable—the four-quarter rate of change of GDP—was included in the exercise, but its lags were not included as explanatory variables; this step is made just to obtain its forecast errors[19].

To identify the structural shocks, we again follow Blanchard (1993) in assuming that every variable is affected only by its structural shock and by the current GDP structural shock. GDP is assumed to be independent, so it is not affected by the other shocks.[20] To compute the effect of the GDP

17. Walsh (1993) carries out an alternative and more elaborated analysis.
18. Total consumption is the sum of private consumption, inventory investment, and government consumption.
19. For a more detailed explanation of this methodology, see Blanchard (1993).
20. This implies that the forecast error is exactly the structural shock.

Table 7. Shocks to GDP and its Components
Percent

Normalized Shocks[a]

	GDP	*Total consumption*	*Fixed investment*	*Net exports*
1997.IV	-0.655	0.509	0.547	-1.321
1998.I	-1.167	0.120	-0.702	0.161
1998.II	0.762	-1.103	0.561	0.019
1998.III	-0.583	-0.413	-0.471	1.494
1998.IV	1.212	-0.932	0.015	1.403
1999.I	0.630	-0.707	0.097	0.531
1999.II	-0.268	1.383	-0.575	-0.285
1999.III	-1.008	0.828	-1.570	0.325
1999.IV	-0.542	-0.369	-0.477	0.404

Source: Authors' calculations.
a. Shocks are normally distributed with mean 0 and standard deviation 1.

structural error on the rest of the variables, we estimate three equations, one for each forecasting error, with the GDP shock included as an explanatory variable. These regressions are estimated using two-stage least squares (TSLS); the instruments used are the GDP growth of the main trade partners, the change in the U.S. dollar London interbank offer rate (LIBOR), and the rate of change in the terms of trade.[21] The structural errors are reported in table 7.

The picture presented in the table is not as clear as we would like. Fixed investment suffered a severe negative shock in the second half of 1999, but before that there is no evidence of changes not forecast by the lagged structure of the VAR model. GDP suffered a large negative shock the first quarter of 1998, but this was offset by a large positive one in the fourth quarter.

What is important to note is the presence of two large positive shocks to the foreign demand component in the last two quarters of 1998, perhaps reflecting the good external environment provided by a sound U.S. economy. So, apart from some large and specific shocks, the evolution of GDP is almost entirely explained by the internal dynamic of the economy implied in the model. Total consumption has just one signifi-

21. We use different sets of instruments, and the results are robust to these changes. The results also hold when the estimation is carried out using ordinary least squares (OLS) instead of TSLS.

cant shock, but after the second quarter of 1998, it suffered four consecutive negative shocks that may have pushed its significant deceleration. The puzzling result is the important positive effect of the external demand component.

3. Sources of the Economic Slowdown: Results from a Nonstructural VAR Model

A further step toward understanding the post-1997 slowdown involves the use of a nonstructural VAR model. We estimate a nonstructural VAR including six endogenous and two exogenous variables.[22] The endogenous variables are the interest rate of the PRBC-90, the gap between core inflation rate and the linearized target inflation rate, the twelve-month rate of change of nominal money (M1A), the twelve-month rate of change of the real exchange rate, a monthly measure of the current account (as a percent of GDP), and the twelve-month rate of change of a monthly activity index (IMACEC).[23] The two exogenous variables are lags of the logarithm of the terms of trade and lags of the external inflation (expressed as a twelve-month rate of change).[24] We also estimate a VAR including the twelve-month rate of change of the monthly aggregate expenditure (AGEXP) instead of overall economic activity among the endogenous variables (IMACEC).[25] The variables included here are frequently used in VAR analyses of monetary policy in Chile.

We use these nonstructural VARs to simulate alternative scenarios starting from two different break points: September 1997 and June 1998. For the first period, we estimate the VAR up to September 1997 and then simulate it forward using the observed values of the exogenous variables. These simulated values are used as a benchmark for comparisons with simulations that use alternative scenarios for the

22. For a review of the VAR methodology, see Hamilton (1994); Greene (2000); Stock and Watson (2001). For references on VAR estimation for Chile with surveys of related work, see Valdés (1997); García (2000); Cabrera and Lagos (2000). Our estimations closely follow the structure used by Valdés (1997).

23. The PRBC-90 corresponds to the rate of the Central Bank's ninety-day indexed bonds. The lags were selected according to the Akaike info criteria. All the individual equations presented a good fit of the data, with R-squared statistics higher than 0.8 in almost every case.

24. The monthly terms of trade were obtained from Bennett and Valdés (2001). They also compute a different measure of the monthly terms of trade; our results do not change significantly when we employ this alternative.

25. The authors compute monthly aggregate expenditure.

exogenous variables. The results of the dynamic simulation are very interesting. Comparing the observed values of the IMACEC with the dynamic forecasts, we observe no great differences up to April 1998. This is not the case for AGEXP. When aggregate expenditure is used, the dynamic forecasts are not very good; in fact, the strong acceleration of its growth observed during the first months of 1998 is not explained by the VAR (see figure 3).

After the third quarter of 1997, the current account steadily decreased during the simulated period. This major deficit is almost entirely captured by the dynamic simulations, especially when the aggregate expenditure is added.

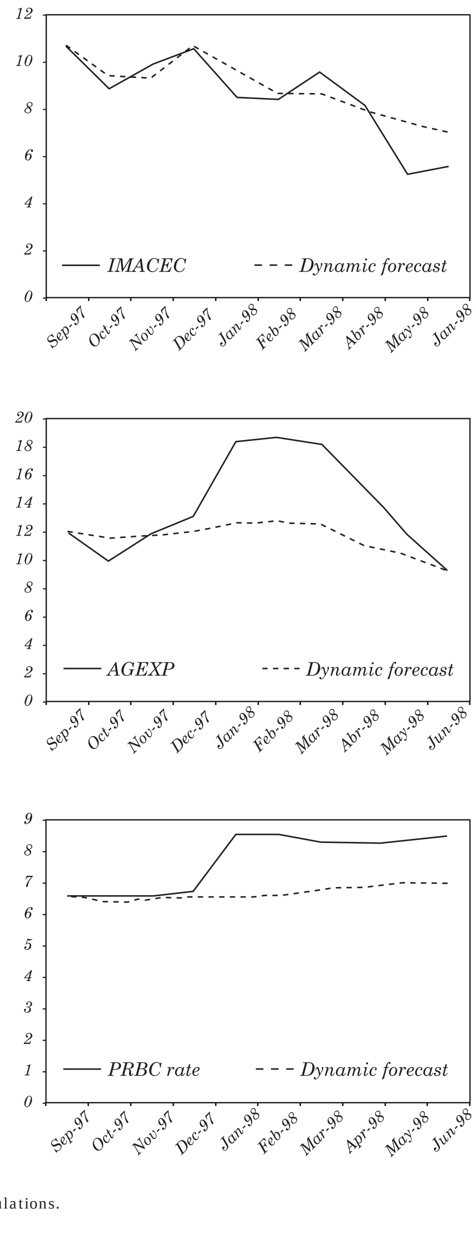
In the case of the real interest rate, the results are qualitatively similar to the AGEXP results. The dynamic forecasts are very different from the actual values, and the difference is important from January 1998 up to the last point of the simulation. The divergence coincides with an episode of strong pressure on the Chilean peso and a sharp increase in the overnight interest rate in mid-January. After the pressure on the currency was reduced as a result of the very high overnight and short-term interest rates, the Central Bank reacted by officially changing the interpretation of the policy interest rate from a guide for the overnight interest rate to a floor for the same rate. The policy rate was raised at the same time. The policy response is not explained by the dynamic forecasting errors of domestic spending (AGEXP) or of the current account; an alternative simulation using the observed values of both variables does not eliminate the difference.[26] According to this preliminary evidence, then, monetary policy exhibited a different reaction, understanding as normal what is implied by the VAR equation.[27] We cannot extract strong inference because the model is very simple, but the simulations give us an insight into possible explanations for the slowdown. The justification for this “different” monetary policy reaction is another question entirely, which we address later in the paper by introducing a series of different considerations.

Next we simulate the effect of alternative external environments on the endogenous variables listed above. The alternative scenarios take

26. Corbo (2002) shows that the current account deficit was effectively another target variable for monetary policy during the 1990s in Chile. This view is also supported in the empirical results reported in section 4 below.

27. This raises the question of whether the correspondent equation of the VAR is a good estimator of the policy reaction function. If we assume that monetary policy is forward-looking, the equation implies that the right-hand variables include the entire set of information available to the policymakers and that the estimation method gives us consistent estimators.

Figure 3. Actual and Dynamic Forecasts, VAR Model, October 1997-June 1998



Source: Authors' calculations.

into account different elements of the impact of the change in the external environment on the Chilean economy. The alternative scenarios are simulated from October 1997 up to June 1998, such that period of simulation includes the sudden stop of capital inflows after the third quarter of 1997, the first speculative attack on the peso in January 1998, and the aggregate expenditure and current account boom of the first months of 1998.

There are four alternative scenarios. The first scenario fixes the terms of trade at their September 1997 value and uses the observed values of the other exogenous variable; the solution for the current account balance is obtained from the model.[28] The second examines the external financing shock by fixing the value of the current account balance at its September 1997 value and using the actual values again for the exogenous variables. The third combines the two previously described scenarios, that is, it fixes both the terms of trade and the current account at their September 1997 values. Finally, the fourth scenario takes the observed values of the current account instead of the estimated equation of the VAR, that is, we force the adjustment in the current account that actually took place.[29]

As shown in figure 4 to 7, the results from the alternative scenarios are quite robust. In the case of IMACEC, this variable is closely tracked by each of the simulations, especially for the period up to February 1998. In the case of aggregate expenditure and the market real interest rate, the simulated values deviate substantially from the actual values, with the actual values well above those obtained from the dynamic solution of the model in all the scenarios studied. We conclude that there was an overexpansion of domestic expenditure that is not explained by our historical structure. As stated above, the increase in the real interest rate that began in January 1998 is also not explained, even if we take into account the actual values of the current account and the aggregate expenditure growth.[30]

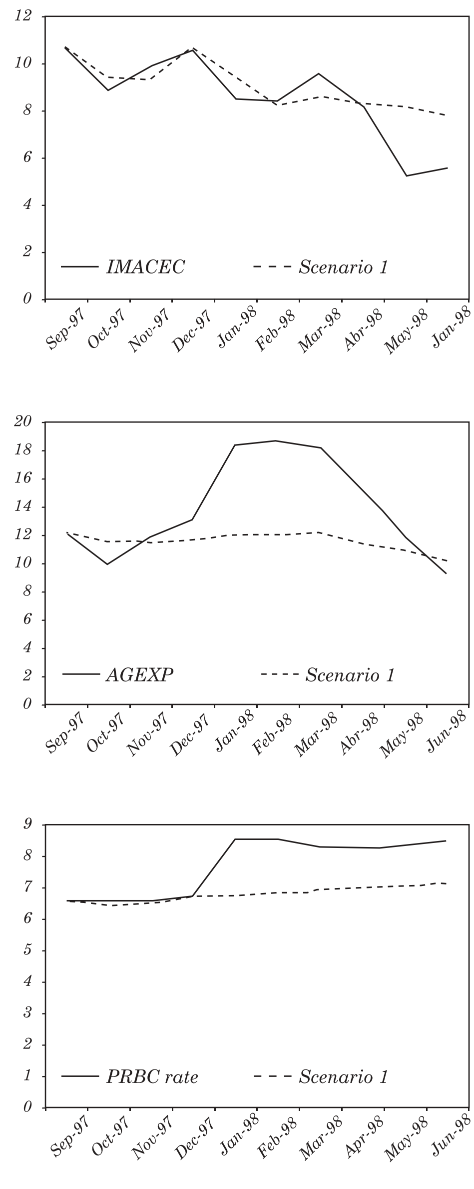
How do we interpret these findings? Generalized volatility on the emerging markets might be one possible answer. Interpreting the apparent overshooting in aggregate expenditure is more difficult, as by

28. This scenario is equivalent to eliminating all the endogenous variables' shocks.

29. These scenarios were simulated using the VAR including the IMACEC and the VAR including the aggregate expenditure, so that we could check the robustness of the results.

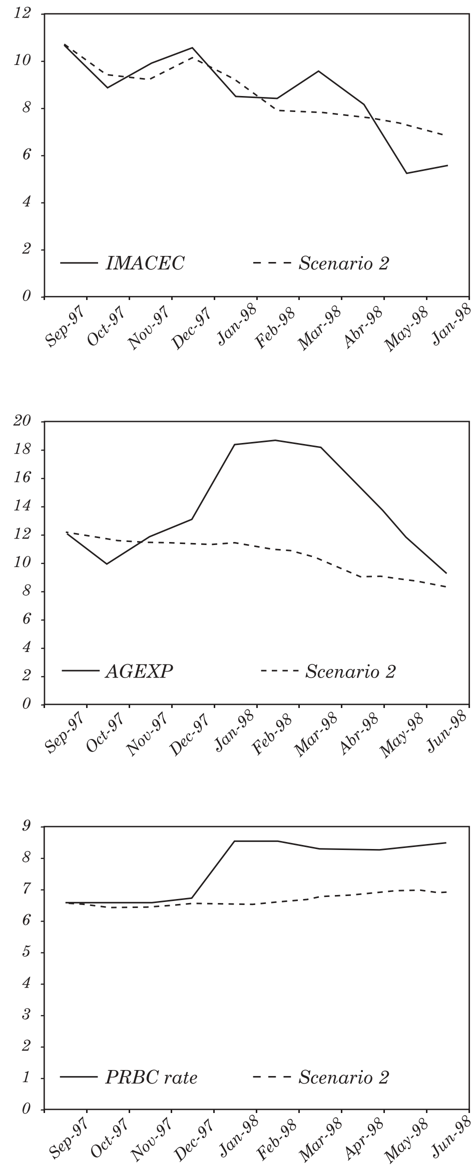
30. Massad (1998) recognizes that the current account deficit was another objective for the Central Bank.

Figure 4. Actual and Scenario 1, VAR Model, October 1997-June 1998



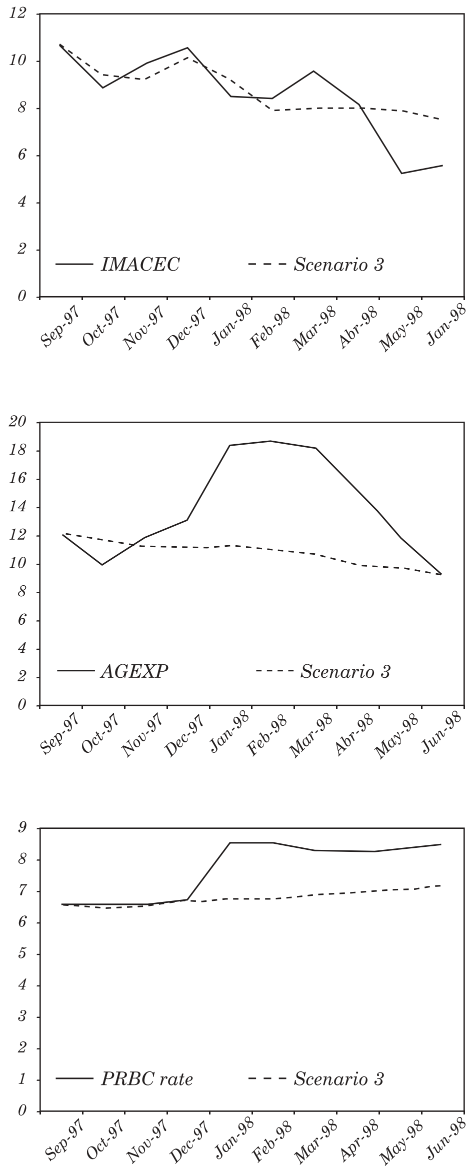
Source: Authors' calculations.

Figure 5. Actual Values and Scenario 2, VAR Model, October 1997-June 1998



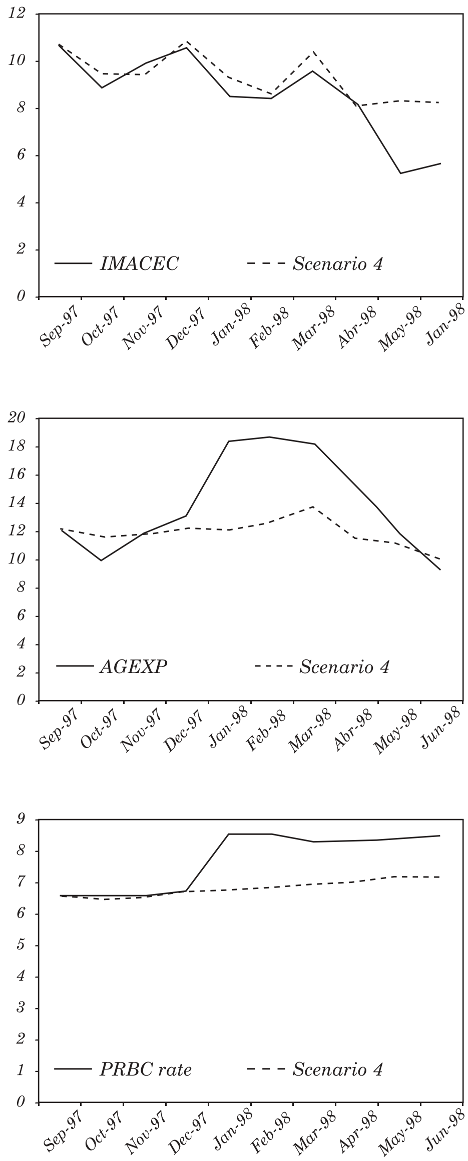
Source: Authors' calculations.

Figure 6. Actual Values and Scenario 3, VAR Model, October 1997-June 1998



Source: Authors' calculations.

Figure 7. Actual Values and Scenario 4, VAR Model, October 1997-June 1998



Source: Authors' calculations.

that time there were already clear signals of a major deceleration of world activity. An expansionary fiscal policy may be the missing piece of the puzzle.[31]

We conduct a second set of simulations to analyze the effects of the post-July 1998 shock that followed the Russian and Brazilian crises. For this purpose, we estimate the VAR model up to June 1998 and simulate it forward through March 1999. This time interval is even more interesting than the previous one because it includes the second episode of severe exchange rate pressure (August and September 1998). During this period, the overnight interest rate rose as high as 63 percent (expressed as an annual nominal rate), and the exchange rate target zone was narrowed to provide a signal that the Central Bank was not going to allow a sharp depreciation of the currency at a time when the pressure on the peso was intensifying. After solving the model forward to derive a benchmark solution, we simulate two alternative scenarios.[32] The first replaces the equation of the real interest rate in the VAR model by the observed real interest rate (scenario 5). That is, we take the observed real interest rate as exogenous in order to analyze whether the decline in real activity in the following months can be explained by monetary policy.[33] The second scenario (scenario 6) fixes the value of the real interest rate at its June 1998 level. That is, it turns off any response of monetary policy, thereby eliminating both the endogenous monetary policy response and the "exogenous" monetary policy shock. It must be noted that both scenarios include the observed values of the exogenous variables to control for any additional external shock that may have occurred during the simulation period.

The results for this second period are quite interesting. With regard to the real interest rate, the more interesting evidence derives from the comparison of the observed values and the values obtained from the dynamic solution (figure 8). The difference is very clear: neither the September hike nor the posterior reductions are similar to the dynamic derived from the historical values. The difference observed during the first months of 1999 could be explained as the endogenous

31. A more detailed analysis of the fiscal stance during the period is presented in appendix B.

32. Both alternative scenarios are very similar to the ones included in Bernanke, Gertler, and Watson (1997).

33. Here we include the endogenous response to the other shocks, as well as any possible monetary policy shocks. The benchmark case of the dynamic simulation includes only the endogenous response of the real interest rate to the rest of the variables of the economy. Since all the shocks are ignored, there is no endogenous response to exogenous shocks on the other variables.

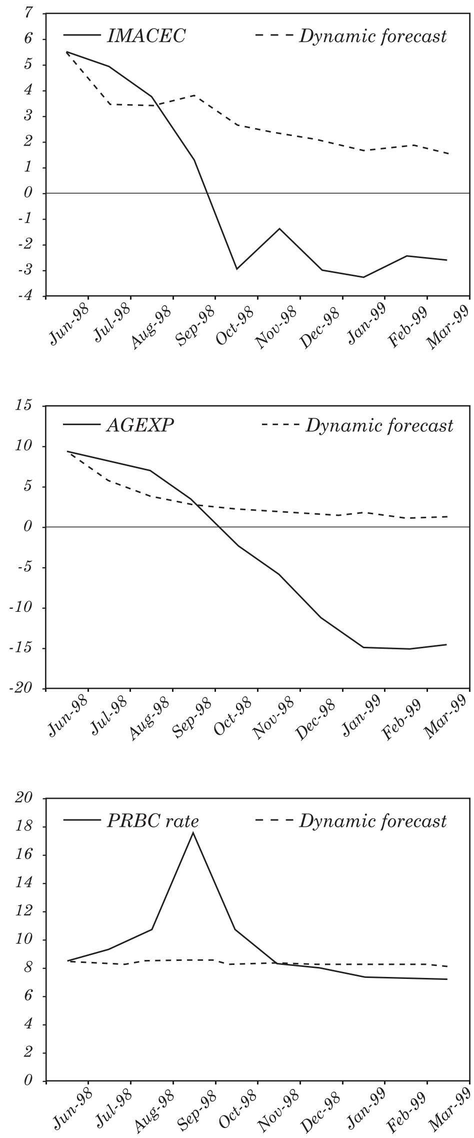
response of monetary policy to a deteriorated real activity resulting from the very high interest rate of the previous months.[34] A consideration similar to the one identified for the first simulation period applies here. Analyzing the policy response in terms of its compatibility with the previous behavior is not necessarily equal to analyzing it in terms of rationality or optimality. Also, new information that arrived during this period is not included in the simulations, and so we cannot control for them.

We now turn to the results generated when the overall economic activity index (IMACEC) is replaced by the aggregate expenditure index (AGEXP). The dynamic solution shows a smooth and steady deceleration, but it does not exhibit negative growth rates. The results are completely different, however, if we look at the simulation obtained when the observed values of the real interest rate are used. The expenditure index shows an abrupt slowdown, slightly smoother than the observed trend but with the dynamic continuing through February-March 1999.[35] One can interpret this result as evidence that the posterior slowdown was the result of monetary policy actions, both at the beginning of the simulation period and during the months immediately preceding it. When the IMACEC is used as the economic activity variable instead of domestic expenditure (AGEXP), the results are qualitatively similar. There is one problem, however: the point forecast for December 1998 is abnormally high owing to the lagged structure of the real interest rate variable in the equation for the IMACEC. If we ignore the effect of this month, the simulated values are somewhat lower than the actual ones, although they are significantly closer than the values obtained either with the dynamic simulation or under the alternative scenario with the real interest rate fixed at its June 1998 level. The picture here is almost exactly the same as that derived from the above analysis for the expenditure index. Based on this evidence, we can say that the mayor part of the deceleration of real activity during the period can be explained by external factors—mainly terms of trade—and the high real interest rate path. Results of the simulations of scenarios 5 and 6 are presented in figures 9 and 10.

34. An additional consideration for explaining this reduction can be inferred from the deceleration of observed and core inflation.

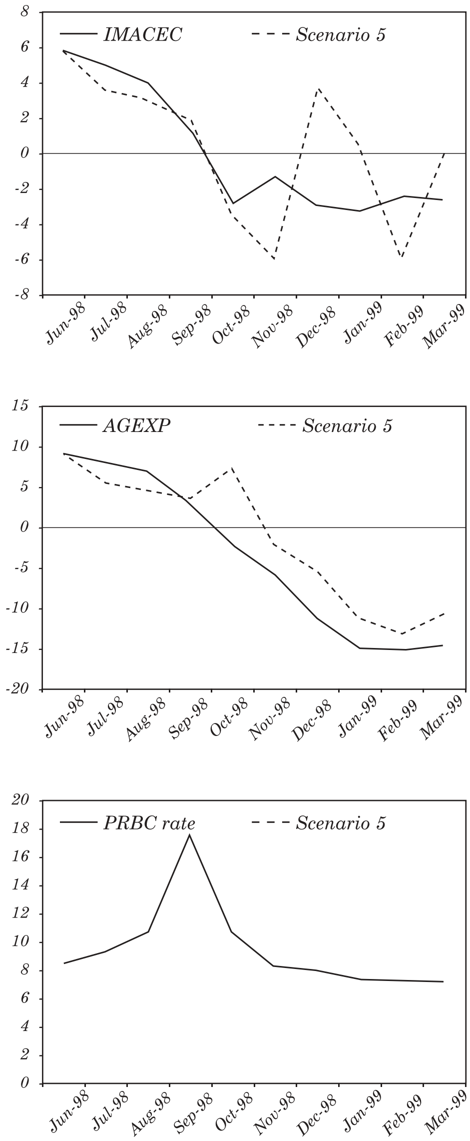
35. When the same scenario is simulated for a longer period, the recovery implied by the model is faster than the observed recovery. This difference might be the result of the previously unobserved (in the sample used for the estimations) real interest rate and some type of nonlinear effects of monetary policy on real activity not captured by the VAR model.

Figure 8. Actual and Dynamic Forecasts, VAR Model, July 1998-March 1999



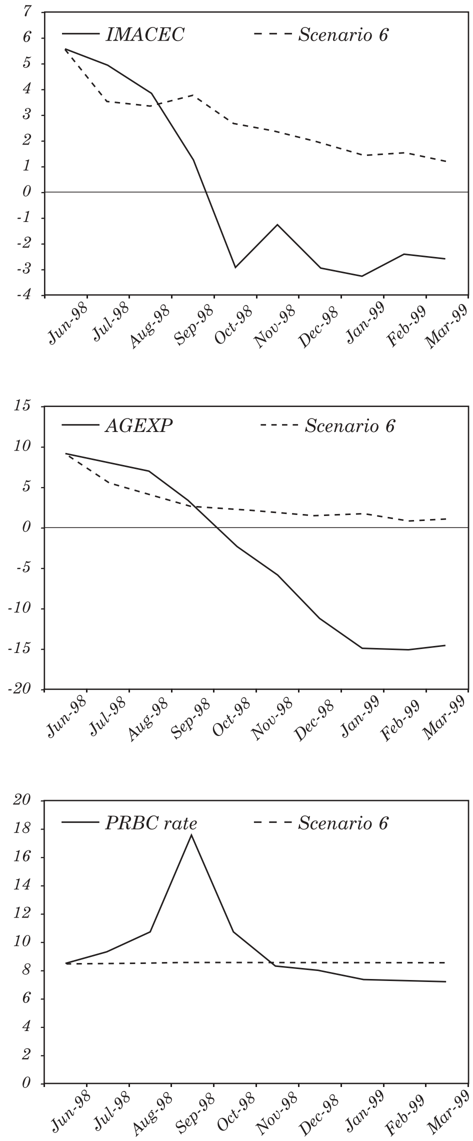
Source: Authors' calculations.

Figure 9. Actual Values and Scenario 5, VAR Model, July 1998-March 1999



Source: Authors' calculations.

Figure 10. Actual Values and Scenario 6, VAR Model, July 1998-March 1999



Source: Authors' calculations.

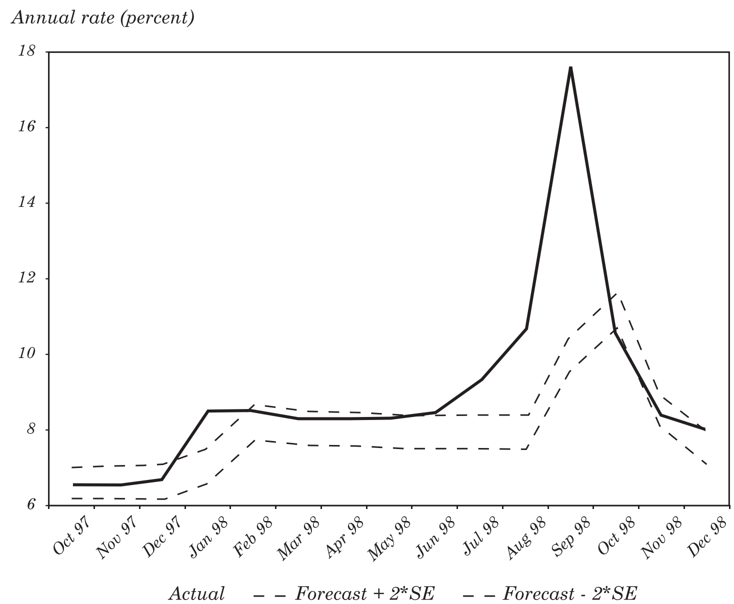
One additional point needs to be addressed. In January 1998 and again in August-September of the same year, the market real interest rate (the PRBC-90, which is the same rate used in our estimations) deviated significantly from the policy interest rate (*tasa de instancia*). During both periods, the policy rate was raised after the market rate reached its peak. This is related to a change in policy. Before January 1998, the *tasa de instancia* was closely related to the overnight rate and the real market interest rate (the PRBC-90 rate), as monetary policy was geared toward providing enough liquidity to move the overnight rate toward the policy rate. When the currency was attacked in January 1998, however, the Central Bank abstained from providing enough liquidity to keep market rates close to the policy rate. Market rates were thus left to adjust on their own in order to defend the currency. The disconnection between the market rates and the policy rate without any previous warning represents an important change in the interpretation of monetary policy, which could have had important effects on balance sheets and private behavior. After the meeting of the Central Bank's Board on 3 February 1998, the policy rate was increased and its interpretation was officially changed to a floor rate for the overnight interbank rate. To analyze the importance of this change, we carry out an experiment in which we retain the relation between the market rate (PRBC-90) and the policy rate that existed before September 1997—that is, we assume that the conduct of monetary policy had not changed. We first estimate a linear relationship between the policy rate and the market rate.[36] The estimated equation is then used to obtain forecasts of the market rate for the period from October 1997 to December 1998 (see figure 11). In January and July-September 1998, the observed values of the market rate (the PRBC-90 rate) lie outside of the band of plus or minus two standard errors. The implications for the two periods are quite different, however. In January, the change was abrupt. The sharp increase in market rates most likely took economic agents by surprise and thus resulted in important losses for those that were indebted in local currency at market rates. On the other hand, the Central Bank's actions to defend the currency against the attack protected economic agents that were short in dollars from a capital loss[37]. In July 1998, the market real interest rate (the PRBC-90)

36. The estimation was carried out using monthly data from June 1995 up to September 1997. The equation used in the simulation is as follows ($R^2 = 0.87$):

$$\text{Market Rate}_t = 1.41 + 0.80{*}\text{Policy Rate}_t + 0.41{*}(\text{Market Rate} - \text{Policy Rate})_{t-1}.$$

37. Indeed, a statement by the Central Bank on 22 December clearly recognizes that in 1998 the Board of the Central Bank was concerned with the balance sheet effects of a sudden and abrupt depreciation of the peso.

Figure 11. PRBC-90 Rate and Forecasts based on Policy Rate



Source: Authors' calculations.

started to rise slowly, following increases in the overnight rate. The difference reached a maximum by mid-September and disappeared when the policy rate was raised at the Board's meeting on 16 September.

The January and September episodes were thus quite different. By September, the market knew that the market rate could be significantly higher than the policy rate. Nobody could have been aware of that in January, however, because the official interpretation was completely different. This unannounced change of methodology was not a minor one. As pointed out by Lefort (2000), the joint existence of a floor policy rate and a legal ceiling on the lending interest rates (in accordance with Chilean banking law) may leave a fraction of borrowers unable to obtain financing from the formal market. These were the high-risk and high-cost-of-intermediation borrowers, including small and medium-sized enterprises that had reduced access to foreign financing and not enough high-quality collateral. Just looking at the market real interest is misleading because some firms face an unobserved interest rate that is much higher than the market rate, or are simply unable to borrow.

Caballero's (2002) interpretation is related to ours. Apart from the reduced supply of financial resources stemming from the monetary-policy-induced credit crunch, the much-reduced access to external markets forced large enterprises—which were credit worthy in the internal financial market—to look for internal resources, further worsening the squeeze on small and medium-sized firms. This means that at least part of the explanation of the slowdown could have been an adverse supply shock owing to financial constraints. This shock was exogenous to borrowers, but its origin can be attributed, at least partially, to monetary policy actions. This effect was probably exacerbated by portfolio adjustment toward dollar assets in anticipation of an eventual exchange rate adjustment that was postponed through the high real interest rates.

4. Macroeconomic Policies in 1997–1999: Evaluation with a Small Structural Model

The analysis of the previous two sections generates a number of questions about the appropriateness of the policy response to the increased pressure over the peso. The Central Bank faced the problem of fulfilling its main responsibility—namely, achieving and maintaining low inflation—in a situation in which the currency was under attack and the economy was overheating. Without the help of a contractionary fiscal policy, all the weight of the expenditure reduction fell on monetary policy. At the same time, the exchange rate adjustment that has to accompany the expenditure reduction to avoid a sharp increase in unemployment was postponed because of a fear of depreciation. This fear was linked to the estimated inflationary effects of the depreciation in an economy that was overheating when the first attack came.

In this section we use a small semi-structural model of the Chilean economy to throw more light on these episodes. This type of model is widely used in studies on Chilean inflation.[38] Corbo and Schmidt-Hebbel (2001) use a similar model to assess the role played by the inflation-targeting policy during the inflation reduction of the 1990s. The model corresponds to a short-run version of a traditional small open economy model. Models of the same type are commonly used in policy evaluations by researchers and central banks.[39]

38. See, for example, Corbo (1985, 1998); Corbo and Fischer (1994); Edwards (1993).

39. See, for example, Hargreaves (1999) for New Zealand; Beechey and others (2000) for Australia; Cunningham and Haldane (2000), Bank of England (1999), and Dhar, Pain, and Thomas (2000) for the United Kingdom.

The model used here closely follows the one used in Corbo and Schmidt-Hebbel (2001), but we have made some modifications to address the issue of interest, to capture the effect of the 1998 policy change. Because we want to assess policy changes that occurred in late 1997 and early 1998, the dataset includes only information that was publicly available by the end of the third quarter of 1997.

There is some international evidence on the use of revised data to evaluate or study policy decisions made in a specific time moment. For example, Runkle (1998) presents evidence that revisions of U.S. data are important and that the differences between the first estimates and the final values are sometimes large. Orphanides (2001), who focuses on estimated Taylor rules, also emphasizes the striking divergences that can emerge when policy actions are evaluated with ex post data instead of real-time data

The estimated model is presented in equations 1 through 9 and also summarized in table 8.

$$\pi_t^S = \alpha_0 + \alpha_1 \omega_t + \alpha_2 \hat{e}_{t-1} + \alpha_3 \mathrm{GAP4}_t + \alpha_4 \pi_{t-1}^E + \alpha_5 \pi_{t-1}^S \quad (1)$$

(2)

$$\mathrm{SHOCK}_t \; \omega_{t+1} = (1-\rho_\omega)\left[\beta_0 + \beta_1 \pi^{E}_{t-1} \ldots\right] + \rho_\omega \omega_t \;\; \hat{e}_t = \phi_0 + \phi_1 \pi_{t-1} + \phi_2 \pi^*_{t-1} + \phi_3 \mathrm{CA}_{t-1} + \phi_4 \Delta \mathrm{RIN}_t + \phi_5 \hat{e}_{t-1}$$

$$\mathrm{GAP}_t = \gamma_0 + \gamma_1 \mathrm{LTOT}_t + \gamma_2 \mathrm{PRBC}_{t-2} + \gamma_3 \mathrm{CK}_t \cdot \mathrm{D96} + \gamma_4 \mathrm{GAPX}_{t-1} + \gamma_5 \mathrm{GAP}_{t-1} \quad (3)$$

$$\mathrm{CA}_t = \delta_0 + \delta_1 \mathrm{GAP}_t + \delta_2 \mathrm{LTOT}_t + \delta_3 \mathrm{LRER}_t + \delta_4 \mathrm{CA}_{t-1} \quad (4)$$

$$\pi_t^E = \chi_0 + \chi_1 \mathrm{TAR}_{t+4} + \chi_2 \pi_t \quad (5)$$

(6)

$$\mathrm{PRBC}_t = (1-\rho_{\mathrm{PRBC}})\left[\mu_0 + \mu_1\left(\pi_{t+3}^S - \mathrm{TAR}_{t+3}\right) + \mu_2 \mathrm{CA}_{t+2}\right] + \rho_{\mathrm{PRBC}} \mathrm{PRBC}_{t-1} \quad (7)$$

$$\pi_t = \pi_t^S + \mathrm{SHOCK}_t \quad (8)$$

$$\mathrm{LRER}_t = \mathrm{LRER}_{t-1} + \pi_t^* + \hat{e}_t - \pi_t \quad (9)$$

where is the annualized core inflation, is the annualized CPI inflation, and the divergence between them. The expected rate of annual inflation in Chile, , is measured as the difference between nominal and real interest rates charged on 90- to 365-day deposits in the banking system. The inflation target announced by the Central Bank is denoted [40] while represents the annualized international inflation. The annualized change in average wages is denoted by while the devaluation of the nominal exchange rate (Ch$ to the US$) is denoted .

The output gap ( ) is computed as the log difference between the seasonally adjusted quarterly GDP and its long-run trend, measured by the Hodrick-Prescott filter.[41] is the four-quarter moving average of .The gap in Chile's main trading partners is labeled . We use to denote the logarithm of the terms of trade, for the logarithm of the real exchange rate, and for the real interest rate of the Central Bank bonds with ninety-day maturity. Finally, capital inflows and the current account balance are computed at the end of each period and expressed as percentage of GDP, while is the change in the foreign reserves of the Central Bank, in dollars.

Each equation was estimated separately from the others to avoid spillover effects from specification errors in a particular equation to the estimation of other equations in the model. The estimation of equation 7 is more complicated because two of the right-hand variables depend on observed values of the left-hand variable, creating an endogeneity problem (as explained in Clarida, Galí, and Gertler, 1998; Corbo, 2002). Following previous work on the issue, we use generalized method of moments (GMM) to obtain consistent estimators of the coefficients.[42]

Analyzing alternative scenarios

As cited above, Morandé (2001a) describes how the Central Bank's concerns about its ability to reach the inflation target pushed it to try to avoid a major depreciation of the peso when the attack on the currency first developed in late 1997. In fact, the nominal exchange rate depreciated more than 11 percent during the last days of 1997 and the first days of January 1998. Had this depreciation been permanent, the resulting effects on the inflation rate—the target of monetary policy—

40. Computed by the authors, linearizing the official target expressed as a December-to-December rate of change.

41. Trend GDP was computed up to the third quarter of 1997.

42. For a review of generalized method of moments, see Hamilton (1994); Greene (2000); Matyas (1998). For a review of previous works on the estimation of monetary policy reaction functions, see Clarida, Galí, and Gertler (1998) in the case of developed countries and Corbo (2002) in the case of Latin American countries.

Table 8. Econometric Results

First period

$$\pi_t^S = \underset{(0.56)}{-0.88} + \underset{(0.06)}{0.14}\omega_t + \underset{(0.05)}{0.10}\hat{e}_{t-1} + \underset{(0.22)}{0.48}\text{GAP4}_t + \underset{(0.06)}{0.15}\pi_{t+3}^E + \underset{(0.10)}{0.67}\pi_{t-1}^S$$

Sample 86.4-97.3 $R^2 = 0.977$

Sample 86.2-97.3 $R^2 = 0.941$

$$\text{GAP}_t = \underset{(1.32)}{5.81} + \underset{(0.02)}{0.04}\text{LTOT}_t - \underset{(0.19)}{1.06}\text{PRBC}_{t-2} + \underset{(0.02)}{0.13}\text{CK}_t \cdot \text{D96} + \underset{(0.34)}{0.42}\text{GAPX}_{t-1} + \underset{(0.12)}{0.35}\text{GAP}_{t-1}$$

Sample 90.1-97.3 $R^2 = 0.616$

$$\text{CA}_t = \underset{(0.06)}{-0.18} - \underset{(0.001)}{0.002}\text{GAP}_t + \underset{(0.02)}{0.04}\text{LTOT}_t + \underset{(0.01)}{0.03}\text{LRER}_t + \underset{(0.06)}{0.71}\text{CA}_{t-1}$$

Sample 86.4-97.3 $R^2 = 0.868$

$$\pi_t^E = \underset{(0.86)}{1.00} + \underset{(0.07)}{0.93}\text{TAR}_{t+4} + \underset{(-)}{0.00}\pi_t$$

Sample 89.4-97.3 $R^2 = 0.939$

$$\hat{e}_t = \underset{(2.34)}{-5.35} + \underset{(0.17)}{0.63}\pi_{t-1} - \underset{(0.11)}{0.16}\pi_{t-1}^* - \underset{(0.34)}{0.79}\text{CA}_t - \underset{(0.001)}{0.003}\Delta\text{RIN}_t + \underset{(0.12)}{0.44}\hat{e}_{t-1}$$

Sample 87.2-97.3 $R^2 = 0.826$

$$\text{PRBC}_t = \left(1 - \underset{(0.07)}{0.67}\right)\left[\underset{(0.27)}{6.14} + \underset{(0.12)}{0.53}\left(\pi_{t+3}^S - \text{TAR}_{t+3}\right) - \underset{(0.12)}{0.27}\text{CA}_{t+2}\right] + \underset{(0.07)}{0.67}\text{PRBC}_{t-1}$$

Sample 90.1-97.4 $R^2 = 0.627$

$$\omega_t = \left(1 - \underset{(0.08)}{0.44}\right)\left[\underset{(0.47)}{3.87} + \underset{(0.10)}{0.80}\pi_{t-1} + \left(1 - \underset{(0.10)}{0.80}\right)\pi_{t-1}^E\right] + \underset{(0.08)}{0.44}\omega_t$$

Second period

$$\omega_t = \left(1 - \underset{(0.11)}{0.46}\right)\left[\underset{(0.40)}{3.84} + \underset{(0.11)}{0.90}\pi_{t-1} + \left(1 - \underset{(0.11)}{0.90}\right)\pi_{t-1}^E\right] + \underset{(0.08)}{0.46}\omega_t$$

$$\pi_t^S = \underset{(0.33)}{-0.83} + \underset{(0.06)}{0.14}\omega_t + \underset{(0.04)}{0.09}\hat{e}_{t-1} + \underset{(0.19)}{0.50}\text{GAP4}_t + \underset{(0.05)}{0.14}\pi_{t+3}^E + \underset{(0.09)}{0.67}\pi_{t-1}^S$$

Sample 86.4-98.2 $R^2 = 0.981$

Sample 86.2-98.2 $R^2 = 0.949$

$$\text{GAP}_t = \underset{(1.29)}{5.91} + \underset{(0.02)}{0.04}\text{LTOT}_t - \underset{(0.18)}{1.07}\text{PRBC}_{t-2} + \underset{(0.02)}{0.11}\text{CK}_t \cdot \text{D96} + \underset{(0.31)}{0.41}\text{GAPX}_{t-1} + \underset{(0.12)}{0.33}\text{GAP}_{t-1}$$

Sample 90.1-98.2 $R^2 = 0.604$

$$\text{CA}_t = \underset{(0.06)}{-0.22} - \underset{(0.001)}{0.001}\text{GAP}_t + \underset{(0.02)}{0.04}\text{LTOT}_t + \underset{(0.01)}{0.04}\text{LRER}_t + \underset{(0.06)}{0.73}\text{CA}_{t-1}$$

Sample 86.4-98.2 $R^2 = 0.879$

$$\pi_t^E = \underset{(1.18)}{1.93} + \underset{(0.11)}{0.92}\text{TAR}_{t+4} + \underset{(-)}{0.00}\pi_t$$

Sample 89.4-98.2 $R^2 = 0.915$

$$\hat{e}_t = \underset{(2.25)}{-5.47} + \underset{(0.16)}{0.62}\pi_{t-1} - \underset{(0.11)}{0.15}\pi_{t-1}^* - \underset{(0.32)}{0.76}\text{CA}_t - \underset{(0.001)}{0.003}\Delta\text{RIN}_t + \underset{(0.12)}{0.45}\hat{e}_{t-1}$$

Sample 87.2-98.2 $R^2 = 0.827$

$$\text{PRBC}_t = \left(1 - \underset{(0.07)}{0.71}\right)\left[\underset{(0.31)}{6.58} + \underset{(0.15)}{0.59}\left(\pi_{t+3}^S - \text{TAR}_{t+3}\right) - \underset{(0.14)}{0.46}\text{CA}_{t+2}\right] + \underset{(0.07)}{0.71}\text{PRBC}_{t-1}$$

Sample 90.1-98.2 $R^2 = 0.647$

Note: Standard errors are shown in parentheses.
First period estimates are used in the simulations of the first semester of 1998. Second period estimates are used in the simulations of the end of 1998 and 1999.

would have depended on the pass-through coefficient. To analyze this episode, we start by using the estimated model to determine the effect of depreciation on inflation by late 1997. First, we solve the model dynamically for the year 1998 as a whole to see whether it fits the out-of-sample data. The results are very different from the historical event. This could be because of flaws on the model or because the structure of the model changed after this period. We assess this point by replacing equations with the observed values of some key variables; the results are very interesting. The major differences stem from two variables: the nominal exchange rate and the monetary policy real interest rate. These two equations give poor forecasts even if we take into account the observed values of the other variables. The model-simulated values for the nominal depreciation are higher than the actual values, while the simulated values for the real interest rate are lower than the actual values. In the same simulation exercise, the rest of variables perform quite well after taking into account the differences in the interest rate and in the nominal devaluation.

If the problem is just with the two mentioned variables, then replacing them by their actual values should eliminate the problem; this also serves as a test for the remaining equations of the model. As expected, the use of the actual values of the interest rate and the nominal depreciation without further modifications of the model gives us forecast values of the inflation rate very close to the actual ones. We therefore conclude that when we impose the new trajectory of the nominal depreciation and the real interest rate that emerged after the third quarter of 1997, the model explains the short-run structure of the economy quite well. The simulated values from this amended model are used as a benchmark to evaluate alternative policies.

The next step was to define the alternative scenarios to be considered for the counterfactual simulations. The first, and simpler, scenario is the dynamic solution of the model using the estimated equations for the nominal depreciation and for the real interest rate. As already mentioned, nominal depreciation is above actual depreciation, core and headline CPI inflations are well above their actual values, and the real interest rate is much below the actual interest rate. These findings are consistent with those derived from the analysis using the reduced-form VAR models described in section 3. Thus, the structural changes associated with the reduction in the unremunerated reserve requirement on capital inflows, in the exchange rate policy, and in the design of monetary policy (the interpretation of the monetary policy interest rate) had important effects, changing not only the parameters of the equations, but also the values of the variables most closely affected by policy actions. The most important point to single out is that under the old structure, the shock was bound to result in an acceleration of inflation that would have left the inflation rate for 1998 much above the annual target, resulting in a loss of credibility for monetary policy. This finding supports the point that monetary policy actions in the first semester of 1998 were a response to an anticipation of an acceleration of inflation above the target. Throughout this period, there was a continuous tension between an expansionary fiscal policy and the need to adjust the real exchange rate to facilitate the real depreciation that must accompany the expenditure reduction while keeping inflation within the target. In this game of coordination between the independent Central Bank and the Ministry of Finance, society was forced to pay a higher cost in terms of the output gap and unemployment than would otherwise have been the case.

The second alternative scenario employs the uncovered interest parity to compute the nominal depreciation expected by the market, which was implicit in the spread between peso and dollar rates for the same maturity and type of instrument. Although the empirical evidence in favor of uncovered interest rate parity is weak, a recent paper of Flood and Rose (2001) shows that it works quite well for periods of high inflation and crisis. We use the uncovered interest rate parity to obtain alternative paths for the nominal exchange rate devaluation. We use two different assumptions to compute the behavior of the exchange rate in 1998[43]. First, we compute the nominal exchange rate from the uncovered interest rate parity condition for February 1998, and then use the previously estimated equation to obtain the values for the rest of the year. Second, we assume that after February the exchange rate follows a random walk with a drift, the latter measured as the difference between internal and external inflation[44]. No matter which assumption is made for the rest of the year, the results are qualitatively the same: an inflation rate well above both the target and the effectively observed one. The differences are important; they represent as much as one-third of the target set for the year. Table 9 presents the

43. To check the robustness of the conclusions, we also compute a third scenario for the exchange rate by applying the actually observed monthly depreciations to the level computed for February under the assumption of uncovered interest parity. We thus obtain a monthly series of the nominal exchange rate used to derive the four-quarter depreciations included in the model.

44. Which is equivalent to assuming purchasing power parity for the rest of the year.

results, both as deviations from the benchmark and as percentage of the target.[45] The table also contains two additional columns, in which we recalculate the second scenario using the reaction function presented in Corbo (2002), who uses the same data definition over a longer period.[46] The results confirm our analysis and also indicate some kind of instability of the monetary policy reaction function. Corbo's estimated reaction function effectively implies a stronger reaction of monetary authorities to expected deviations of inflation from the target.

Another key element in the setting of monetary policy was the size of the pass-through coefficient from depreciation to inflation. According to our estimation, the pass-through coefficient turned out to be smaller than the 0.6 value mentioned in Morandé (2001a). Our estimated value is 0.09 for the impact effect coefficient and 0.28 for the total or long-run effect—about half of Morandé's value. While the pass-through could conceivably have been higher in an economy that was overheating, the economy should have had a greater capacity to absorb a depreciation with less effect on inflation, given that the equilibrium exchange rate had increased as a result of changes in fundamentals.[47]

The reduction in the pass-through is not a phenomenon exclusive to the Chilean economy. Cunningham and Haldane (2000) show that Europe underwent three remarkable experiences between 1992 and 1996, in which CPI inflation did not show major changes after pronounced shifts in the nominal exchange rate (both appreciations and depreciations). Taylor (2000) argues that the extent of the adjustment of prices to changes in costs depends on expectations about how persistent the changes will be—and an environment with reduced inflation persistence generally gives rise to perceptions that the changes will last for a shorter period.[48] Choudhri and Hakura (2001) test the implications derived by Taylor (2000) for a comprehensive set of countries for the period 1979–2000. They confirm the existence of a positive relation between the pass-through and the average inflation level, which is related

45. Another robustness test was made by using the actual depreciation rates to compute the nominal exchange rate for the whole year. This series obviously contains a lot more information than anyone could have supposed by January 1998.

46. His estimations include information through year-end 1999.

47. Unfortunately, in our empirical work we were unable to find a relation between the pass-through coefficient and the cycle.

48. Taylor also mentions a work by J. McCarthy of the Federal Reserve Bank of New York, who documents the declining pass-through for nine OECD countries in a comparison of the periods 1976–1982 and 1983–1998. Goldfajn and Werlang (2000) present a comprehensive study analyzing possible determinants of the magnitude of the pass-through.

Table 9. Structural Model Simulations: Inflation (%, 4-quarter rate of change)

			No defense scenario				*No defense scenario using Corbo (2001)**			
	Dynamic simulation		*Using equation 6*		*Assuming PPP*		*Using equation 6*		*Assuming PPP*	
	(a)	*(b)*	*(a)*	*(b)*	*(a)*	*(b)*	*(a)*	*(b)*	*(a)*	*(b)*
98.I	0.0	12.8	0.0	12.8	0.0	12.8	0.0	12.8	0.0	12.8
98.II	0.1	18.4	0.4	24.0	0.4	24.0	0.4	24.0	0.4	24.0
98.III	0.3	20.8	0.6	27.5	0.7	28.5	0.6	26.6	0.6	27.5
98.IV	0.8	24.7	1.1	30.9	0.9	28.0	0.9	27.0	0.8	24.2

Source: Author's calculations in base of the estimated model presented in the paper.
(a) Result expressed as deviation in percentage points from the benchmark.
(b) Difference between the result and the linearized target expressed as percentage of the target.
* The monetary policy reaction function estimated in the model (equation 7) is replaced by the equation presented in Corbo (2001).

to Taylor's idea about permanent and transitory effects. Policy implications of this result are straightforward: the sole existence of a credible commitment to maintaining a low and stable inflation rate contributes to a modification of expectations that proves crucial when a country faces abrupt exchange rate fluctuations.

We now proceed to examine possible reasons behind the sharp contraction of monetary policy that occurred during the third quarter of 1998 in the midst of high pressure on the Chilean peso. We focus our analysis on the trajectory of the inflation rate under alternative monetary policies in the period from the second quarter of 1998 to year-end 1999, as controlling inflation is the main objective of monetary policy. An alternative explanation for the sharp rise in the interest rate could have been, as claimed by Morandé (2001b), to reduce the size of the current account deficit. To determine the weight of these different considerations, we re-estimate the model with the information available through the end of the second quarter of 1998; we also recalculate trend GDP with this new information.[49] The estimated equations do not show major changes in the values of the estimated coefficients, so the exercise also serves as a robustness test for the entire model.

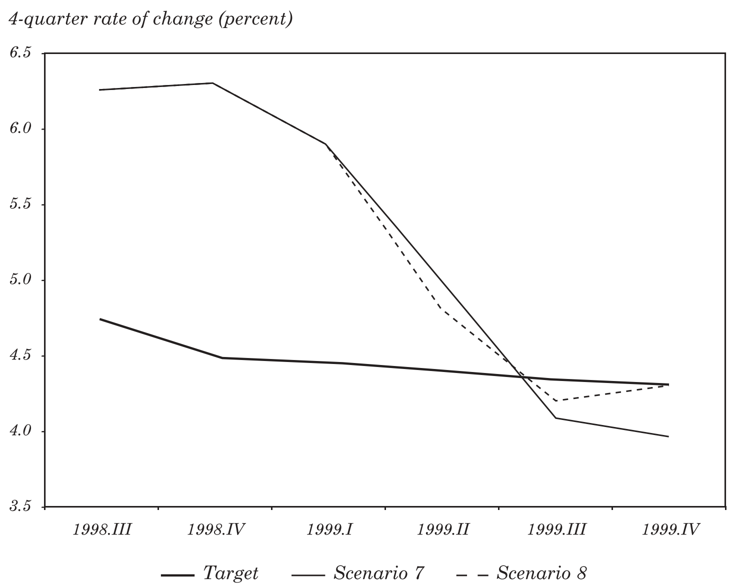
To uncover the possible influence of a concern for an acceleration of the inflation rate in the decision to defend the peso and therefore to resist a depreciation, we simulate a scenario similar to the one used for the previous period. That is, we use the uncovered interest rate parity condition to compute the expected devaluation rate in August and September of 1998, and we then use the estimated value to compute the nominal exchange rate values in the hypothetical scenario of no defense of the currency. The values in October, November, and December 1998 were computed using the monthly depreciation rate effectively observed. We assume two alternative scenarios to compute the trajectory in 1999, first using the estimated equation for the nominal devaluation (scenario 7) and second assuming PPP (scenario 8). The forecast values under scenario 7 are below the linearized target, but under scenario 8 the value is close to the target (see figure 12).[50] From this exercise, we conclude that the risk of missing the inflation target was not evident, and in any case it was much lower than in January 1998.

We now investigate the real costs associated with the alternative strategies. We compare the forecast output gaps under a base scenario

49. The trend GDP was obtained using the Hodrick-Prescott filter.

50. In both scenarios the real interest rate of the PRBC-90 is modeled with the estimated reaction function.

Figure 12. Core Inflation: Scenario 7, Scenario 8 and Linearized Target



Source: Authors' own calculation.

(scenario 7 above), allowing for the nominal devaluation and using the estimated reaction function to obtain monetary policy. The alternative scenario (scenario 9) corresponds to the simulation of the model using the observed values of the real interest rate for the entire period.[51] The differences in the simulated values of the output gap are very large (figure 13). Throughout 1999, the output gap with the effective real interest rate is well below the benchmark; this result is also valid in the case of the real interest rate (figure 14). If we compute the cumulative difference between both trajectories, the result is approximately –10.5 percentage points.[52] Had the nominal devaluation been allowed, real output would have been much higher, on average, than what actually occurred under the extremely contractionary monetary policy. Furthermore, the simulated reduction in the current account deficit is

51. Alternatively, the model was also solved using the actual values for the nominal exchange rate; the results did not significantly change.

52. Output gap is measured as the deviation from potential output as a percentage of potential or trend output.

not as abrupt in either scenario as was effectively observed. Finally, because the adjustment was carried out mainly through interest rates, firms without access to dollar-denominated liabilities suffered the major burden of the adjustment while the firms with net dollar liabilities were protected from the adjustment. This was an implicit cost of relying mostly on monetary policy to face the threat of an acceleration of inflation and reduce the size of the current account deficit.

5. Conclusions

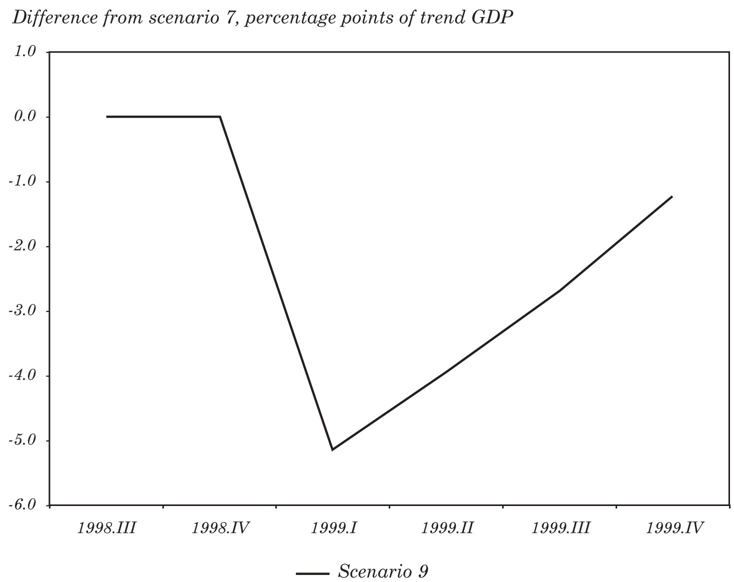
The sharp slowdown of the Chilean economy starting in the second quarter of 1998 has been a source of heated debate. This slowdown is related to a series of negative shocks and the policy response to these shocks. In particular, Chile suffered a series of external shocks—terms of trade, increase in country risk, and contagion from the Asian and Russian crises—while at the same time facing the highest interest rates of the decade. Chile was using an inflation-targeting monetary policy framework, but throughout, the Board of the Central Bank was also keeping a close watch on the size of the current account deficit. The main concern was that a high current account deficit would make the country vulnerable to a sharp reversal in capital inflows. The crisis of the early 1980s probably motivated this concern.

The deterioration in the external environment coincided with a very expansionary cycle of the economy, and it set in motion several speculative attacks on the exchange rate system, by this time an exchange rate band. Policy adjustment to the shock and to the successive attacks was not easy, since the cooperation between fiscal and monetary policy was fairly weak. Indeed, the paper shows that the period of adjustment coincides with an expansionary fiscal policy, such that the two policies worked at cross-purposes.

Much of the slowdown is traced to a sharp reduction in private investment and consumption. The results of the analysis carried out using both a nonstructural VAR model and a small structural model of the Chilean economy indicate that much of the dynamic of the Chilean economy in the post-1997 period can be explained by the external shocks and the policy response to these shocks. The main episodes studied are the ones related to attacks on the Chilean peso (January 1998, June 1998 and September 1998).

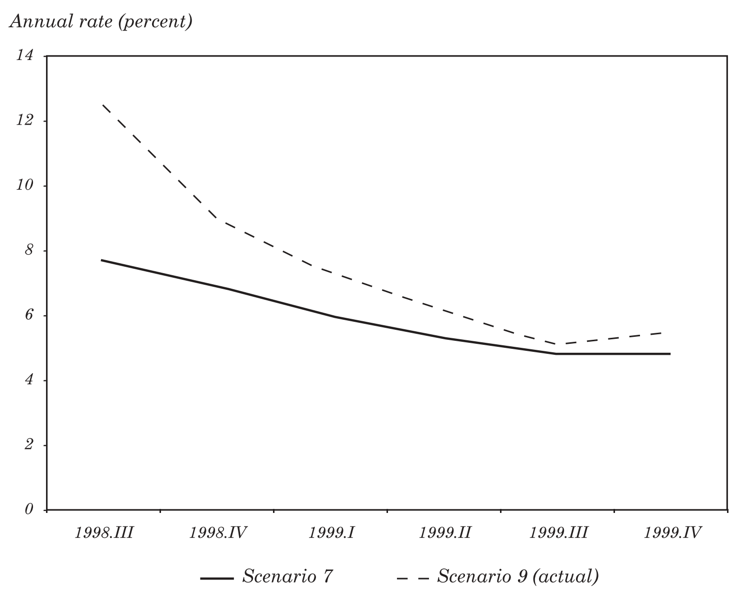
The results of the simulations with the VAR model estimated through June 1998 and simulated through March 1999 show that aggregate expenditures was bound to decelerate as a result of the shocks, although

Figure 13. Output Gap: Scenario 9



Source: Authors' own calculation.

Figure 14. Real Interest Rate (PRBC-90): Scenario 9



its growth rate did not become negative. In contrast, when the simulation is performed using the observed values of the real interest rate instead of the VAR equation estimates, the resulting abrupt slowdown in aggregate expenditures is slightly smoother than the observed trend, but it basically follows the same dynamic through February-March 1999. This provides strong evidence that the posterior slowdown was the result of monetary policy actions, both at the beginning of the simulation period and during the months just before the simulation period.

Finally, we use this small macroeconomic model to analyze the policy response to the speculative attack. With respect to the speculative attack of January 1998, we find that under the old structure, the shock was bound to result in an acceleration of inflation that would have left the inflation rate for 1998 much above the annual target and thus resulted in a loss of credibility for monetary policy. This finding supports the point that monetary policy actions of the first semester of 1998 were a response to an anticipation of an acceleration of inflation above the target. This result is robust to alternative assumptions about the size of the exchange rate adjustment. When we use the same model to analyze the August-September episode, we find that allowing the exchange rate to depreciate did not impose a high risk of inflation acceleration, and therefore other reasons must be found for this policy. The cost of this policy in terms of the gap between actual and potential output was significant.

Appendix A
Data Sources

The following series were obtained from the database of the Central Bank of Chile: gross domestic product, domestic expenditure, trade balance, current account balance, real prices of copper, inflation, unemployment, real exchange rate, and the real interest rate (90-365 lending operations). Nominal oil prices were obtained from the Central Bank database and deflated by the US WPI. Unemployment figures are from INE (National Institutes of Statistics). The annual public sector balance was taken from Larraín and Vergara (2000) and corresponds to the non-financial public sector balance.The quarterly series on public sector balance were obtained from the Ministry of Finance (DIPRES) and corresponds to the Central Government Balance. The data on terms of trade were obtained from Bennett and Valdés (2001).

Appendix B
Further Comments on the Role of Fiscal Policy

In this appendix, we briefly discuss two additional points that were mentioned in the paper: the coordination between fiscal and monetary policy and the estimation of the fiscal impulse for the period.

Fiscal and Monetary Policy Coordination in 1997–1998.

Almost every modern economy features the interaction of two macroeconomic policies—fiscal and monetary—with each using its own instruments to achieve certain goals. When the central bank and monetary policy are independent, the coordination of fiscal and monetary policy becomes a central issue in the evolution of the economy. Under certain circumstances, a lack of coordination between the two policies could generate results that run contrary to the general purpose of the central policy orientation and may increase the costs of economic downturns, in terms of the output gap (or unemployment) or output volatility.

A growing literature models this point as a game and then characterizes the situation as a problem of strategy and coordination. Different studies emphasize different elements that may lead to suboptimal outcomes. Frankel (1998) highlights the problems that may arise when there are differences in the model used to analyze the economy, such that policy actions may differ even without different preferences. Bennett and Loayza (2000) analyze a case in which there are different preferences, but only one model, with the fiscal authority concerned primarily about unemployment and the monetary authority concerned primarily about inflation.

In the case of Chile, the 1998 budget approved by the Congress in 1997 was expansionary. In fact, the assumption made about GDP growth was above what was prudent in light of the highly uncertain evolution of the world economy, as emerging economies were already feeling pressure from the Asian crisis. Additional fiscal decisions, perhaps not directly affecting the budget, might also have had a perverse effect on the evolution of private sector expenditures and wage arrangements. The high adjustment made to the minimum wage, which was highly resisted by employers, and the very high adjust to public sector wages gave a bad signal to private sector workers. This was not a good idea in the face of a very high current account deficit and a sudden stop in net capital inflows. The required adjustment on aggregate expenditures would be extremely difficult given an expansionary budget and a major wage pressure on the labor market. A more conservative budget, combined with lower wage adjustments, might have helped adjust domestic demand without putting all the pressure on monetary policy. Furthermore, given the deep concern about a possible overvaluation of the peso, a moderate expansion of aggregate expenditures could have helped avoid a large nominal and real depreciation, thereby reducing inflationary pressures. These fiscal policy decisions forced monetary policy to confront an important trade-off between the inflation target and the possibility of deteriorated real activity given the large deterioration of the external environment.

Estimating the Fiscal Impulse[1]

We base our estimation of the fiscal impulse on the Central Government accounts, including the Treasury, the ministries, and transferences to and from local governments, public enterprises, and public universities.[2] This definition is useful for our purposes because (a) local governments are not able to raised debt, and if they present a deficit, it must be financed by the Central Government; (b) universities are relatively small (in financial terms) compared with the public sector; (c) public enterprises, for the most part, post a surplus that is considered in the Central Government accounting; and; (d) the Central Bank is an independent institution.

Another topic that deserves special attention when estimating fiscal indicators is the selection of the fiscal aggregates to be considered above the line, because choosing different aggregates may lead to different conclusions. In this study, we select those aggregates that seem to have the most direct impact on domestic absorption, taking as a starting point the selection carried out by the Government Budget Office (DIPRES) in the estimation of the Structural Budget Balance.[3] One adjustment was necessary: we leave out copper incomes, because its inclusion may lead to a completely opposite conclusion about right fiscal stance. For example, if copper prices in a given period are higher than an arbitrarily chosen neutral price, this would imply that the government should implement a contractive policy, when actually the

1. This section draws on work in progress by Oscar Facusse.

2. These data are available at the Dirección de Presupuestos de Chile website (www.dipres.cl).

3. For the estimation of the structural budget balance for 2002, DIPRES changed its procedures to estimate recognition bonds. The old methodology better suits our requirements here, however.

effect on demand of this positive terms-of- trade shock would be just the opposite (that is, an expansion of aggregate demand). Thus, the income and expenditure aggregates were constructed as shown in table B1. Adjusted income equals total income less loan recovery, sales of financial assets, returns on investment, and income from copper exports (net of deposits and withdrawals from the Copper Price compensation Fund FCC). Adjusted expenditures equals total expenditures plus the net use of funds from the Oil Price Compensation Fund minus financial investment and estimated pension fund RB stock.[4]

Finally, we use the Hodrick-Prescott filter for the estimation of the potential product, although we recognize the limitations that this method imposes (in particular, the ending points problem). Considering its simplicity, however, we conclude it is a good proxy for the potential product.

With all this in mind, we proceed to the construction of the annual fiscal impulse. The results are shown in table B2. The calculations were carried out using two similar methods. First, we calculate the total impulse variable following the IMF method and using trend revenues and expenditures as defined in selected Chilean issues (IMF, 2001). Second, we calculate the total impulse using the following equation:

$$FI_t = \frac{\left[E_t - E_{t-1} - g_0\left(YP_t - YP_{t-1}\right)\right] - \left[I_t - I_{t-1} - t_0\left(Y_t - Y_{t-1}\right)\right]}{Y_t} \tag{B.1}$$

where E_t is adjusted expenditures in period t; I_t is adjusted incomes in period t; YP_t is potential product in period t; Y_t is GDP in period t; g_0 is the average ratio of adjusted expenditure to potential product for the years 1992–1997; and t_0 is the average ratio of adjusted income to GDP for the same period.

The two indicators present extremely close results, as expected, which indicates that the government pursued an expansive fiscal policy in the period 1995–1999, with a more expansive stance in the period after 1997.

Next we estimate the quarterly fiscal impulse for the relevant period (1997:1 to 2000:4). Here we use the equation presented above. The

4. FCC is a copper price-compensation fund. FEPP is an oil price-stabilization fund. The RB stock represents mandatory government transfers to private pension funds cumulative under the previous public pension fund scheme (which was changed in 1981); in this calculation, this is the stock of assets that are not supposed to have direct macroeconomic impact. For more detail, see Marcel and others (2001).

Table B.1: Fiscal Aggregates Construction

Total Income	*Total Expenditure*
- Loan recovering	
- Financial assets selling	- Financial Investment
- Investment return	+ FEPP[b] use of funds
- Copper net of FCC[a]	- Estimated RB Stock[c]
Adjusted Incomes	**Adjusted Expenditures**

a. FCC is a cooper price compensation fund.
b. FEPP is an oil price stabilization fund.
c. Due to the pension reform of 1981, the government transfers to the private pension funds the existing stock of resources collected by the previous public scheme (RB). In this calculation, this stock of assets is asummed to have no direct macroeconomic impact.

Table B.2: Fiscal Impulse (As a % of GDP)

	1992	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Actual									
Revenue	21.76	22.57	21.63	21.20	22.69	22.34	22.36	21.53	22.07
Expenditure	20.48	20.98	20.55	19.52	20.89	20.90	22.01	23.65	23.43
Trend									
Revenue	19.30	19.30	19.30	19.30	19.30	19.30	19.30	19.30	19.30
Expenditure	22.91	22.98	23.24	22.37	22.10	21.80	22.00	23.20	23.10
Actual less Trend									
Revenue	2.46	3.27	2.33	1.90	3.39	3.04	3.06	2.23	2.77
Expenditure	-2.43	-1.99	-2.68	-2.85	-1.21	-0.90	0.01	0.45	0.33
Total Impulse	-0.06	-0.37	0.25	0.26	0.16	0.65	0.90	1.27	-0.66
Revenue Impulse	-0.56	-0.81	0.94	0.43	-1.49	0.34	-0.01	0.83	-0.54
Expenditure Impulse	0.50	0.44	-0.69	-0.17	1.65	0.30	0.91	0.44	-0.12
Total Impulse 2	-0.14	-0.39	0.19	0.14	0.13	0.68	0.89	1.27	-0.37

Source: Authors' calculations.

objective is to figure out what happened with the fiscal accounts during the economic slowdown. The methodology is exactly the same as presented before, but on a quarterly basis.[5] Here, g_0 and t_0 correspond to the quarterly average for 1996, and the differences $(X_t - X_{t-1})$ consider changes over four quarters.

5. Quarterly GDP was seasonally adjusted before detrending with a Hodrick-Prescott filter. Here the fiscal aggregates were constructed without adjusting by the FEPP owing to a lack of quarterly data, although the results do not present significant changes.

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Estimating Gaps and Trends for the Chilean Economy

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Over the past few years, the Chilean economy has experienced a marked deceleration in economic growth. Labor productivity growth averaged more than 6 percent annually from 1994 to 1997, but since 2000 it has registered between 3 and 4 percent. Moreover, the period since the outbreak of the Asian and Russian crises in 1997 and 1998 seems to indicate that more than purely cyclical factors are at play in determining the expansion of productivity and the recent rates of aggregate growth: monetary policy has clearly shifted to a more expansionary stance, and since 1999 long-term interest rates have declined sharply in real terms.

The debate on whether the current and forecast growth rates of the Chilean economy in the short term reflect a shift in the underlying expansion of productivity or are only a symptom of weak aggregate demand reflects the difficulties in separating trends from cycle. The same can be said about the different opinions regarding the size of current slack in capacity utilization. This is unfortunate, though, because these two variables are key inputs in the formulation of monetary and fiscal policy. On the one hand, the current slack in factor and goods markets determines the present underlying inflationary tendencies, through their impact on wages and markups. On the other, the expansion of capacity utilization over the next quarters or years affects the trends in these inflationary pressures.

Since 1999 monetary policy in Chile has been guided by forecast inflation targeting, in which the current stance of monetary policy is

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endogenous to the expected or forecast path of prices. Erring on one side or the other of the output gap or trend growth can affect the achievement of the inflation target. Moreover, whereas supply shocks or relative price shocks (such as oil prices and the exchange rate) are immediately observed, the true extent of underlying price and wage pressures remains uncertain until it is too late to act with monetary policy. The transmission mechanism of monetary policy to inflation through the labor market is likely to have the longest lags of all such mechanisms.

Similar difficulties arise with regard to fiscal policy. The current framework in Chile aims at the achievement of a structural surplus of 1 percent of GDP over the cycle. The yearly discussion of the budget therefore requires an actual quantification of the size of the output gap, to fix the path of real expenditure. Again, using assumptions about the gap or trend growth over the short run can introduce a bias in fiscal policy, inducing too much or too little aggregate demand impulse relative to what is deemed convenient.

Unfortunately, the construction of output gap measures is plagued with difficulties. After briefly reviewing related studies in section 1, we begin our analysis in section 2 with a data-based approach that relies on a two-step procedure. First, we use traditional growth accounting exercises to obtain a measure of total factor productivity (TFP). Second, we define potential output based on the assumption that inputs (labor and capital) are at their normal or trend utilization rates. This procedure is sensitive to assumptions in both steps. An accurate measurement of inputs used in the production process includes issues that should not be accounted for as TFP fluctuations, such as shifting quality and composition of labor and capital, as well as time-varying utilization rates. The second step, in turn, requires assumptions about the trend or normal use of inputs, to work backwards and estimate potential output.

In simple terms, and leaving aside the measurement issues related to quality trends, the data-based approach actually requires identifying a priori the cyclical and trends components in the data. A typical case is the capital utilization rate, which is usually associated with the unemployment rate following Solow's classic exercise. To construct potential output (an exercise that Solow did not pursue), the production function is then evaluated at a "normal" utilization rate (that is, the "natural" unemployment rate, defined in a particular way). It is thus paradoxical that the key identification assumption corresponds closely to the result of the calculation. By going through the two steps mentioned above, we do not pretend to circumvent these difficulties, but rather aim to highlight the type of assumptions needed for this approach.

Section 3 complements the data-based estimates with a simple empirical methodology that estimates the output gap directly from macroeconomic aggregate demand and aggregate supply models. Given that the output gap measures are typically used as inputs in a macroeconomic model such as the one we use, the simultaneous estimation through state-space techniques of the macroeconomic variables and the underlying unobserved level of the output gap provides an interesting alternative to the data-based approach.

This model-consistent estimate still requires some identification assumptions. The first is the actual specification of the macroeconomic model, particularly the functional form and the excluded variables. This is unavoidable, however, given that the output gap measures are used in the context of specific models of the macroeconomy. The second main identification assumption relates to the assumed volatility of output trend.

1. A Review of Related Work

Interest in potential growth is not novel to Chile. Most of the research refers to the period before 1997, however, and it generally does not acknowledge the importance of the specific identification issues surrounding the estimation.

Roldós (1997) combines two different forms of analysis—namely, growth accounting and regression analysis—to examine economic growth determinants and the relation between economic growth and inflationary pressures. He estimates an aggregate production function using a cointegrating vector, which relates total GDP and production factors (capital and labor) adjusted by quality indexes. These indexes measure changes in the composition of production factors that make aggregate factors more productive. The factor shares obtained from the estimation of the production function allow Roldós to calculate the Solow's residual, or the TFP. He uses a Hodrick-Prescott (HP) filter to remove the cyclical components of the TFP and employment before estimating the potential output. Roldós does not find a positive correlation between output gap and inflation, but rather a small negative one. He interprets these results as a product of the high average inflation throughout the 1990s. However, he does not control for movements in the exchange rate.

Rojas, López, and Jiménez (1997) carry out a similar exercise in a growth accounting model, considering not only capital and labor as production factors, but also the contribution of international trade to growth. They estimate the contribution of Chile's increasing commercial integration in the last decades to effective and potential growth.

Using a cointegration focus, the study estimates a production function that considers capital and labor—corrected by grade of utilization and by quality indexes—and a terms-of-trade variable that controls for fluctuations of international prices faced by the economy. It then calculates the potential output of the Chilean economy during 1960–1996 using a cointegration vector comprising labor, capital, terms of trade, and commercial integration, all filtered by HP.

It is typical for such studies to filter the series to obtain a measure of the gap, although it is questionable how much this differs from directly filtering the GDP data (see figure 1). Studies that do not use filtering methods still imply strong identification assumptions. Marfán and Artiagoitía (1989) use linear programming techniques to obtain a measure of the gap. However, they impose a production function that is linear in capital. García (1995) uses an indirect approach: he estimates a labor demand function to identify the parameters of the production function and then defines potential output as output at full employment. The gap is thus the mirror image of the unemployment rate. Jadresic and Sanhueza (1992) similarly identify the output gap by assuming an increase in the natural rate of unemployment by the late 1970s and early 1980s.

Coeymans (1999) does not estimate a measure of potential output, but rather focuses on an approach based on sources of growth to measure trends in GDP. He estimates a production function in which growth determinants are centered in aggregate supply factors: namely, capital accumulation, hiring of new workers, and TFP.[1] Assuming constant returns to scale, this analysis shows an important cyclical component in productivity. The high correlation between productivity and external shocks reveals their importance as principal determinants of productivity cycles and output.[2]

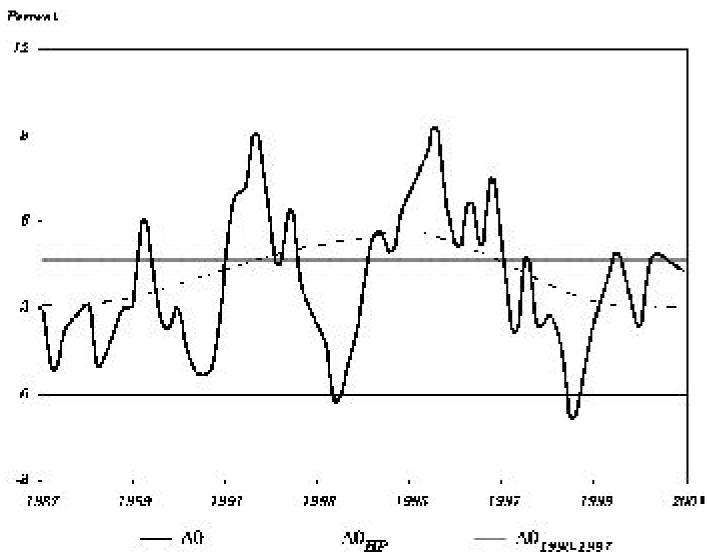
In a related effort, Nadal de Simone (2001) estimates a small macroeconometric model using state-space techniques similar to the ones used here. The main difference between his work and ours is that while he uses an approach based exclusively on unobserved trends in GDP, we incorporate more structure on the main macroeconomic relations, including aggregate demand and price determination.

As is evident from this brief review, we do not stray too far from previous efforts. It is important, however, to acknowledge the

1. TFP includes changes in the level of utilization of capital and labor, reallocation of resources from low to high productivity activities, and technical advance.

2. For example, terms of trade, impact of international interest rate on financial services, and external crisis index.

Figure 1. Aggregate Labor Productivity Growth Rate



$\Delta\theta$ is the change in average labor productivity.
$\Delta\theta_{HP}$ is the change in the HP filtered average labor productivity.
$\Delta\theta_{1990\text{-}1997}$ is the average annual growth in labor productivity, from 1990 to 1997.

importance of the assumptions behind the estimates of trends and gaps. This is why we use two very different approaches. The results of these two methodologies are different, as expected, and are also quantitatively different from simple filtering techniques such as the Hodrick-Prescott (HP) filter. This reveals that, not unlike many of the other aspects surrounding monetary policy under inflation targeting, considerable judgement must be used to evaluate the underlying inflationary pressures in the economy. The use of a single mechanical procedure to estimate trends and gaps is therefore dangerous, because it is very likely to introduce biases in the conduct of monetary policy.

2. Data-Based Estimates of Potential Output and the Output Gap

In this section, we construct estimates of total factor productivity growth and assess its contribution to the slowdown of aggregate growth experienced in Chile over the last few years.

2.1 Dual and Primal Estimates of TFP: Notation

The two possible strategies for estimating TFP are the primal and dual approaches. They differ in the data required, and they are generally viewed as complementary. The primal approach relies on the calculation of Solow's residual, through the use of aggregate GDP data, along with estimates for the capital stock and labor employment. The dual estimate focuses on the path of relative prices: wages and the cost of capital. The relationship between these two approaches is easily demonstrated by assuming a production function for value added and using the income identity of national accounts, both in real terms:

$$Y = F\left(A, K, N\right) = C_k K + C_n N \ . \tag{1}$$

The only assumption underlying equation (1) is that output equals payments before direct taxation to the factors of production—labor ($C_n N$) and capital ($C_k K$). These include depreciation and eventually rents owing to imperfect competition in labor or capital markets. Note that Y is cost-based value added, not including indirect taxes. No assumption is made about the shape of the production function, in particular the way technological change A affects the relative demands for capital and labor.

First order differentiation with respect to time, using the normalization $(\partial F/\partial K) = 1$, leads to

$$\Delta Y = \Delta A + \frac{\partial F}{\partial K}\Delta K + \frac{\partial F}{\partial N}\Delta N = K\,\Delta C_k + C_k \Delta K + N\,\Delta C_n + C_n \Delta N \ . \tag{2}$$

Dividing both sides of the equation by Y yields

$$\Delta y = \Delta a + \frac{\partial F}{\partial K}\frac{K}{Y}\Delta k + \frac{\partial F}{\partial N}\frac{N}{Y}\Delta n = \frac{C_k K}{Y}\left(\Delta c_k + \Delta k\right) + \frac{C_n N}{Y}\left(\Delta c_n + \Delta n\right). \tag{3}$$

If $\alpha = (C_k K / Y)$ is the share of capital in total costs, then

$$\Delta y = \Delta a + \alpha \Delta k + \left(1-\alpha\right)\Delta n = \alpha\left(\Delta c_k + \Delta k\right) + \left(1-\alpha\right)\left(\Delta c_n + \Delta n\right). \tag{4}$$

This formulation is correct under both perfect and imperfect competition, as long as markups enter as a wedge between marginal factor productivity and the reservation wage and cost of capital:

$$C_k = \bar{C}_k \left(1 + \mu_k\right) = \frac{\partial F}{\partial K} \text{ and} \tag{5}$$

$$C_n = \bar{C}_n \left(1 + \mu_n\right) = \frac{\partial F}{\partial N} .$$

This means that both approaches should have the same measurement error. The primal (Δa^{primal}) and dual (Δa^{dual}) estimates of TFP growth can now be defined:

$$\underbrace{\Delta y - \alpha\Delta k - (1-\alpha)\Delta n}_{\Delta a^{\text{primal}}} = \underbrace{\alpha\Delta c_k + (1-\alpha)\Delta c_n}_{\Delta a^{\text{dual}}} . \tag{6}$$

The intuition for this identity is simple: TFP grows if real wages or the real return on capital is growing, too, because these relative prices (not adjusted for quality) should be constant in steady state.

Before moving to the primal and dual estimates of TFP growth, some measurement issues must be highlighted. These revolve around two main aspects: the changing quality of the inputs in production and their varying utilization over the business cycle.

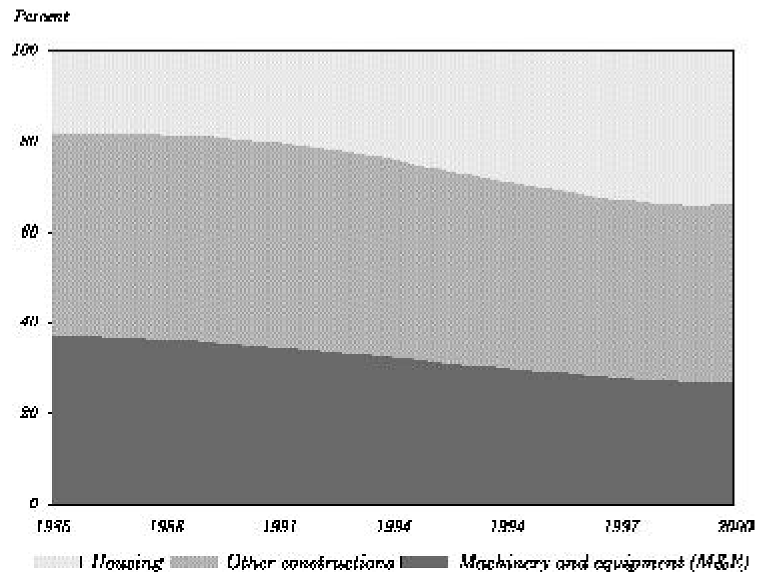
2.2 Dealing with Quality Trends

Important quality trends are found in both capital and labor. With regard to capital, the composition of gross fixed investment has shifted dramatically over the last decade and a half. In 1986, machinery and equipment (M&E) composed 43 percent of gross capital formation (in constant 1986 prices), while from 1995 onwards its share stabilized around 60 percent. In nominal terms, the share of M&E first increased from close to 40 percent in the mid-1980s to 50 percent in the early to mid-1990s; it then declined to slightly over 40 percent in recent years.[3] Fairly large shifts also occurred within M&E over time. The imported component increased from 80 percent in the mid-1990s to close to 90 percent in 1998, and then experienced a steep decline in 1999 and 2000, reaching 76 percent.[4]

3. Official data on nominal investment are available through 1998, so we used estimates for investment deflators for 1999 and 2000.

4. Again, the later data are estimates based on the path of capital imports quantum, which fell close to 35 percent in 1999. The years 2000 and 2001 have seen a modest recovery: third quarter data are only 11 percent higher than the 2000 average.

Figure 2. Composition of the Capital Stock



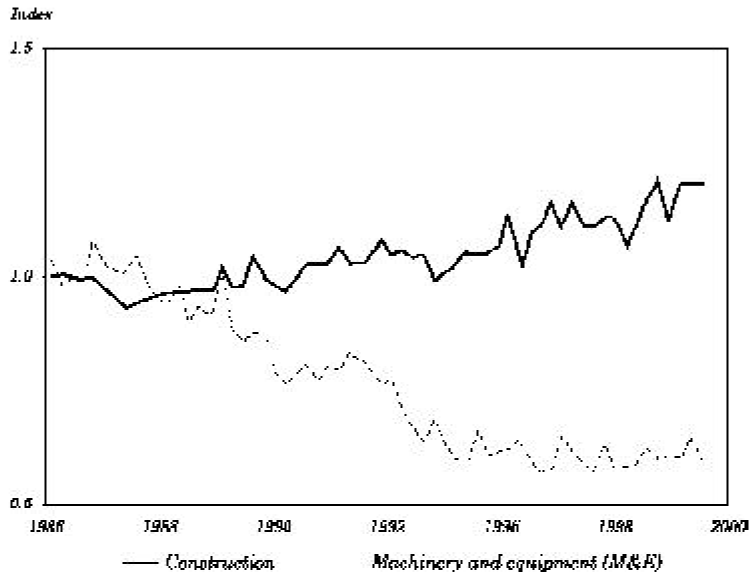
Accounting for these large shifts in the composition of investment is important. They have been substantial enough to matter in the composition of the capital stock over the last decade and a half. Recent estimates by Aguilar and Collinao (2001) show that M&E as a share of the capital stock increased from 18 percent in 1985 to 33 percent in 1997, and has remained stable since (see figure 2).

These shifts have potentially large effects on the dual estimate of TFP growth, as shown by D. W. Jorgenson's definition of the cost of capital. Let $C_{k,i}$ represent the capital cost of brand i of capital, measured relative to the GDP deflator P, while R_i is the net return on capital, D_i the depreciation rate, P_i its own deflator, and τ_i any tax-induced wedge:

$$C_{k,i} = \tau_i \left(R_i + D_i\right)\frac{P_i}{P}. \tag{7}$$

If we abstract from the importance of different tax treatments, τ_i, and if by arbitrage we set R_i equal for all i, different rates of depreciation, as well as different relative prices P_i/P for each brand of capital, will still have an important incidence in the cost of capital. In particular, M&E must be treated differently from construction because it has a high relative rate of depreciation and an important imported component. These

Figure 3. Investment Deflators (Relative to GDP Deflator)

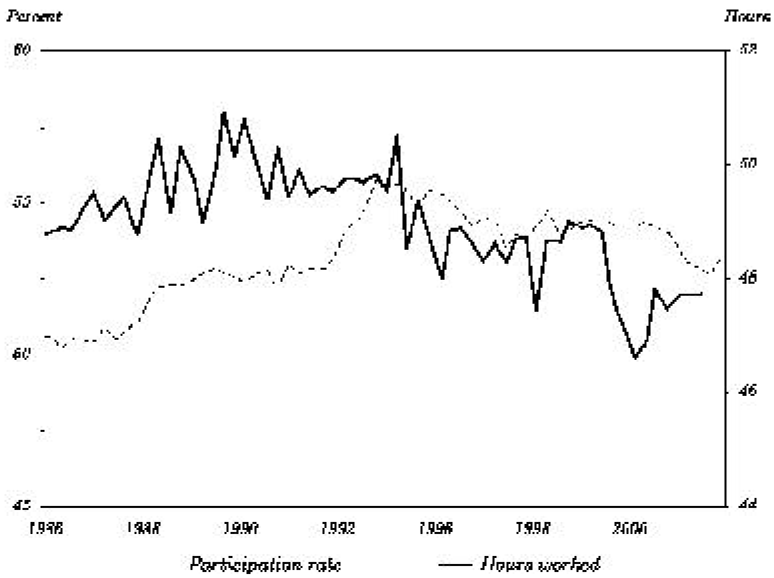


facts affect not only the estimated path of the cost of capital for the dual estimate of TFP, but also the share of M&E in total costs, which is an input for primal growth accounting.

How important quantitatively are these factors in determining the path of the cost of capital? Figure 3 shows quarterly M&E and construction deflators, normalized by the GDP deflator for the period 1986 to 2001. The two deflators display very different evolutionary paths. The increase of the construction deflator has been fairly stable, increasing by a little more than 1 percent over the increase in the GDP deflator. Meanwhile, the appreciation of the real exchange rate had a large impact on the relative price of M&E, which fell around 40 percent between 1990 and 1996. It has remained stable since then: the depreciation of the nominal exchange rate was offset not only by a decrease in the dollar-unit import value of capital goods, which fell 15 percent after peaking in early 1996, but also by a reduction in the average tariff rate of 3 percentage points. The relative price of M&E vis-à-vis construction thus declined 50 percent between the mid-1980s and 1997.

In the area of labor, the quantity and quality of inputs changed considerably over time as a result of increases in educational attainment, the sectoral reallocation of labor, and secular trends in labor

Figure 4. Hours Worked and Average Participation Rate



participation and hours worked. In simple terms, the actual labor input that enters the production function is a combination of the participation rate, *p*; the employment rate, (1-*u*), with *u* being the unemployment rate; hours worked, *H*; effort, *E;* and educational attainment, *S*:

$$N = Pp\left(1-u\right)HES \ . \tag{8}$$

All these factor played a role in Chile over the last decade and a half. Since the mid-1980s, the labor force has increased its average years of schooling by over 10 percent. At the same time, the participation rate also shifted up, especially among women and especially in the early 1990s. Since 1999, though, participation has declined by a couple of percentage points. The number of hours worked shows a downward trend since 1986 (see figure 4).

2.3 Dealing with Utilization over the Cycle

Over and above the changing quality of the inputs, their utilization over the cycle can introduce “false” movements in TFP. Existing frictions prevent the full utilization of the existing stock of capital or the labor force. This paper does not address why this might be so; we are simply pointing out that this fact must be taken into account to prevent a spurious relationship between TFP and the business cycle.

In the case of labor input, unemployment figures allow at least a partial disentangling of the labor utilization effect. The issue is further complicated, however, because participation rates themselves are not exogenous, and they have a relationship with the business cycle through the combined added-worker and discouraged-worker effects. These two effects actually show interesting empirical dynamics over the cycle, depending on the persistence of the path of unemployment: an increase in unemployment initially increases participation (the added-worker effect), but if this increase persists over time, participation starts to drop below its initial level (the discouraged-worker effect) (see García and Contreras, 2001). Moreover, the intensity of physical labor can vary over the cycle, reflecting changes in hours worked and effort expended. These factors not only affect labor input trends as shown above, but they also have a quantitative impact over the cycle, particularly labor force participation.

The above issues are relevant for a correct interpretation of the primal TFP estimation. They also come into play for the case of the dual estimate. Real wages, controlled for inflation fluctuations, move with unemployment fluctuations in a significant way.[5] Even more, the real return on long-term bonds, which is the variable used to construct the cost of capital because it is not subject to arbitrage, is sensitive to monetary policy shifts, which themselves react to perceived output deviations from trend and inflationary pressures. Therefore, the dual estimate of TFP growth will be polluted by the cyclical behavior of the cost of capital and wages (see figure 5).

2.4 Identifying Assumptions

Constructing the primal and dual measures of TFP thus requires separately identifying the cyclical and trend components of each of the stock (for the primal) or price (for the dual) estimates. The key identification assumption we make here is the estimation of the natural rate of unemployment, which plays an important role in all the corrections for the TFP estimation.

To obtain the natural rate of unemployment we filter the unemployment rate with the Hodrick-Prescott filter, setting l = 20,000 and

5. See García and Restrepo (2001); Coeymans (1999).

Figure 5. Annual Interest Rates

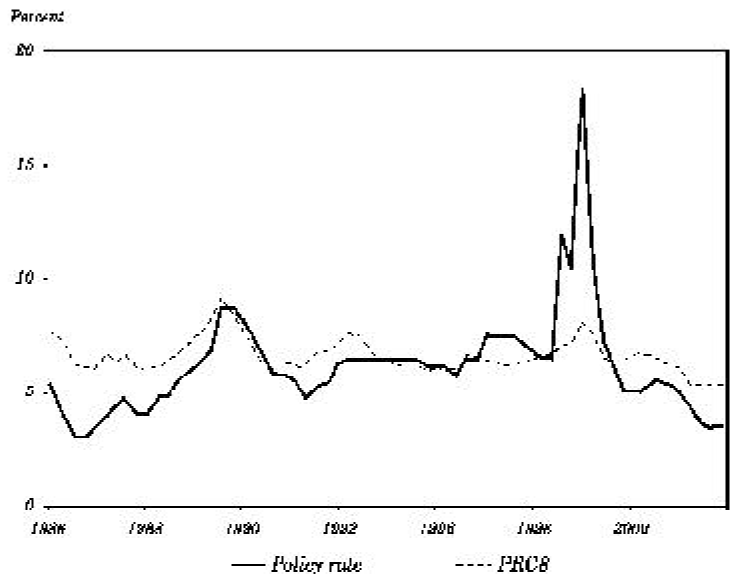
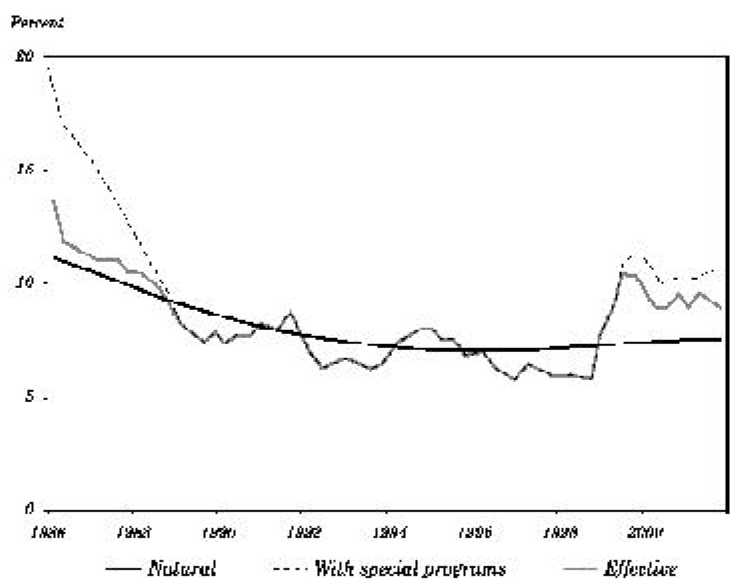


Figure 6. Effective and Natural Unemployment Rates



restricting the sample up to the first quarter of 2000. The HP filter has a well-known problem in dealing with end points; we therefore exclude the last six quarters and instead fix the natural rate of unemployment at 7.5 percent for this subperiod (see figure 6). We define the unemployment gap as $u - un$.

We assume that the effective use of capital over the cycle is similar to the gap between the effective unemployment rate and the natural rate.[6] Utilization is thus over 100 percent during a boom and below 100 percent in a slump. We further assume that the utilization of M&E and the utilization of construction move in tandem. These effective measures of the capital stock are defined as

$$\overline{K_i} = K_i\left(1 + un - u\right). \tag{9}$$

Long-term interest rates in Chile were highly volatile in the past, reflecting, in part, the impact of monetary policy decisions. For the dual calculation of TFP, however, we are interested in more persistent factors affecting the demand for long-term bonds, such as, precisely, growth prospects. We therefore need to break down the path of interest rates, disentangling all movements associated with short-term rates. We proceed in two steps. First, we use the Kalman filter to estimate a policy rule for short-term interest rates, including the unemployment gap, the difference between actual inflation and the inflation target, and an autoregressive term.[7] We interpret the state variable that results as an indicator of the unobserved neutral stance for monetary policy. Second, we input the resulting neutral policy rate into an estimated equation for long-term interest rates, which includes leads and lags of itself. In this manner, we recover a path for long-term interest rates that we hope is unrelated to the cyclical situation of the economy (see figure 7).

Finally, a similar exercise needs to be performed on labor to correct for hours worked. We estimate a simple specification, regressing average hours worked on the unemployment gap, and a quadratic trend. The resulting equation is

$$\ln H = \underset{(0.010)}{3.88} + \underset{(0.009)}{0.03} \ln trend - \underset{(0.001)}{0.008}\left(\ln trend\right)^2 - \underset{(0.155)}{0.778}\left(u - un\right),$$

6. This is the same assumption used in the literature since Solow's classic article (Solow, 1957). It does not imply that the labor-to-capital ratio is constant. Rather, this ratio does not move mechanically with the employment rate.

7. For details, see the Appendix.

Figure 7. Cyclically Adjusted Long-Term Interest Rate (PRC8)

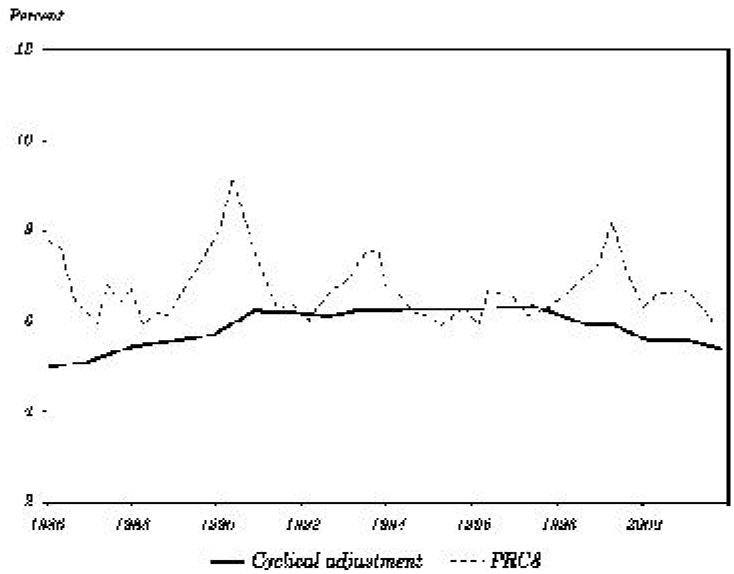


Figure 8. Cyclical Correction of Hours Worked

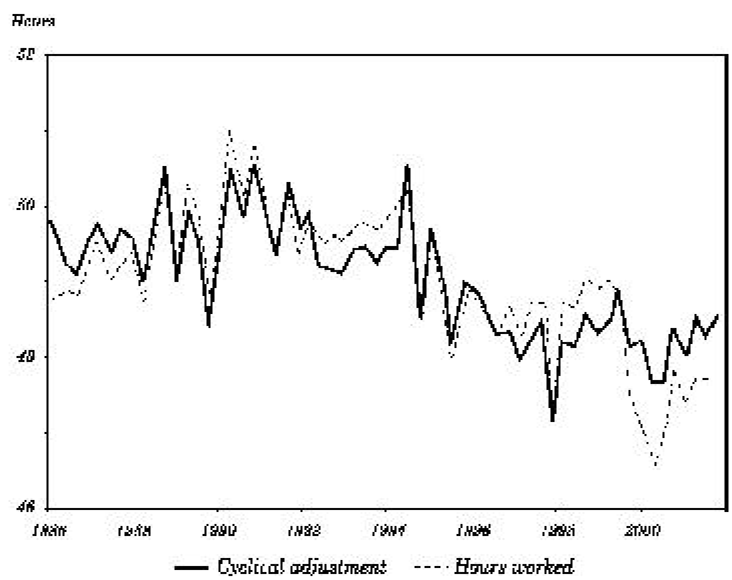
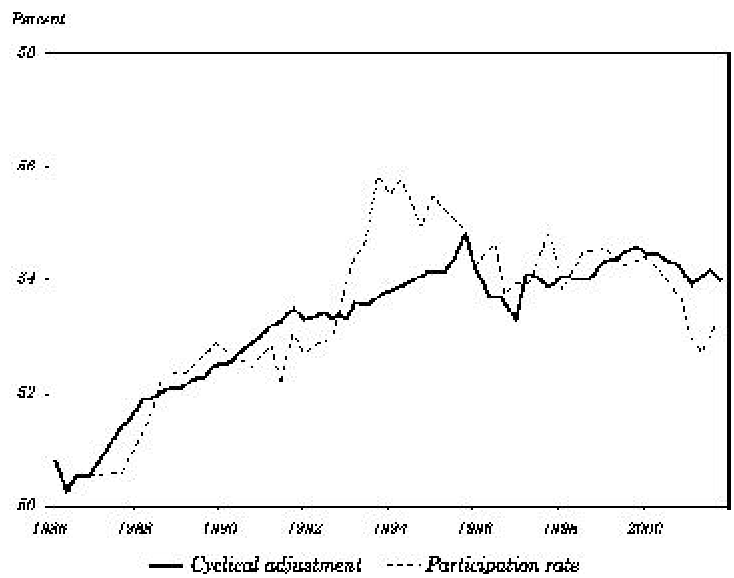


Figure 9. Cyclical Correction of Participation Rate



with Newey-West standard errors listed in parentheses below the coefficients and with *R*-squared equal to 0.63, a standard error of 0.01, and a Durbin-Watson statistic of 1.59. The number of hours worked tends to be quite procyclical: a 1.3 percentage point increase in the rate of unemployment leads to a fall of 1 hour worked (see figure 8).

With regard to participation rates, García and Contreras (2001) estimate that the long-run elasticity of the participation rate to unemployment is close to one.[8] The short-run dynamics play an important role, however, although the cyclical correction, based on their estimates, still shows a large procyclical component in the participation rate (see figure 9).

2.5 Estimation Results

The results of our dual and primal estimates of TFP growth, including forecasts for 2001 and 2002, are not radically different from what other studies obtain (see figure 10).[9] The period of high average

8. Central Bank of Chile (2001).

9. The forecasts for 2001 and 2002 are not to be taken as official projections by the Central Bank of Chile.

GDP growth (1986–1997) can be decomposed into several subperiods, according to the relative importance of the different growth determinants.

In the mid to late 1980s, high average growth was sustained by a sharp increase in the labor input, after the recession of 1982–1983. This was manifest not only in the increases in employment, but also in the greater hours worked and higher levels of schooling relative to earlier periods. Capital accumulation was less important than labor, although the utilization rate rose sharply. This factor is key in explaining the flat behavior of TFP over the period: not controlling for utilization would result in a larger role for TFP growth over this period. In terms of the dual estimate, slow real wage growth and declining real interest rates confirm this panorama.

The period from 1990 to 1994 displays some of the features of the previous period. In particular, the employment growth rate reached 3 percent a year, on average—well below the rates experienced in the 1980s, but still high. Capital accumulation picked up significantly, and utilization rates reached 100 percent. This period also saw real wage gains that seem to have led to increased female labor participation. TFP growth increased, reaching around 2 percent a year, on average (3 percent in the dual estimate).

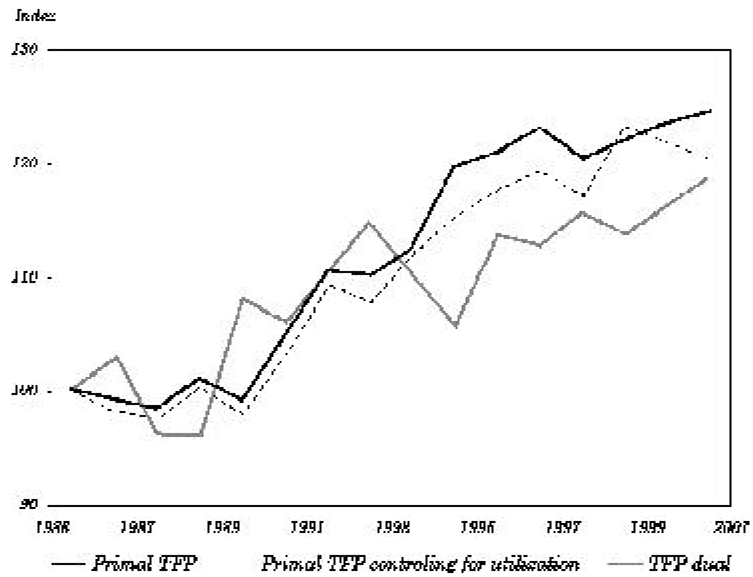
The years between the Mexican and Asian crises (1995–1998) saw an unprecedented acceleration of economic growth. This boom was accompanied by a swift accumulation of capital and a further increase in primal TFP growth measures. The economy was clearly at full employment: employment growth slowed to rates similar to the increase in the working-age population, and real wages grew at close to 6 percent a year. The dual estimates for TFP continue to show high rates of growth, although lower than earlier in the decade.

Growth slowed dramatically following the Asian and Russian crises, with a tightening in monetary policy. However, the reduction in growth was mostly reflected in a sharp stop in the almost continuous expansion of employment over the previous decade, as well as in a sharp reduction in TFP growth and the utilization of the capital stock. Capital accumulation proceeded at a high rate, reflecting relatively important rates of investment even after the sharp fall in 1999.

Finally, the aftermath of the crisis years witnessed a resumption of growth, to rates higher than those seen in 1998 and 1999 but lower than those earlier in the 1990s. This new situation is consistent with increases in the capital output ratio and a flat TFP.

These different periods are reflected in the path of TFP over the last decade and a half (see tables 1 and 2). First, TFP growth was modest in

Figure 10. Primal and Dual TFP



the late 1980s. This is a result of controlling for a varying utilization of capital, which might incorrectly be measured as TFP growth. A second period, featuring high TFP growth, lasts from 1991 to 1995 for the primal estimates and from 1989 to 1994 for the dual estimates. In the final period, TFP growth remained positive, but slowed considerably.

We also constructed an additional measure of the primal TFP estimate, excluding inventory accumulation to reduce the cyclical nature of output. The different types of adjustments matter in the estimates. For example, calculating the primal measure of TFP without making any adjustments results is an additional cumulative growth of 10 percent (see figure 11). This is close to half the growth of adjusted TFP. The cyclical behavior of TFP remains an issue, however, and this affects the estimation of the gap. If one directly uses TFP for the calculation of potential output, the gap in the mid-1980s is close to zero, and the current slack is also small, especially in the unadjusted series (figure 12). Like other authors, we find that the filtering of TFP then seems a reasonable option. Here we applied the HP filter, but with λ = 10,000. The gap appears more procyclical.[10] The filtering approach

10. The correlations between the three gaps presented and quarterly growth of seasonally adjusted GDP are –0.03, 0.01, and 0.40.

Table 1. Sources of Growth, Primal Estimate of TFP

	GDP		*Capital*				*Employment*			*TFP*	
Period	*Total*	*Without stock*	*Total*	*M&E*	*Construction*	*Utilization rate*	*Employed*	*Hours*	*Schooling*	*With stock*	*Without stock*
1987–1989	8.2	8.0	4.5	6.2	3.9	98.8	7.2	0.6	1.2	0.3	0.1
1990–1994	7.3	7.4	6.9	10.9	5.3	100.3	3.0	–0.2	0.9	2.2	2.3
1995–1997	8.5	7.6	9.1	14.8	6.3	100.5	1.6	–0.6	0.6	3.0	2.1
1998–1999	1.5	3.5	7.8	10.8	6.1	98.9	–0.6	–1.4	0.5	–0.4	1.7
2000–2002[a]	4.3	3.9	5.1	5.5	4.8	97.5	0.5	1.2	0.5	0.8	0.3

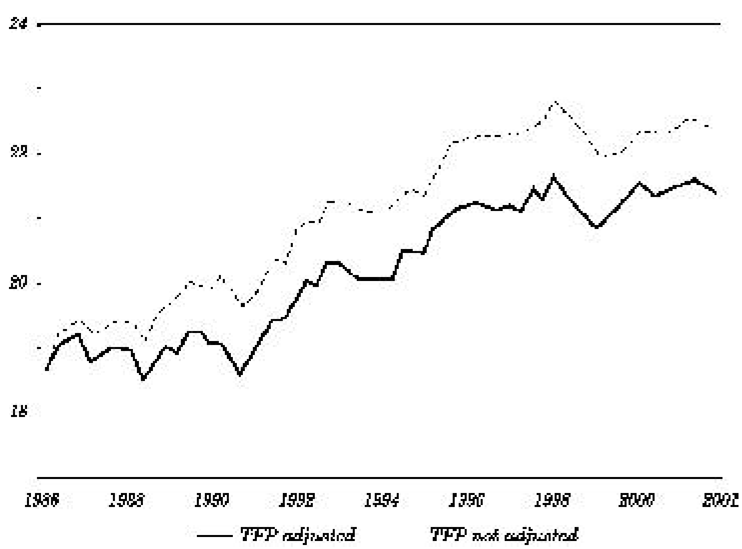
a. Forecast.

Table 2. Sources of Growth, Dual Estimates of TFP

		Cost of capital use			
Period	*Employment cost*	*KC*	*KM*	*KT*	*TFP*
1987–1989	0.9	–3.9	–6.3	–5.1	–1.8
1990–1994	5.4	2.6	–3.5	0.6	3.2
1995–1997	5.7	1.9	–4.9	–1.7	2.4
1998–1999	4.9	1.0	–1.8	0.5	2.9
2000–2002[a]	0.5	3.9	–0.8	0.4	0.1

a. Forecast.

Figure 11. Primal TFP

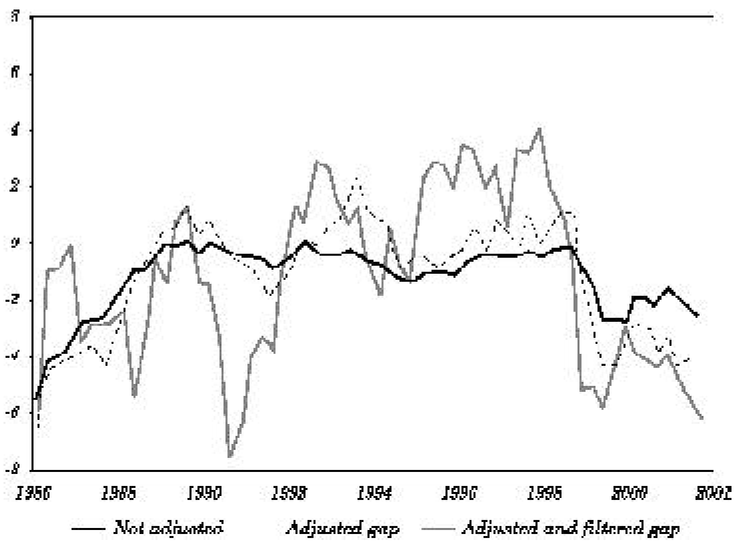


is required not only for the inputs, but also for the TFP measures that are finally obtained. This difficulty should not be underestimated.

3. Model-Consistent Estimates

Given the difficulties surrounding the direct estimation of trend GDP starting from the data, in this section we propose the joint estimation of the output gap and the macroeconomic dynamics embedded

Figure 12. Primal Output Gap



in small macroeconometric models for the Chilean economy. This strategy still requires imposing some identification restrictions, which we describe below.

We use two models for the estimation, based on the aggregate demand and price blocks of a more complete model discussed in García, Herrera, and Valdés (2002), who center on empirically based equations that are not explicitly derived from first principles. The two models have a similar structure, with an equation that describes the short-run macroeconomic dynamics, an equation for the unobserved state variable that captures underlying productivity, and a definition of either trend GDP growth or the output gap (or both).

3.1 The Structure of the Models

Our first model (the aggregate demand, or AD, model) consists of an aggregate output growth equation, which relates the first difference of seasonally adjusted log output to its unobserved trend component (γ) and the deviations from steady state of a set of domestic and external variables. Among the former, it includes the stance of monetary policy, given by the slope of the yield curve $r - rl$, and long-term interest rates, rl.

External conditions are here identified with international interest rates, rx, and the log price of copper, ($\ln P_{cu}$). Two lags are included to capture the dynamics. A disturbance term (ε_y) is also added to account for short-term fluctuations. The model can thus be specified as

$$\begin{aligned}\Delta y = \lambda &+ \phi_r\left[\left(r - rl\right)_{-1} - \left(\overline{r} - \overline{rl}\right)\right] + \phi_{rl}\left(rl_{-2} - \overline{rl}\right)\\ &+ \phi_{rx}\left(rx_{-2} - \overline{rx}\right) + \phi_{cu}\left(\ln P_{cu} - \ln \overline{P}_{cu}\right)\\ &+ \phi_{y1}\left(\Delta y_{-1} - \gamma_{-1}\right) + \phi_{y2}\left(\Delta y_{-2} - \gamma_{-2}\right) + \varepsilon_y .\end{aligned} \tag{10}$$

We think of the state variable, γ, as capturing underlying trends in output growth. Although the level of productivity should be smooth, we do not have any prior assumptions about the process that drives the growth rate of productivity. We therefore impose an autoregressive functional form:

$$\gamma = \rho\,\gamma_{-1} + \varepsilon_{\gamma}. \tag{11}$$

After estimating this small model, we cannot recover trend GDP, but we can infer its rate of change through time. We define trend growth when every variable of the AD model reaches its equilibrium level:[11]

$$\Delta\overline{y} = \gamma. \tag{12}$$

An identification assumption behind this definition is that external conditions do not affect the unobserved underlying productivity component. This view differs from other studies that consider the inclusion of external conditions.[12]

Our second model (the aggregate supply, or AS, model) focuses on prices, determining core consumer price index (CPI) inflation through an accelerationist Phillips curve.[13] Core inflation is related to its own lags and leads, as well as to imported inflation, given by the sum of

11. For simplicity we imposed the average levels as equilibrium values for each variable.

12. Beechey and others (2000) use this assumption for the estimation of Australian trend growth, as do Rojas, López, and Jiménez (1997) for the Chilean economy, with a focus on terms of trade. Coeymans (1999), however, considers that external conditions play a role in trend growth.

13. Noncore CPI inflation includes products such as fuels, regulates services, and perishables, which follow simple price-setting rules.

nominal exchange rate depreciation and foreign (dollar) inflation. The equation is homogeneous to the first degree in these determinants, reflecting long-term neutrality. Another factor that influences core CPI inflation is the output gap. This is obviously a reduced form, whereas a more general framework would include wage setting and unemployment as determinants. A positive output gap tends to accelerate inflation.

The first (restricted) version of the model imposes dynamic homogeneity on the inflationary process, to guarantee neutrality and a vertical Phillips curve in the long run. This implies adding up restrictions on some of the right-hand-side regressors, as well as the restriction of a zero constant. This model is very simple, whereas inflation in Chile appears to follow more complex dynamics.[14] We therefore also estimate an unrestricted version of the model. However, we cannot reject the null hypothesis of homogeneity and a zero constant.[15]

Thus, our AS model is as follows:

$$\begin{aligned}\Delta\pi = {} & \xi_l \sum_{i=2}^{4} \frac{\pi_{-i} - \pi_{-1}}{3} + \xi_f \sum_{i=1}^{2} \frac{\pi_{+i} - \pi_{-1}}{2} + \xi_e \sum_{i=1}^{2} \frac{\hat{e}_{-i}\pi^*_{-i} - \pi_{-1}}{2} \\ & + \xi_{iva}\Delta \ln IVA + \xi_y \sum_{i=2}^{4} \frac{y_{-i} - \overline{y}_{-1}}{3}\end{aligned} \tag{13}$$

The definition of trend GDP in this case is straightforward, as it is directly specified as the unobserved state variable:

$$\overline{y} = \rho\overline{y}_{-1} + \varepsilon_{\overline{y}}. \tag{14}$$

3.2 Estimation Results

The above models are estimated using state-space techniques, imposing identification restrictions with respect to the volatility of the trend components of GDP. We assume throughout that trend output is smoother than actual output. Our choice for the dependent variable is total GDP minus mining, fishing, and energy. These sectors are linked to natural resources, and their expansion over time responds more to exogenous factors.

14. See García and Restrepo (2001).

15. The p value of a chi-squared test of the joint hypothesis of a zero constant and adding-up constraint is 0.756.

Table 3. Estimation Result: AD Models[a]

	OLS		*State-space*	
Parameter	*Coefficient*	*Std. error*[a]	*Coefficient*	*Std. error*[a]
γ	0.013	0.038	0.016[b]	
ϕ_r	−0.404	0.067	−0.404	0.087
ϕ_{rl}	−1.501	0.288	−1.461	0.314
ϕ_{rx}	−0.564	0.281	−0.553	0.233
ϕ_{cu}	0.029	0.011	0.028	0.010
ϕ_{y1}	−0.288	0.107	−0.226	0.179
ϕ_{y2}	−0.282	0.068	−0.331	0.252
ρ			−0.494	1.174
$\sigma(\varepsilon_y)$ (in percent)	1.250		1.050	
$\sigma(\varepsilon_\gamma)$ (in percent)			0.470	
Adjusted R^2	0.477			
Log likelihood	175.440		175.520	

a. Newey-West-corrected standard errors.
b. Average for the sample period.

The results of the aggregate demand estimation are broadly consistent with single-equation estimates by ordinary least squares (OLS) (see table 3). As expected, the results show the sensitivity of GDP growth to interest rates, owing to both monetary policy actions and shifts in the cost of external finance.[16] The price of copper also affects GDP growth significantly. The state-space estimates are similar to the OLS estimates, in terms of both their size and statistical significance. However, both models exhibit considerable difference in the estimates of trend output growth (γ), because OLS estimations do not distinguish between the volatility of the trend and cycle components.

The state-space estimation also delivers some interesting results. First, the autocorrelation in the growth rate of the state variable (measured by ρ), although large, is not statistically different from zero. This implies that shocks to the underlying productivity growth show little persistence over time, at least in the context of the AD model. In fact, the state-space estimation of the AD model differs

16. The international interest rate, *rx*, was constructed using the ten-year U.S. Treasury bond as a benchmark, deflated by U.S. core inflation and adjusted for a measure of the sovereign spread and the incidence of capital controls in the 1990s.

Figure 13. Actual and Trend Output Growth in AD Model

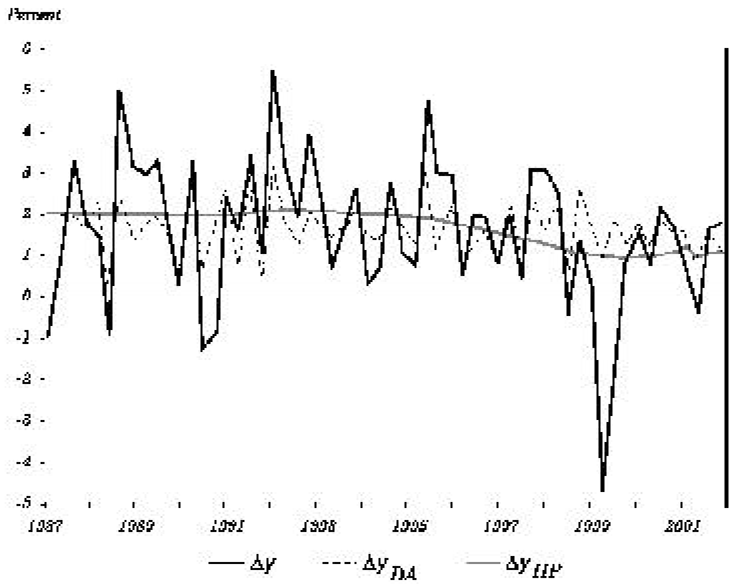
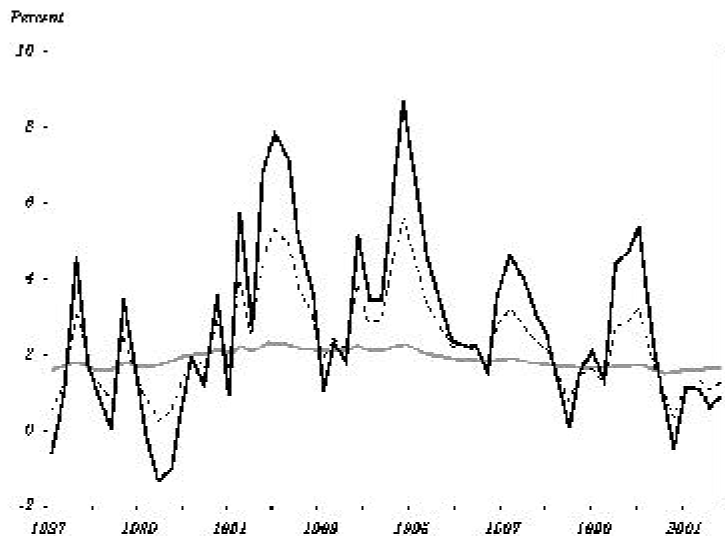


Table 4. Estimation Results: AS Models[a]

		State-space		
Parameter	*IV*	$\sigma(\varepsilon_{\bar{y}})$ = *1.0%*	$\sigma(\varepsilon_{\bar{y}})$ = *3.95%*	*Unrestricted* $\sigma(\varepsilon_{\bar{y}})$
ξ_l	0.462	0.410	0.322	0.305
	(0.122)	(0.127)	(0.116)	(0.124)
ξ_f	0.332	0.195	0.406	0.442
	(0.113)	(0.117)	(0.106)	(0.141)
ξ_e	0.085	0.094	0.055	0.048
	(0.037)	(0.050)	(0.051)	(0.054)
ξ_{iva}	0.700	0.663	0.650	0.641
	(0.206)	(0.264)	(0.258)	(0.260)
ξ_y	0.048	0.054	0.038	0.025
	(0.036)	(0.037)	(0.036)	(0.045)
ρ		0.982	0.974	0.972
		(0.062)	(0.066)	(0.065)
$\sigma(\pi)$ (in percent)	0.730	0.660	0.560	0.580
$\sigma(\pi)$ (in percent)		1.000	3.950	6.900
Adjusted R^2	0.477			
Log likelihood		208.52	211.62	211.73

a. Estimated with instrumental variables. Instruments used for $p_{+}i$ include inflation, interest rate, and unemployment lags. An HP trend is used as a proxy for the gap. Standard errors are in parentheses.

Figure 14. Trend Output Growth in AS Model, $s(e_y)$ Î **[0.1% - 1%]**



very little from the OLS estimation, in that only a small fraction of the variation in the data can be attributed to the state variable. Figure 13 shows the path of actual output growth (the thick line), the trend growth rate that result from the state-space model, and the results from an HP filter.

These results show that little information about trends is gained from direct observation of the path of output. With the AS model, however, the inference about the size of the output gap and the growth rate of trend GDP depends on how much information can be taken from the path of inflation.

As before, some identification assumptions must be made, this time related to the magnitude of the volatility of trend GDP. We estimate the AS model with a variety of assumptions about this volatility. Table 4 shows the resulting estimates.

The growth rates of trend output differ, but they tend to be stable over time (see figure 14). However, some of the estimations show evidence of a slowdown in trend growth. The measures of the gap differ, as well, generally showing a positive gap throughout most of the 1990s and a negative one since 1999 (figure 15). The magnitudes are important: over 10 percent in recent quarters. This is probably related to the low pass-through from exchange rate depreciation until now, which the state-space estimation interprets as a large, negative output gap.

Figure 15. Output Gap in AS Model, $s(e_y)$ = 0.5% and HP Filter

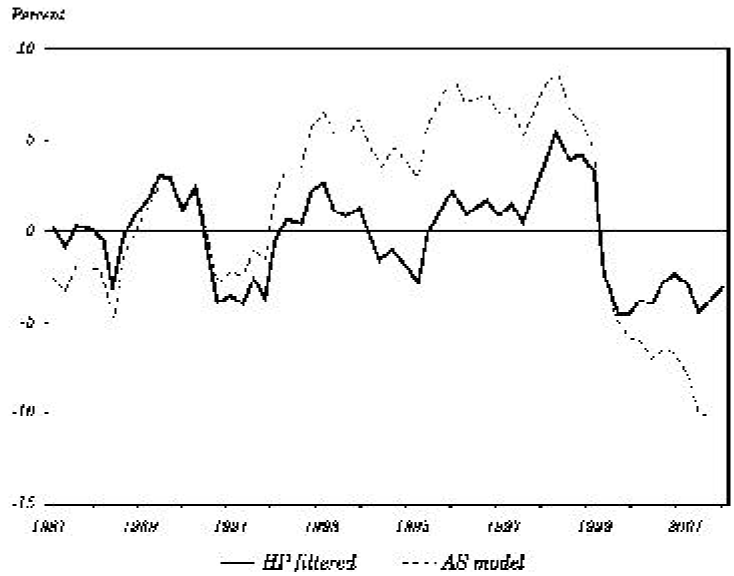


Figure 16. Output Gap: AD-AS Model and HP Filter

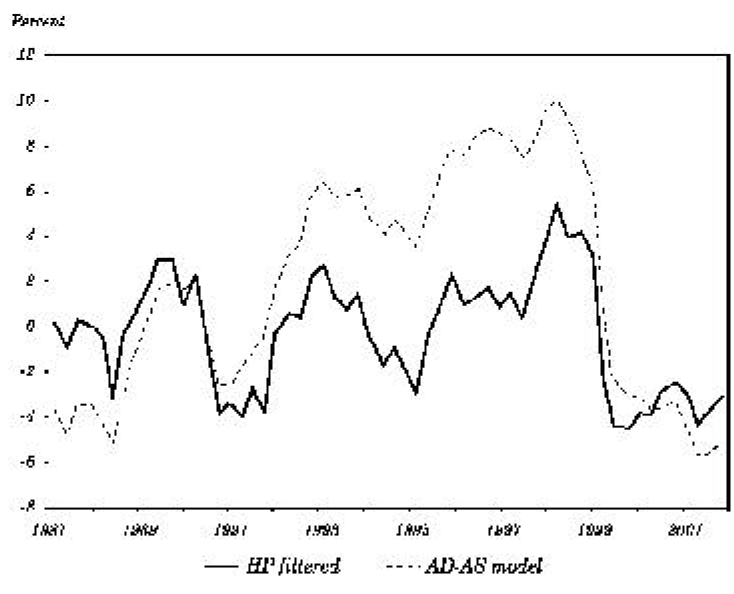


Table 5. Correlation between Gaps

Gap estimates	*HP filter (l = 1600)*	*AS model*	*Primal estimate* *Adjusted*	*Primal estimate* *Not adjusted*	*Primal estimate* *Filtered*	*Unemployment gap*
HP filter	1.00	0.53	0.41	0.29	0.76	0.36
AS model		1.00	0.77	0.59	0.75	0.66
Primal adjusted			1.00	0.90	0.57	0.92
Primal not adjusted				1.00	0.40	0.99
Primal filtered					1.00	0.49
Unemployment gap						1.00

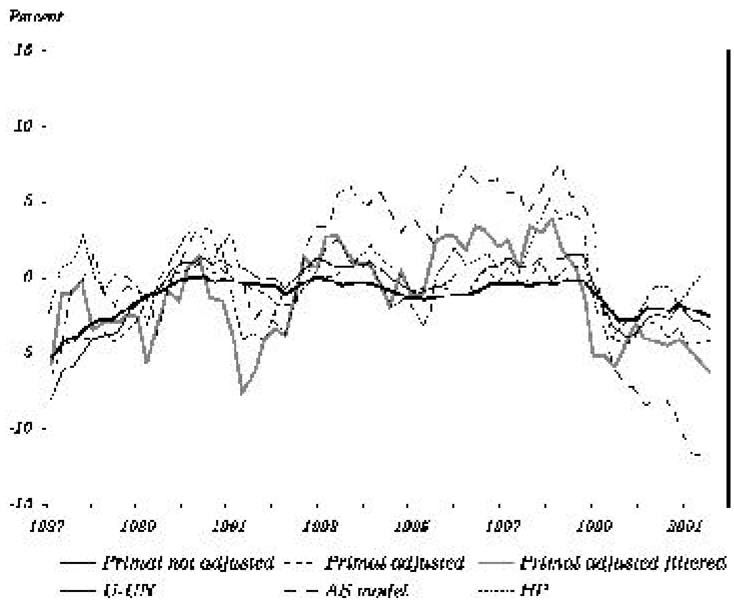
The disadvantage of estimating AD and AS model separately is that one obtains two unrelated measures of trend growth. To resolve this problem, we estimated the two models together in an equation system, using the state-space method. This generates a consistent measure of the output trend (shown in figure 16). For this purpose, however, we imposed the coefficients on the right-hand-side variables obtained from single equation estimates, given the difficulties of obtaining convergence.

4. Concluding Remarks

The estimates presented in this work give rise to four important lessons. First, both the magnitude and the trends of the different estimates of the output gap are widely dispersed (see table 5). Figure 17 displays several measures of the output gap that have been presented in the course of this work. One relies on growth accounting exercises, another results from assuming a particular natural rate of unemployment, and a third is the product of a state-space estimation of a simple Phillips curve. As a benchmark, the thick gray line results from a simple HP filter. While some seem very procyclical, others are smoother. Some show a stable gap over the last quarters, whereas others indicate an increasing slack. Some are not very correlated with each other, and others are extremely so. This is particularly the case with the filtered primal TFP estimate and the unemployment gap, which shows the importance of particular identification assumptions.

Second, all the measures indicate that current slack lies between 2 and 11 percent and, more importantly, that it has been mostly stable since 1999. The notable exception is the simple, $\lambda = 1600$ HP filter,

Figure 17. Output Gaps



which actually indicates a positive output gap for the second quarter of 2002. The well-known sensitivity of this filter to end-points is the culprit for this somewhat counterintuitive result.[17]

Third, growth accounting must be treated carefully, for two reasons. It is the first step for the estimation of potential output, although the dual approach is not useful for estimating the gap since it leads to the growth rate—not the level—of TFP. Moreover, no matter what alternative statistical method is used for in-sample estimation, for forecasting purposes there is no easy substitute for a sources-of-growth approach.

Finally, our findings stand as a warning to the mechanical application of statistical methods, loosely related to economic theory, for the measurement of trends and gaps. Some structure is necessary to infer economically sensible conclusions about the measurement, through a particular method, of the output gap. A judgmental approach seems best: using a variety of methods provides a wider perspective on an issue that is key to the efficient conduct of monetary policy. Potential

17. See Chumacero and Gallego (2001) for evidence on the sensitivity of this filter to new information.

output and the output gap are conditional statistics, and they are thus sensitive to the particular identifying assumptions chosen.

Most of the output gap measures derived in the paper are either stable or increasingly negative over the last few years. This, coupled with the results from the aggregate demand models and TFP estimates, implies that trend GDP growth has probably stayed above actual growth but below the levels of the 1990s. We therefore discard the alternative that the recent slowdown in growth is due mainly to supply side factors, although the prospects for longer term growth depend critically on them.

APPENDIX
Policy Rule and the Yield Curve

To obtain the dual estimation of TFP, we consider only those factors that affect the long-run demand for long-term bonds, such as growth prospects. We thus correct for the volatility of long-term interest rates caused by the impact of movements of monetary policy decisions (associated with short-term interest rates).

We start by estimating the neutral stance for monetary policy using a Kalman filter in a policy rule for short-term interest rates. This regression includes the unemployment gap, the difference between inflation and the target, an autoregressive term, and an unobserved state variable. This variable, which we interpret as the neutral policy rate, is used as an input into an estimated equation for long-term interest rates, which includes leads and lags of itself. Hence, we recover the cyclically adjusted long-term interest rates.

First, we model the policy rule:

$$r = r_n + \alpha_\pi\left(\pi - \pi_{\text{meta}}\right) + \alpha_u\left(u - un\right) + \alpha_r r_{-1} + \varepsilon_r. \tag{A1}$$

The construction of the natural rate of unemployment, u_n, is explained in the text. We use a dummy variable (D_{98}) for the year 1998, when interest rates were allowed to float and the de facto exchange rate arrangement was closer to a fixed than a floating exchange rate.

We impose an autoregressive functional form for the neutral policy rate, restricting the disturbance term ε_{rn} to take a standard deviation of 0.22:

$$rn = \rho rn_{-1} + \varepsilon_{rn}. \tag{A2}$$

The last two equations form the state-space model, which is resolved with the Kalman filter; results are in table A1. The initial condition needed for *rn* is taken from the OLS estimates. With the neutral policy rate one can obtain the equilibrium short-run interest rate, when inflation reached target inflation and employment gap is null:

$$\bar{r} = \frac{rn}{1-\alpha_r}. \tag{A3}$$

Finally the cyclically adjusted long-term interest rate is obtained,

Table A1. Estimation Results: Policy Rule Model

	OLS[a]		*State-space*[b]	
Parameter	*Coefficient*	*Std error*[a]	*Coefficient*	*Std error*[a]
α_π	0.063	0.026	0.085	0.095
α_u	0.430	0.053	0.192	0.364
α_r	0.502	0.042	0.396	0.091
α_{98}	7.574	0.507	5.902	0.587
ρ			0.994	0.015
$\sigma(\varepsilon_r)$ (in percent)	0.690		0.920	
Adjusted R^2	0.920			
Log likelihood	–59.970		–86.621	

a. Newey-West-corrected standard errors.
b. Standard errors in italics. Ordinary least square estimates were used as initial conditions.

replacing *r* of equation 17 in the already-estimated equation for *rl*.[18] This construction needs values for the initial and final conditions of the long-term interest rate, which are assumed as 5.5 (1986:1) and 5.2 (2002:1). The result is

$$rl = \underset{(0.387)}{0.31} + \underset{(0.053)}{0.36}\, rl_{-1} + \underset{(0.035)}{0.54}\, rl_{+1} + \underset{(0.008)}{0.05}\, r, \tag{A4}$$

with *R*-squared equal to 0.83, a standard error of 0.29, and a Durbin-Watson statistic of 2.34.

18. This model uses instrumental variables for the lead of the long-term interest rate, including the exchange rate, lags of interest rates, the difference between actual inflation and the inflation target, and the exchange rate band.

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