Monetary Policy under Financial Turbulence: An Overview

Luis Felipe Céspedes
Central Bank of Chile

Roberto Chang
Rutgers University

Diego Saravia
Central Bank of Chile

The financial crisis that started in 2007 brought the global economy to the brink, and in many respects it is still unfolding, especially in Europe. How to understand and deal with the crisis has naturally been the subject of fierce debates that continue today. However, some consensus appears to be emerging with regard to the shocks that originated the crisis, the mechanisms that amplified those shocks, and official policy responses, especially from central banks. All of these aspects of the new consensus assign a substantially bigger role to financial imperfections and institutions than previously assumed, to the point that one can safely say that for the next several years, research on macroeconomic policy will be dominated by the interaction between financial frictions, the financial system, and aggregate fluctuations.

To set the stage for the rest of the book, this introduction starts with a review of this consensus and contrasts it with received macroeconomic wisdom. As for the causes of the current crisis, the consensus (as given by Brunnermeier, 2009; Rajan, 2010; Allen and Carletti, in this volume) blames a lax monetary policy in the United States, together with policies in China and other countries that fostered excess savings at the global level, for creating an

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environment prone to bubbles in housing and other asset markets, whose bursting around 2007 marked the onset of the crisis.[1]

While this view echoes similar analyses of the origin of previous crises (such as the 1997–98 crisis in Asia), a new dimension related to changes in the nature of financial instruments and the emergence of a so-called "shadow" banking industry may have been key for triggering the crisis.[2] The development of collateralized debt obligations (CDO), credit default swaps, and a myriad of other financial engineering products allowed banks to move towards an "originate-and-distribute" model, under which banks offload risk by repackaging loans and passing them to other agents.[3] As noted by Brunnermeier (2009), this process and the fact that the banking sector increasingly incurred maturity mismatches by financing their assets with debt at shorter maturities contributed to building a fragile situation in financial markets.

The increased use of the securitized products and the lack of an adequate regulatory framework combined to deliver poor incentives, cheap and excessive credit, and a fertile ground for the growth of asset price bubbles.[4] Moreover, this financial innovation process within an unregulated (shadow) banking sector gave rise to the possibility of old-fashioned panics in financial markets (Gorton, 2008, 2010). While identifying a bubble as it is occurring is exceedingly hard, many commentators did warn that historically high price-to-earning ratios and other indicators suggested that several asset markets were

1. One indicator of lax monetary policy is the difference between the observed interest rate in the United States in the period 2002–06 and the interest rate computed from a conventional Taylor rule. See Taylor (2008).

2. The term shadow banking industry refers to financial intermediaries that conduct maturity, credit, and liquidity transformation without access to public guarantees or central bank liquidity. See Pozsar and others (2010) for a detailed description of shadow banking activities.

3. This process of financial innovation is reminiscent of episodes of financial liberalization when proper regulation is missing. Díaz-Alejandro (1985) documents some common characteristics of cases of financial liberalization in Latin America where domestic financial intermediation flourished and then collapsed. First, regardless of whether or not deposits were explicitly insured, the public expected governments to intervene to save most depositors from losses when financial intermediaries ran into trouble. Second, the central bank neglected prudential regulations over financial intermediaries, either because of a misguided belief that banks are like butcher shops or because of lack of trained personnel. Finally, the end of financial repression (which can be read as the beginning of financial innovation) encouraged many types of financial savings. Paradoxically, however, total domestic savings did not increase in the South American experiments in financial liberalization.

4. See Rajan (2005) for an early warning regarding the risks that financial innovation and poor incentives (and regulation) were generating for the world economy.

indeed frothy and would eventually implode. Ex post, of course, it is evident that bubbles did take place. Why they were allowed to grow can be explained by an alleged lack of policy instruments to prick bubbles without causing more harm than good (as some have argued to have been the case in Japan) or by the lack of decisive information at the time, in a fashion reminiscent of Caplin and Leahy's (1994) "business as usual" phase.

In short, the dominant explanation maintains that the key shock underlying the recent worldwide crisis was the bursting of asset price bubbles that emerged thanks to a combination of factors such as easy monetary policy, excess global savings, financial engineering, and poor regulation and oversight.[5] Whether or not one agrees with this position, it does not take much to realize how much of a departure from conventional macroeconomic wisdom it represents. Dominant macroeconomic models are built on assumptions, such as complete financial markets, that downplay the role of financial institutions, regulation, and the like, so that the shocks of interest are often restricted to exogenous productivity shocks or shocks to monetary and fiscal policy rules.

A second component of the dominant explanation is the crucial role played by financial frictions and institutions in amplifying the effects of the bubble bursting. This is a key ingredient of the argument, since by virtually every account the initial impact of the collapsing bubbles was quite small relative to the size of the financial crisis, its worldwide effects, and the impact on the real economy. Most estimates of the subprime mortgage "problem" in the United States around 2007, the start of the crisis period, were in the region of a few hundred billion dollars, while the financial wealth lost in the crisis easily surpasses many trillion dollars. The necessary multiplier effects, according to the new consensus, are to be found in the nature of financial imperfections and the structure intended to deal with them. Of course, financial-based explanations are not the only possible candidates for solving the puzzle of how

5. The importance of the factors mentioned and the connections among them differ, however. For example, Obstfeld and Rogoff (2009) argue that for the United States, the interaction among the Federal Reserve's monetary stance, global real interest rates, credit market distortions, and financial innovation created the toxic mix of conditions that made the United States the epicenter of the global financial crisis. Moreover, economic policies followed by emerging markets such as China contributed to the United States' ability to borrow cheaply abroad and thereby finance its unsustainable housing bubble.

small shocks translate into big real effects. However, they offer the advantage of being consistent with the plethora of accompanying phenomena that characterized the recent crisis, such as stock market panics, the freezing of interbank credit markets, and skyrocketing interest rate spreads.

The key intuition on how financial frictions can result in quantitatively significant multiplier effects goes back to Bernanke and Gertler (1989) and Kiyotaki and Moore (1998). In these papers, potential investors need external financing, but their borrowing capacity is limited by their own net worth. The crucial ingredient is that the value of net worth may depend on the prices of assets, such as land or capital, which are endogenous. Under such conditions, an exogenous shock may initiate a loss spiral (to use Brunnermeier's 2009 term), in which financially constrained agents must sell some of their assets to fulfill collateral requirements, which in turn depresses the price of the assets and, therefore, the value of the agents' net worth, their borrowing capacity, and so on.[6] The interaction between asset prices and borrowing constraints can be exacerbated by the fact that in a financial crisis, margins, haircuts, and lending standards become more stringent after price drops, as emphasized by Gorton and Metrick (2009). This means that financially constrained agents need to deleverage, which causes an even stronger drop in prices, an effect that Brunnermeier and Pedersen (2009) term the margin spiral.[7]

The related literature, however, has yet to address several issues that became prominent in the current crisis. One of them is the role of banks and interbank credit. As Gertler and Karadi (2009) emphasize, banks are absent from most existing models of the interaction between financial frictions and the macroeconomy. Recently, a number of papers have attempted to address this deficiency (Gertler and Karadi, 2009; Cúrdia and Woodford, 2009; Gertler and Kiyotaki, 2010), but, as discussed by Céspedes, Chang, and García-Cicco in their contribution to this volume, the current state of play is still one of exploration.

A second aspect of the current crisis that warrants new research is the role of financial engineering, leverage, and the so-called shadow

6. Similar fire sale processes have been stressed by Diamond and Rajan (2010), Acharya, Shin, and Yorulmazer (2009), Allen and Gale (2004), and Caballero and Simsek (2009).

7. See Brunnermeier (2009) for explanations of the rise in margins during huge price drops. That paper also discusses other works that address the loss spiral and the margin spiral.

financial system. Indeed, the crisis was dramatically marked by the implosion of derivatives markets, insurance markets, and investment houses. The rapid growth of the markets for collateralized debt obligations, credit default swaps (CDS), and other derivatives may have occurred because financial innovation increased speculators' ability to mount bets over bets, resulting in staggering amounts of systemic risk. For example, according to one estimate, the notional amount of CDS outstanding at the end of 2007 was more than US$62 trillion.[8] By the end of 2009, the size of the CDS market had fallen to less than half that amount.

While the significance of these developments remains to be clarified, the new consensus on the crisis is that financial frictions and institutions have taken center stage in explaining the amplification mechanism. This contrasts with dominant New Keynesian models, which, as synthesized in Woodford (2003), are built on the assumption of complete and perfect financial markets and thus imply, in Modigliani-Miller fashion, that financial structure is irrelevant.

One consequence has been that macroeconomic policy, particularly central banking, has had to radically modify its strategy and goals and resort to new tools to implement them. To an extent, this was forced by the fact that at the onset of the crisis, many central banks lowered policy interest rates to virtually zero, but additional monetary stimulus was warranted. Nevertheless, the proliferation of a number of new tools and credit facilities—such as the U.S. Federal Reserve's Troubled Asset Relief Program (TARP), Term Asset-Backed Securities Loan Facility (TALF), and several others—and the decisions to expand the range of securities that the Federal Reserve and the European Central Bank purchase in open markets can only be justified by the need to shore up the financial system. In other words, it can be argued that the goals of fiscal and monetary policy have expanded to include the stability of the financial system along with the traditional objectives of full employment and low and stable inflation.

In sum, the recent financial crisis has required novel thinking in terms of the ultimate triggers of the crisis, the mechanisms that amplified the initial shocks, and the kinds of policies and tools that governments should use in response. This state of affairs may have profound implications for research in macroeconomics, as the

8. See the ISDA Market Survey for mid-year 2010, compiled by the International Swaps and Derivatives Association.

conventional paradigms had little to say in the recent period. Several questions remain, however. Can conventional theory be amended to deal with and perhaps include the new consensus? Or will we have to live with the uncomfortable position of using the extant theory during "normal" times and other, substantially different models in "crisis" times? If the conventional theory can be fixed, wouldn't it have to admit financial frictions and shocks as integral components even in normal times? What are the implications of all this for macroeconomic policy, especially for central banking and its now-dominant version, inflation targeting?

The chapters in this volume attack these and related questions from different angles and perspectives. They can be grouped into four broad themes, with some papers contributing to more than one group. The first group emphasizes the identification of the causes of the crisis, as well as the relation of this episode to previous ones. A second set of contributions focuses on the role of credit market imperfections in the occurrence and propagation of crises. A third group includes works addressing monetary and fiscal policies in crisis periods. Finally, the last group explores financial stability and its implications for monetary policy and macroeconomic performance. The remainder of this introduction summarizes the chapters in each group and puts them in the context of the new consensus just discussed, thus providing a guide to the rest of the volume.

1. The Origins of the Recent Crisis

As already noted, the contribution of Allen and Carletti to this volume reflects the view that the ultimate source of the current global crisis was the existence of a real estate bubble in the United States and other countries, such as Spain, Ireland, and the United Kingdom. The authors play down the role of distorted incentives caused by financial instruments, arguing that these were a symptom rather than the cause of the crisis. This raises the question of what made the real estate bubbles possible and whether policy was responsible for their appearance, a question that has not been addressed satisfactorily by existing theory. Allen and Carletti argue that the bubbles had two causes: the Federal Reserve's policy of low interest rates after 2001 in response to the tech bubble and terrorist attacks; and the existence of global imbalances caused by precautionary savings in Asian economies after the crisis in the late 1990s. This diagnosis coincides with Brunnermeier's (2009) influential analysis.

Nevertheless, the debate regarding how or why bubbles must emerge in an environment of easy money is still open.

Allen and Carletti provide an insightful discussion of the consequences of the bubble bursting. They emphasize that prices were then not useful for guiding economic decisions and that the financial sector therefore performed poorly, aggravating the situation. They argue that the poor performance was due to the lack of regulation directed toward correcting financial market imperfections, such as inefficient provision of liquidity, persistent mispricing of assets due to arbitrage limits, and contagion.[9]

In terms of policy implications, Allen and Carletti argue that the financial system should be regulated appropriately to prevent excessive risk taking by the private sector. It is also necessary to revise the policies and governance mechanisms leading to excessive risk taking in the public sector. For example, quantitative easing may cause a future run on the dollar if there is a burst of inflation. They further call for a debate on the desirability of mark-to-market accounting, on the basis that asset prices can be quite misaligned in a crisis and can therefore be misleading as a guide to value net worth positions.

Finally, Allen and Carletti propose that Asian countries should be treated as European ones in the International Monetary Fund (IMF). This institution, arguably, contributed to the existence of global imbalances by imposing harsh policies on Asian countries following the crisis of the late 1990s, exacerbating the incentives to build excess reserves in order to avoid needing IMF assistance in the future.

The apparent contrast between conventional macroeconomic wisdom and the dramatic events surrounding the current crisis has led many to seek guidance from historical perspectives, especially from comparisons between the current period and the Great Depression. Barry Eichengreen's contribution to this volume follows this strategy in making a selective review of similarities and differences between the Great Depression and the current crisis, after which he speculates on the lessons for the future of globalization.[10]

Eichengreen argues that the 1929 crash decisively influenced the policy response to the current crisis. In contrast with the policy

9. They recognize, as does Eichengreen (in this volume), that regulation of the banking sector was mainly aimed at reducing the occurrence of crises after the crash in 1929.

10. Eichengreen's contribution to this volume corresponds to his keynote speech for the conference.

response at the beginning of the Great Depression, governments fought the recent crisis forcefully with expansionary monetary and fiscal policy, as well as liquidity and other measures to shore up the financial system. Eichengreen argues that this strategy was successful in preventing a replay of the Great Depression. He also argues, however, that policymakers may have focused excessively on the lessons of that crash, as they mainly concentrated on the banking industry, which was the principal financial actor in the Great Depression. This focus on the banking sector did not take into account new characteristics of the sector, such as securitization. In Eichengreen's words, this "reflected the difficulty of realizing that, while history repeats itself, it never repeats itself in the same way."

Another lesson learned, Eichengreen emphasizes, is that this time policymakers around the world cooperated in addressing the crisis, whereas that was not the case in 1929. For example, institutions like the U.S. Federal Reserve System, the European Central Bank, and the Bank of England extended swap lines to each other to cope with potential liquidity shortages. Swap lines were also extended to countries outside Europe and the United States, such as Brazil and Mexico. International cooperation was further seen in countries' resistance to isolate their economies, avoiding protectionism to a reasonable extent.

As for the consequences of the crisis for globalization, Eichengreen draws a key distinction between financial globalization and other kinds of globalization. He expects to see countries regulating their financial systems more extensively and putting some sand on the wheels of capital flows. After all, countries relying more heavily on capital inflows suffered the greatest dislocations once the crisis hit. To slow these inflows, according to Eichengreen, countries are likely to rely more on capital controls and regulations and, perhaps more notably, enhanced exchange rate flexibility in order to eliminate one form of currency bets and curtail the carry trade.

On the other hand, Eichengreen argues that a lower degree of financial globalization is not likely to be accompanied by a similar reduction in other kinds of globalization, such as global supply chains and production networks, as these phenomena are explained by technological progress and other real developments. Again, Eichengreen reminds us that history may provide some hope here, as trade opening continued in the post-war era despite the existence of stringent barriers to capital movements for decades.

2. Financial Frictions and the Dynamics of Crises

Whether the reason behind the initial shock was a low interest rate policy followed by the U.S. Federal Reserve, global imbalances, poor incentives in a context of lax regulation, or a combination of these factors, there is a growing consensus that financial markets played a crucial role in the amplification of the initial disturbance. Understanding the connection between financial markets and economic activity in these episodes is therefore crucial.

Claessens, Kose, and Terrones provide an overview of the linkages between recessions and financial market disruptions for a group of emerging and developed economies. They study a sample of 23 emerging market economies and 21 members of the Organization for Economic Cooperation and Development (OECD) between 1978 and 2007, and they develop a dating methodology to identify turning points and cycles in the series for output growth, credit growth, and equity prices. This methodology allows them to uncover revealing differences across countries, as well as the association between financial disruptions and the severity of recessions. For example, they find that time spent in recession is 50 percent longer in Latin American countries than in Asian ones, and that recessions in Latin American countries are twice as costly, in terms of cumulative output loss, as those in Asian countries. They also show evidence that recessions are deeper in emerging markets than in developed ones and that they are synchronized across emerging economies.

Perhaps more significantly for the purpose of this volume, Claessens, Kose, and Terrones present convincing evidence that recessions in emerging economies are longer and deeper when accompanied by financial disruptions. The average output decline in a recession jumps from 5.0 percent if there is no concomitant credit crunch to 8.5 percent if there is a credit crunch. Likewise, recessions associated with equity price busts result in a 6.8 percent decline in output, on average, versus a milder 3.3 percent fall in the absence of equity price busts. Notably, these associations are statistically significant only for emerging economies and not for advanced countries. This is quite suggestive, as it is consistent with the view that differences in the severity of financial frictions between developed and developing countries may be a key factor underlying their differences in macroeconomic dynamics (see Céspedes, Chang, and Velasco, 2004).

The paper by Catão and Pagan in this volume also explores the connections between macroeconomic models, financial frictions, and the data. The authors extend a canonical dynamic stochastic general equilibrium (DSGE) model to allow for a bank-dependent domestic sector. A key assumption is that credit growth, which interacts with absorption, depends on the real exchange rate; this is consistent with recent theoretical models that emphasize balance sheet effects and currency mismatches. They estimate the model for two countries that use inflation targeting (namely, Brazil and Chile), which yields interesting differences.

A methodological point of the Catão and Pagan study is to emphasize the analysis of the structural equations underlying the model, in contrast with the current emphasis on impulse responses. They argue that the structural equation approach helps in interpreting whether the model does, in fact, support the theory used to build it. This is clearest in the case of Brazil, where they find that a real exchange rate appreciation has a significant, positive coefficient in the credit growth equation. Since credit growth, in turn, has a positive effect on absorption, this means that there is a mechanism through which a monetary contraction has an expansionary effect on activity: such a contraction leads to an appreciation of the exchange rate and, hence, an increase in credit growth, which boosts absorption. Given that the monetary contraction has other negative effects on absorption (for conventional reasons), the question emerges as to what is the net impact on expenditure, income, and output. Catão and Pagan find, based on the impulse responses of output, that the conventional contractionary forces dominate, but the link between exchange rates, credit growth, and expenditure does moderate the response substantially, at least in the case of Brazil. These effects are less powerful for Chile, which is itself a suggestive finding, as it may reflect a more sophisticated financial system or a smaller degree of liability dollarization.

One channel through which financial imperfections may exacerbate the effects of shocks in activity is by increasing the vulnerability of the economy. Benigno, Chen, Otrok, Rebucci, and Young (in this volume) expand on a recent debate concerning the possibility of excessive borrowing by emerging countries. This debate has focused on the interaction between collateral constraints and relative prices. Such an interaction emerges, in particular, if foreign borrowing is limited by the value (in terms of tradable goods) of national income or wealth: if national income or wealth include some nontradable goods or assets, its value in terms of tradable goods depends on the real exchange rate (that is, the relative price of tradable goods in terms of nontradable goods).

As Benigno and others note, the literature emphasizes the possibility of overborrowing, which occurs if individual borrowers take real exchange rates as given and hence do not internalize the negative impact of their own borrowing on the collateral constraints of their conationals. This emphasis has led to a call for taxes on private borrowing to correct the externality in a Pigovian fashion (Jeanne and Korinek, 2010). More generally, the possibility of socially excessive borrowing raises the question of whether international borrowing should be discouraged in normal times.

To shed light on this issue, Benigno and others study a dynamic stochastic economy in which domestic households can borrow internationally up to a multiple of the tradable value of their current income, which includes profits and the wage bill. The economy has an endowment of tradables and produces nontradables. This specification has the implication, which turns out to be quite significant here, that the tradables value of the wage depends on the consumption and production of both tradables and nontradables. Since the collateral restriction depends on the wage in tradables, this raises the possibility of affecting and even overturning the likelihood of overborrowing.

Indeed, after comparing the decentralized equilibria of the economy against the solution of a social planner's problem, Benigno and others show that the model can yield both overborrowing and underborrowing, depending on the volatility of exogenous shocks and other parameters such as the rate of time preference. In terms of policy, this implies that ex ante economy-wide macroprudential policies, such as taxes and controls on capital flows, do not receive unqualified support from the theory: they may or may not be welfare improving, depending on the case. On the other hand, Benigno and others argue that ex post interventions to alleviate the effects of the crisis once it occurs, such as bailouts, are supported by the model.

In many countries, the sharp fall in asset prices and economic activity after the Lehman Brothers collapse was followed by a rapid recovery. Caputo, Medina, and Soto argue that this significant rebound could be described as an overreaction of market participants to the initial shock, followed by a reassessment of the severity of the initial shock and an adjustment of expectations upward. They show that imperfections in financial markets, coupled with small departures from the standard rational expectations assumption of most macroeconomic models, may lead to a significant amplification of the effects of shocks. In particular, Caputo, Medina, and Soto build a DSGE model with nominal frictions and a financial accelerator mechanism as in Bernanke, Gertler, and Gilchrist (1999), and they depart from rational expectations, assuming instead that individuals form expectations about shocks through adaptive learning, as in Evans and Honkapohja (2001).

They argue that the interaction of financial frictions and learning is a key ingredient for generating enough amplification of initial shocks to mimic the busts and recoveries observed during the post-Lehman episode. The underlying mechanism is the momentum in asset prices described by Adam, Marcet, and Nicolini (2008), interacted with financial frictions. Caputo, Medina, and Soto argue that sequential and negative shocks that reduce output, asset prices, and net worth feed back into expectations formation. When shocks are sequential, the expectations formation mechanism can endogenously generate a deviation of asset prices from their fundamental values. These asset price fluctuations interact with the financial accelerator mechanism, reinforcing movements in real variables that, in turn, affect expectations and asset prices.

Should monetary policy respond to asset prices in this context? Previous literature has responded to this question under the assumption that any deviation of asset prices from fundamentals is exogenous. In Caputo, Medina, and Soto's work, these deviations have an endogenous component that may change the prescription that responding aggressively to inflation is sufficient to reduce output and inflation volatility (as in Bernanke and Gertler, 2001). Asset prices are informative in this context to the extent that they signal potential inflationary or deflationary forces. Caputo, Medina, and Soto find that responding exclusively to inflation still leads to lower output and inflation volatility. Responding to asset prices may reduce output volatility and inflation volatility in the short run, but it leads to a surge in inflation in the medium term.

3. Monetary and Fiscal Policy Responses

As mentioned above, most governments responded forcefully to the current crisis with expansionary monetary and fiscal policies, and many of them resorted to policy tools that had seldom, if ever, been used. The justification for these unconventional policies was that the severity and characteristics of this crisis demanded extreme interventions and that conventional instruments, foremost among them interest rate control, reached a limit at some point in the process (such as a zero lower bound). The use of these extreme interventions revived some debates about the effectiveness of monetary and fiscal policies and their possible future consequences. The next set of papers in this volume discusses different aspects of unconventional monetary interventions and the effects of associated fiscal policy in this special environment.

Céspedes, Chang, and García-Cicco discuss theoretical and practical aspects of heterodox monetary policies. Their theoretical discussion focuses on the two main lines of argument that have been used to justify heterodox policy. The first argument is that quantitative easing and other heterodox policies are needed once the monetary policy instrument, an overnight interest rate, has been brought to zero while monetary stimulus is still warranted. The second line of argument is that the incompleteness of markets, financial frictions, and the like may warrant direct intervention by a central bank in credit markets, as well as other unconventional policy measures, an argument outlined by Gertler and Karadi (2009), Gertler and Kiyotaki (2010), and others.

With respect to the first argument, Céspedes, Chang, and García-Cicco draw attention to the issue of central bank credibility, and they show that unconventional monetary policy may be called for if and only if the central bank is unable to commit to honoring past policy promises. They provide a fairly general analysis and illustrate it in a simple open economy model borrowed mostly from Jeanne and Svensson (2007). In that model, optimal policy in response to an adverse shock may justify bringing the policy interest rate all the way down to zero. Somewhat surprisingly, a central bank that has perfect commitment power cannot gain any more from quantitative easing, credit easing, or any other unconventional policy, a result that echoes Eggertsson and Woodford (2003).

Céspedes, Chang, and García-Cicco also show, however, that if the central bank has a time inconsistency problem, the maturity structure of the central bank's balance sheet can be used as a commitment device to implement optimal policy. This takes the form of the central bank issuing short-term debt to purchase long-term assets, an operation that has no effect on the central bank's balance sheet under the optimal policy, but results in a capital loss to the central bank if it departs from its promised policy ex post.

The use of unconventional policies to bolster the credibility of policy announcements may be a tight theoretical point, but in practice it is another kind of argument, based on financial frictions, that may have had more influence on actual policy. In fact, Céspedes, Chang, and García-Cicco argue that unconventional policy has often been justified by the need to unlock credit markets and reduce unwarranted interest rate spreads. These arguments can only be understood in the context of a model that allows for financial frictions and, in order to have a realistic picture of actual policies, that also features banks and financial institutions playing an essential role in the allocation of funds.

To illustrate, Céspedes, Chang, and García-Cicco develop a preliminary dynamic small open economy model with banks à la Edwards and Végh (1997). They crucially depart from Edwards and Végh's model in assuming that bank capital limits the amount of credit that banks can extend. They use this model to evaluate the relevance of alternative credit policies and draw lessons for policy, as well as to assess the current literature. In particular, the authors argue that the introduction of financial intermediaries in standard models leads to results that may challenge existing wisdom regarding the effects of unconventional policies.

The last part of the paper is devoted to presenting some evidence regarding the recent experience with heterodox central banking. They discuss the timing and type of unconventional policies implemented so far, compiling a list of announcements made by central banks regarding those policies. They then present descriptive evidence to assess the impact of these policies on the shape of the yield curve and the lending-deposit spread. The analysis reveals significant heterogeneity in the success of different types of measures in reducing the slope of the yield curve and decreasing lending spreads. Moreover, it appears that the effectiveness of these policies was particularly influenced by the stance of the policy rate, being generally more effective if the central bank had committed to keeping the rate at the zero lower bound for some time.

The international financial crisis raised the question of whether inflation-targeting regimes were flexible enough to respond to this extreme event or, on the contrary, whether inflation targeting restricted monetary policy responses. To answer, Calani, Cowan, and García (in this volume) study the experience of nine inflation-targeting central banks (namely, Australia, Brazil, Chile, Colombia, Indonesia, Mexico, New Zealand, Peru, and South Korea) that did not face systemic financial problems during this period. They assess two dimensions of the monetary policy response: monetary policy interest rate changes and unconventional monetary policy actions.

In the first place, they estimate standard Taylor rules for the nine economies under study and detect a structural change that occurs during the very unfolding of the financial panic in late 2008. Calani, Cowan, and García contrast the predicted monetary policy interest rates against actual monetary policy interest rates, documenting large discrepancies. In particular, the reduction in interest rates was more aggressive than the path implied by the estimated Taylor rules up to the structural break. The question that emerges in this case is whether these deviations are related to changes in the persistence parameter of the Taylor rule or to a stronger response to the output gap. They argue that this result might be better understood as a downward shift in the weight of past decisions on current ones (namely, activism), rather than a higher weight on the output gap, or dovishness. Further, they document that even though a sudden fall of inflation expectations can result in a similar path of policy rate decisions, such a fall would be unrealistically large.

Second, in addition to discussing the flexibility of the inflation-targeting regime using monetary policy interest rate reaction rules, they compile the daily history of unconventional measures undertaken by central banks (namely, local and foreign currency facilities and exchange rate interventions). They argue that the unconventional policies were implemented to preserve price stability, in keeping with the inflation-targeting framework, and that their objective was to ensure adequate transmission of monetary policy. To assess the effectiveness of the policy interventions, they explore their impact on local currency and U.S. dollar onshore interest rates and nominal exchange rates. They show that, despite the significant heterogeneity in the specific characteristics of non-monetary-policy measures and their effectiveness, such measures were broadly successful in limiting and reducing tensions in the money market and the foreign exchange rate market.

From these two exercises Calani, Cowan, and García conclude that inflation-targeting frameworks have been flexible enough to accommodate unconventional central bank policies.

As monetary policy seemed to reach its limits during the recent crisis, many governments pursued expansionary fiscal policy as well. While most people believe that such policies may have prevented a bad situation from becoming worse, there is a lot of debate about their effectiveness and the relative merits of specific measures, such as whether to finance additional government expenditure via debt or taxes. Michael Devereux's contribution to this volume sheds light on some aspects of this debate. He points out, correctly, that dominant macroeconomic models have nothing to say about, for example, the distinction between tax finance or debt finance, since they are built on assumptions that imply Ricardian equivalence, such as the irrelevance of the mode of government finance. Therefore, Devereux argues, one needs to develop models in which Ricardian equivalence does not hold in order to be able to say something useful on these issues.

Consequently, Devereux develops a model, originally due to Blanchard and Yaari, for analyzing the impact of government spending, tax cuts, and government deficits. A novel and crucial part of his discussion is to contrast normal times with times in which interest rates have been lowered to their zero lower bound. He finds that, at the zero bound, fiscal policies are much more expansionary if government spending is financed through an increase in the deficit rather than taxes; this contrasts with normal times, when the difference is quantitatively small. The intuition is that the wealth effects are much bigger when the economy is at the zero bound, and government debt can provide an outlet that satisfies the private sector's increased desire to save. Devereux also makes the point that tax cuts could be expansionary if the economy is in a liquidity trap, although they would have little effect in normal times. This suggests that a tax cut may be more desirable than an increase in government spending when the interest rate is close to a lower bound and there is demand for liquidity, a lesson that goes against the consensus that emerged from policy debates. In the context of Devereux's model, tax cuts are effective tools for addressing the reduction in aggregate demand, as they ameliorate the fall of real interest rates and thus prevent the propagation of the initial shock.

The large scale of expansionary fiscal and monetary policy has raised the issue of how such policies will be reversed. This is a difficult question, which is compounded by the fact that, in many advanced economies, growing entitlements and aging populations mean that fiscal transfers as a share of GDP will grow to levels that are hard to manage. Since many governments have failed to explain how they will deal with such a deteriorating fiscal position, Eric Leeper (in this volume) explores the consequences for the effectiveness and impact of monetary policy.

Leeper focuses on a standard model, with the added feature that at some point in the future, the government hits a fiscal limit, that is, a point at which further increases in taxes are infeasible. In such a setting, expectations about how growing fiscal transfers will be financed after the fiscal limit is reached become crucial for the effectiveness of monetary policy today. Leeper shows that the possibility of a fiscal limit implies that the usual monetary prescriptions, such as adherence to a Taylor-type rule, can be very misleading. In fact, he presents examples in which an inflation-targeting regime fails to anchor inflationary expectations in the periods before the fiscal limit is hit. These surprising cases arise because, in a rational expectations world, current beliefs about post-limit policy behavior affect current economic decisions. The policy implication is that the factors that anchor those beliefs may be crucial for the effects of current monetary policy and, in particular, the ability to conduct sound monetary policy can be enhanced if governments can reduce uncertainty about exit strategies and their plans for meeting their fiscal obligations in the medium run.

Leeper applies his theoretical framework to the cases of the United States and Chile. For the United States, the projections indicate that the fiscal situation is not sustainable for a long period of time. This, together with the lack of clarity about policies that will be followed after the fiscal limit is reached, implies a lack of anchor in fiscal and, consequently, monetary expectations. Leeper argues that Chile is in a different situation. Chile's institutional arrangements have been designed to prevent a fiscal limit from emerging, which allows the central bank to target an explicit inflation rate and anchor expectations.

4. Bank Regulation and Stability

As already mentioned, the banking system played a crucial role in the financial crisis of 2008–09. In particular, changes in the nature of financial instruments and the emergence of a shadow banking industry have been blamed as key components of the crisis. The origin of these changes may be found in the process of liberalization of the banking industry started in the 1970s in the United States.[11] Deregulation of the banking sector was seen as a process of increasing

11. From the 1940s to the 1970s, tight regulation was associated with great stability in the financial sector.

competition that triggered a significant expansion of financial intermediation. Vives (in this volume) analyses the trade-offs between banking competition and stability of the banking system.

Because of their particular mix of features, banks are subject to runs, with a potentially systemic impact and strong negative externalities for the economy. Vives indicates that a competitive banking system is often excessively fragile. Financial regulation can reduce the fragility significantly, but at the cost of side effects and regulatory failure.

Vives discusses the theoretical and empirical literature that relates competition and stability. There are two theoretical channels through which competition can negatively affect stability. First, competition makes a bank more susceptible to a run, as competitive pressure worsens both the coordination problem of investors and depositors and the impact of bad news on fundamentals. The second channel is related to incentives on the asset side. An increase in competition will tend to increase risk-taking incentives.

Vives also summarizes empirical evidence showing that some measures of bank competition (such as low entry barriers) are positively related to stability; that liberalization tends to increase the occurrence of banking crises, while a strong institutional environment and adequate regulation mitigate them; that the association between concentration and stability presents mixed results; and that larger banks tend to be better diversified, but can also assume more risks.

A noteworthy point in Vives's discussion regarding regulation is that it can alleviate the competition-stability trade-off, but its design has to take into account the intensity of competition. In particular, capital requirements should be higher when competition is more intense. However, given that fine tuning regulations is difficult, Vives argues that it is unwise to try to completely eliminate market power in banking.

An emerging market economy is typically characterized by higher uncertainty, a higher likelihood and incidence of financial and currency crises, a more predominant financial role for banks, and weak supervisory structures. For these economies, it is more difficult to follow the regulatory strategy typically followed in developed countries. Optimal policy should thus carefully balance the impact of the different levels of friction and the social cost of failure.

Finally, in a systemic crisis as occurred in 2008–09, there is pressure to stabilize the system through arrangements such as guarantee schemes and capital injections. Vives indicates that these interventions are potentially distorting, for example, in terms of moral hazard, protection of inefficient incumbents, and long-term effects on market structures reducing competition in the market.[12] Given the trade-offs implicit in the banking industry, Vives argues that the regulator in charge of stability must collaborate closely with the competition authority. Regulatory requirements and competition policy have to be coordinated.

12. The crisis forced mergers of institutions backed by government subsidies, increasing the market power of the surviving incumbents.

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The Global Financial Crisis

Franklin Allen
University of Pennsylvania

Elena Carletti
European University Institute

Financial crises have been pervasive for many years. Bordo and others (2001) find that in recent decades, their frequency has doubled that of the Bretton Woods period (1945–71) and the gold standard era (1880–1993), becoming comparable only to the period during the Great Depression. Nevertheless, the financial crisis that started in the summer of 2007 came as a great surprise to most people. What initially seemed like difficulties in the U.S. subprime mortgage market rapidly escalated, spilling over into financial markets and then the real economy. The crisis changed the financial landscape worldwide and its full costs are yet to be evaluated.

The purpose of this paper is to consider the causes and consequences of the 2007 crisis and how financial system institutions and regulations should be reformed. Despite its severity and its far-ranging effects, the 2007 crisis is similar to past crises in many dimensions. In a recent series of papers, Reinhart and Rogoff (2008a, 2008b, 2009) document the effects of banking crises using an extensive data set for high- and middle-to-low-income countries. They find that systemic banking crises are typically preceded by credit booms and asset price bubbles. This is consistent with Herring and Wachter (2003) who show that many financial crises are the result of bubbles in real estate markets. In addition, Reinhart and Rogoff find that crises result, on average, in a 35 percent real drop in housing prices, spread over a period of six years. Equity prices fall 55 percent over three and a half years. Output falls by 9 percent over two years, while unemployment rises

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7 percent over a period of four years. Central government debt rises 86 percent over its pre-crisis level. Reinhart and Rogoff stress that major episodes are sufficiently far apart that policymakers and investors typically believe that "this time is different," and they warn that the global nature of the 2007 crisis will make it far more difficult for many countries to grow their way out.

A thorough overview of the events preceding and during the 2007 financial crisis is provided in Adrian and Shin (2010), Brunnermeier (2009), Greenlaw and others (2008), and Taylor (2008). Its seeds can be traced to low interest rate policies adopted by the Federal Reserve and other central banks, after the collapse of the technology stock bubble. In addition, the appetite of Asian central banks for (debt) securities contributed to lax credit. These factors helped fuel a dramatic increase in house prices in the United States and several other countries such as Spain, Ireland, and the United Kingdom. In 2006, this bubble peaked in the United States and house prices there and elsewhere started to fall. Mayer, Pence, and Sherlund (2009) and Nadauld and Sherlund (2008) provide excellent accounts of developments in the housing market prior to the crisis.

The decline in house prices led to a fall in the prices of securitized subprime mortgages, affecting financial markets worldwide. In August 2007, interbank markets, particularly for terms longer than a few days, experienced considerable pressures and central banks were forced to inject massive liquidity. Conditions in collateralized markets also changed significantly. Haircuts increased and it became more difficult to borrow against low quality collateral. The Federal Reserve and other central banks introduced a wide range of measures to improve the functioning of money markets. During the fourth quarter of 2007, the prices of subprime securitizations continued to decline and many financial institutions became strained. In March 2008, the Federal Reserve bailed out Bear Stearns through an arranged merger with J.P. Morgan. Public funds and guarantees were required to induce J.P. Morgan to engage in the transaction.

Although the financial system and banks in particular came under tremendous pressure during this time, the real economy was not much affected. All that changed in September 2008, when Lehman's demise forced markets to re-assess risk. While Lehman's bankruptcy induced substantial losses to several counterparties, its more disruptive consequence was the signal it sent to the international markets. Reassessing risks previously overlooked, investors withdrew from the markets and liquidity dried up.

In the months that followed and the first quarter of 2009, economic activity in the United States and many other countries plunged. Unemployment rose dramatically as a result in some economies. The general consensus is that the 2007 crisis was the worst since the Great Depression.

1. What Caused the Crisis?

From August 2007 until September 2008, there was fairly wide agreement that poor incentives in the U.S. mortgage industry had caused the problem. Traditionally, banks would raise funds, screen borrowers, and then lend money to those approved. If the borrowers defaulted, the banks would bear the losses. This system provided good incentives for banks to carefully assess the creditworthiness of borrowers. Over time, that process changed and incentives were altered. Instead of originating mortgages and holding them to maturity, brokers and also some banks started originating mortgages and selling them to securitize. That led to a new process called the "originate-and-distribute model." In this new model, the originators, either brokers or banks, were not affected by borrowers' defaults, as they were selling the mortgages before maturity. Moreover, they had incentives to originate and sell as many mortgages as possible, as they were paid based on the number of mortgages that they approved, rather than on their performance.

The second stage in the process of this new originate-and-distribute mortgage system was securitization. The securitizing entities, such as investment banks, would pool a whole set of mortgages together from across the country, so that they would be well diversified. Then they would tranche those pools to spread the risk differentially. The buyers of the most junior tranche would be allocated the first default losses. Then, as more losses accumulated, these would be allocated to the next most senior tranche, and so on up the seniority chain. The most senior tranches would bear losses only very rarely, so they were regarded as fairly risk-free and rated triple-A. More junior tranches would have lower ratings.

Initially, securitizing institutions would hold the most junior tranches to maintain the right incentives along the securitization chain. However, at some point the junior tranches also started to be sold off, thus breaking up the incentive mechanism of the securitization process. As shown empirically by Purnanandam (2009), mortgages that originated in the new originate-and-distribute model were of significantly lower quality than those from the traditional system, where mortgages were held by originators until maturity.

Another important incentive issue concerned the rating agencies. Many argue that as rating agencies started to receive a large proportion of their income from rating securitized products, they lost objectivity and started giving ratings that weren't justified.

To sum up, according to the mortgage incentive view of the crisis, the whole procedure for checking the quality of borrowers and the mortgages underlying securitizations broke down, triggering the 2007 crisis. In line with this, the solution to stop the crisis and avoid it occurring again would be to regulate the mortgage industry and restore the appropriate incentive mechanisms.

This seemed to have been the view of both the Federal Reserve Bank and the U.S. Treasury at the start of the 2007 crisis. However, the deepening of the crisis and the dramatic collapse in the global real economy following the default of Lehman Brothers made this mortgage view less plausible.

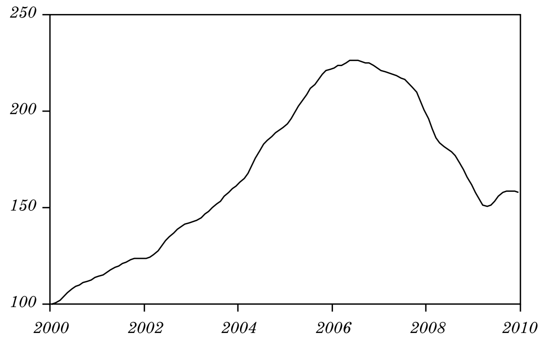
The economies in many countries in Asia and in Europe were drastically affected, even though their banks had very little exposure to U.S. securitizations and remained strong. In Japan, for example, GDP fell by around 4 percent in the first quarter of 2009. Drops in industrial production and GDP, although less severe, occurred all over the world and the global economy began to gradually seize up. As this happened, it became much more difficult to believe that an incentive problem in the U.S. mortgage industry had caused all this.

2. The Real Estate Bubble

We argue that the basic problem that caused the 2007 crisis was a huge bubble in real estate in the United States and several other countries, among them Spain, Ireland, and the United Kingdom. The crisis started with the bubble bursting and caused problems in the securitized mortgage market and the real economy. The magnitude of the bubble is illustrated in figure 1, which shows the dramatic increase in house prices in the early 2000s and their fall since July 2006.

We argue that there were two main causes for the bubble. The most important was the Federal Reserve's low interest rate policy, maintained since 2003. It was originally motivated by the collapse of the tech bubble in 2000 and the 9/11 terrorist attacks in 2001. Interest rates were cut to the very low level of 1 percent at a time when housing

Figure 1. The Case-Shiller Ten-City Composite Index



Source: The S&P/Case-Shiller website.

prices were still rising at significantly more than the inflation rate of 3 percent. In 2003, the year-on-year changes in the Case-Shiller 10-City Composite Index rose from 12.1 percent to 15.3 percent. This created an incentive for people to buy houses, as they could borrow at 1 percent and buy assets whose value was growing much faster.

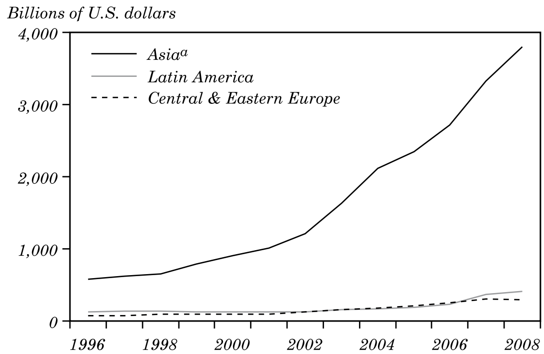
Several other aspects contributed to high demand for houses. These included tax advantages (being able to deduct interest on mortgages, compared to no deductibility of rent payments) and policies to encourage poor people to buy houses. All these factors created huge demand and led to a substantial increase in housing prices in the United States. Outside the United States, some European countries, such as Spain and Ireland, were also experiencing large property bubbles. Here, the ECB policy interest rate was low in relative rather than absolute terms.

The second important element that triggered the bubble in the United States and elsewhere was global imbalances. These started with the Asian Crisis of 1997, when many solid Asian economies fell into serious difficulties. For example, South Korea experienced problems because firms and banks had committed the "original sin" of borrowing too much in foreign currency. They then turned to the International Monetary Fund (IMF) to see them through these difficult times. In exchange for providing financial assistance, the IMF required South Korea to raise interest rates and to cut government spending. That is the exact opposite of what the United States and Europe have done when faced with a deep crisis.

One potential reason for this harsh imposition lies in the governance structure of the IMF. The IMF is a European- and U.S.-dominated institution. So far, it has always been headed by a European, while the World Bank has always been led by an American. That was part of how responsibilities were carved up in the negotiations leading to the Bretton Woods agreement at the end of World War II (even though it is not explicitly stated anywhere in the treaty). Asian countries were not represented at the highest levels, as they were less important, economically and politically, at that time. As they did not have much weight in the governance process, there was also no effective mechanism for the Asian countries to protest against the harsh policies imposed by the IMF during the Asian crisis.

The Asian countries responded by becoming economically independent, to avoid having to rely on the IMF in the future. To do so, they accumulated trillions of dollars' worth of assets. Figure 2 shows this accumulation of reserves by China, Hong Kong, Japan, Singapore, South Korea, and Taiwan. This is the line marked Asia. In contrast, Latin American and Central and Eastern European countries did not increase their reserves during this period.

Figure 2. Foreign Exchange Reserves in Different Regions



Source: IMF website.
a. Asia is the six East Asian countries China, Hong Kong, Japan, Singapore, South Korea, and Taiwan – province of China.

The Asian countries invested these huge reserves mostly in debt instruments, as they found it difficult to buy equities. One example occurred when U.S. authorities blocked the Chinese state oil company's acquisition of the American producer Unocal, on the grounds that Unocal was a strategic firm. As a consequence, Asian countries turned to debt instruments, in particular Treasuries, Fannie and Freddie mortgage-backed securities, and many other debt securities. A similar pattern of debt provision occurred in other countries, such as Spain and Ireland. This huge demand for debt and the consequent huge supply of debt helped to drive down lending standards, to ensure that it was all taken up.

Other factors contributed to the bubble's emergence. One of the most important was the yen carry trade, which allowed investors to borrow in Japan at zero interest rates and invest somewhere else, such as Australia and New Zealand, at much higher rates. This led to a large outflow of funds from Japan and probably contributed to the property bubble in Australia, for example, although the precise magnitude of the yen carry trade is not known.

3. The Effects on the Real Economy

The collapse of the bubble drove the whole global economy into a downward trend. One potential reason for this is that for about a decade, people made the wrong decisions, based on the assumption that asset prices would keep going up. In the United States, the aggregate saving rate fell to zero. Owning houses or stocks was much better than saving. Many people even borrowed to finance consumption. The leverage ratios of households, firms, and institutions all rose. When asset values fell, people found they were overleveraged and had saved too little. Then they had to start saving to pay down debt and build up their assets.

All this caused a huge uncertainty about the value of stocks, properties, and inputs to the production process, so that it was very difficult for people and firms to take decisions. For example, stock prices have been incredibly volatile in both directions. In January and February 2009, they were falling. There was a dramatic drop, with the S&P 500 index going to 686 by early March 2009. Then the price soared upward by about 30 percent in the following weeks. It became very difficult for people to estimate the long-run value of their stock.

Another example of price volatility is commodities. In the third quarter of 2008, oil was trading at 147 dollars a barrel, but the price plunged to 40 in a short space of time. Similarly, exchange rates have also been volatile. In the third quarter of 2008, the pound sterling rose above 2 dollars, then fell to $1.40. The euro stood at $1.60 then, but fell to about $1.25 before rising again.

To sum up, the huge uncertainty about price movements froze economic decisions of people as well as firms, chilling the global economy. Sales of consumer durables, such as cars, and investment goods, such as machine tools, have stalled since 2008, and only now seem to be recovering, although slowly. Bloom (2009) provides a formal analysis of how a macro uncertainty shock leads to a rapid drop in aggregate outcomes, as it induces firms to temporarily pause their investments.

4. The Effects on the Financial System

In addition to price uncertainty, a major cause of the economic difficulties during the crisis was major shortcomings in the financial system. The crisis started in the third quarter of 2007, with the meltdown in subprime mortgages, as discussed above. This caused trouble, because these mortgages were held by debt-based institutions that were, like investment banks or structured investment vehicles (SIVs), financed to a large extent by rolling over short-term debt. When prices fell, lenders didn't know whether they were going to be paid back and thus stopped rolling over their debt.

The problems started in securitized subprime mortgages, but then spread to many other parts of the financial system, because of the interaction with the real economy. The credit risk problem led to a flight to quality, with many people wanting to buy government securities. Central banks tried to deal with the greater desire for high-grade securities, allowing financial institutions to swap a wide range of securities for Treasuries. As a result, the Federal Reserve's balance sheet expanded from \$800-\$900 billion before the start of the crisis to \$2,000-\$2,500 billion afterward.

In short, there were two basic problems. The first was that people and firms didn't know the prices that should be guiding economic decisions. The second problem was that the financial system had enormous problems, and the two interacted.

5. Why Did the Financial System Perform so Poorly?

The financial services industry is the most regulated sector in practically all economies. In the United States, the Federal Reserve, the Office of the Comptroller of the Currency (OCC), the Securities and Exchange Commission (SEC), the Federal Deposit Insurance Corporation (FDIC), and a number of other regulatory bodies are responsible for regulating the financial sector. However, despite the pervasive regulation, the 2007 crisis came as a surprise to the regulators. How was this possible?

The first important point is that banking regulation is very different from other kinds of regulation. For example, there is wide agreement that environmental regulation is needed because there is a missing market. If a firm pollutes, it does not have to compensate the people who are damaged. Regulation is then needed to avoid the pollution of the environment. Antitrust is another important area of regulation. There the problem is monopoly. It is necessary to make sure that firms aren't monopolistic.

With banking regulation, the problem that is being solved is not at all clear. In fact, there is no general agreement that there is even a problem. Before the crisis, many central banks worked with dynamic stochastic general equilibrium models that don't even include a banking sector. The view underlying these models is that the real economy is going to work fine and the financial system is unimportant, except for pricing assets (see, for example, Muellbauer, 2009). In line with this, contagion, panics and more generally crises are not a problem justifying regulation. Given this approach, it is no surprise that so many central banks completely failed to predict the crisis that started in 2007.

The current structure of banking regulation is the result of ad hoc measures introduced in response to past crises. Many regulatory measures and bodies (the Glass-Steagall Act separating investment and commercial banking, the SEC, and all the subsequent SEC Acts) were introduced after the Great Depression to avoid the recurrence of such a deep crisis. This regulation was successful in terms of stopping crises. From 1945 until the early 1970s, there were no financial crises in terms of banking crises, except for one in Brazil in 1962 (see Bordo and others, 2001). This shows that one way to stop crises is to stop financial institutions taking risks.

The problem is that the alternative to private institutions taking risks is that the government intervenes in the allocation of credit. This can be done in different ways. Some countries, such as France, nationalized banks and the government directly made decisions. In the United States, the government introduced so many regulations restricting banks' possibilities to take risk that mostly low-risk industries were allocated credit. As a result, the financial system stopped fulfilling its basic purpose of allocating resources where they are needed. In the 1970s it became clear how inefficient this was and financial liberalization started in many countries. However, this led to a revival of crises. Since then, there have been crises all around the world (see, for example, Boyd, De Nicolò, and Loukoianova, 2009).

This historical evolution has led to a mishmash of regulations designed to stop particular problems, rather than a well thought out way of reversing market failures in the financial system. We would argue that current financial regulation is rather unfortunate, as it requires much time and effort for banks to comply with it, but doesn't actually do much to resolve market failures, as evidenced by the failure of regulations to prevent this crisis.

6. Banking Regulation

To design effective banking regulation, we need to know benefits and costs. The benefit of regulation is that it can potentially avert damaging crises. But the cost is that to do so, the financial system needs to stop allocating resources efficiently, to the detriment of growth and innovation.

The Basel Agreements offer a good example of what can happen when the benefits and the costs of financial regulation are poorly defined. There is no clear statement in the documents of what market failures the Agreements intend to solve. Equally, there is no explanation in the Agreements for the imposed levels of capital ratios. They seem to have been chosen simply at the levels that banks had used in the past. Not surprisingly then, capital regulation was unable to prevent the 2007 crisis.

In our view there are three main market failures in banking, which we consider in turn: the inefficient provision of liquidity; persistent mispricing of assets due to limits to arbitrage; and contagion. The current crisis has underlined the fact that at times, financial markets may not have been able to provide the efficient amount of liquidity (see, for example, Allen and Gale, 2004; Allen and Carletti, 2006). That is why central banks stepped in and designed many programs to inject liquidity into the banking system. The reasons behind the inefficient provision of liquidity are not fully understood yet. The basic problem is that liquidity is costly to hold. Without government intervention, people are willing to hold liquidity in a financial system only if there is significant price volatility. But price volatility causes crises. When prices fall to low enough levels, this can bankrupt financial institutions.

The second market failure is persistent mispricing of assets, due to limits to arbitrage. One of the big issues in the 2007 crisis was how to understand the pricing of mortgage-backed securities. If markets are efficient, market prices reflect the true value of the underlying stock. If something gets underpriced, there is a profit opportunity. Investors can buy the underpriced security and make a profit. This incentive provides the arbitrage mechanism that ensures that prices rise to the correct level.

In the 2007 crisis, this mechanism seems to have stopped working, in that there were limits to arbitrage. A good example is what happened in the fourth quarter of 2007. The prices of mortgage-backed securities fell. Investors then doubled up. But prices kept on going down and investors made big losses. It became too risky to arbitrage the securities. The mispriced securities became the so-called "toxic assets." The same happened during the dotcom bubble. Prices were too high, and kept going up for a prolonged period, so that arbitrage was not possible. That is the limit to arbitrage: prices keep moving in the wrong direction instead of going back to fundamentals. It is important to understand the limits to arbitrage better and develop mechanisms for overcoming them, so markets are efficient and market prices can be trusted.

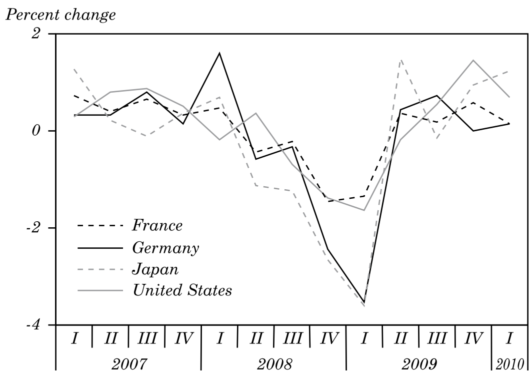
The third market failure is contagion (see, for example, Allen, Babus, and Carletti, 2009, for a survey). This is the market failure that central banks often use to justify intervention. An example is the Federal Reserve's intervention to help arrange the takeover of Bear Stearns. The justification was that otherwise Bear Stearns would have defaulted. That would have led to a whole chain reaction, driving many other financial institutions into bankruptcy, and possibly triggering a complete collapse of the financial system (see Bernanke, 2008). Of course, it is difficult to judge if these arguments are correct. The Federal Reserve had two days to figure out Bear Stearns's degree of interconnectedness, and they couldn't really do it in that time.

Immediately after the arranged takeover of Bear Stearns, the Federal Reserve opened up the discount window to investment banks. In return, these institutions would allow Federal Reserve teams to inspect their books to find out their positions. When, six months later in September 2008, Lehman Brothers got into trouble and could no longer survive on its own, the Fed had a much better idea of the interconnectedness of these banks. Apparently, they believed that the classic kind of contagion would not occur if they allowed Lehman to go bankrupt. In fact there was contagion but it was quite complex.

After Lehman Brothers collapsed, Reserve Capital, the oldest money market mutual fund, “broke the buck”, as it held a significant amount of Lehman debt. In other words, the value of Reserve Capital’s shares fell significantly below the mandated level of one dollar a share. Investors in other money market funds suddenly realized that there could be a wave of similar problems and withdrew massively from money market mutual funds. Within a few days the government was forced to guarantee all money market mutual funds. At the same time, AIG was on the point of default. In this case, the government decided they could not take another risk so, they saved AIG to prevent an even larger contagion.

In addition to these direct contagion effects, there have been indirect effects. The realization that the government might allow a financial institution to fail caused a loss of confidence in many financial service firms. The volumes in many important financial markets fell significantly and there was a large spillover into the real economy. Up to that point, the crisis had been largely confined to the financial sector, with relatively few effects on real economic activity. Figure 3 shows how GDP fell significantly in the fourth quarter of 2008, particularly in Japan and Germany. This underlines the importance of contagion, but there is still much scope for a better understanding of its indirect effects.

Figure 3. Quarterly GDP in Four Countries



Source: Organization for Economic Co-operation and Development (OECD).

Going forward, it is important that banking regulation be structured to solve these and other market failures. We need to better understand the optimal form of central bank intervention to restore liquidity in crucial markets, such as the interbank market. Market structures should be designed to make markets as efficient as possible and avoid extended episodes of asset mispricing. Finally, regulations should be introduced to minimize the pernicious effects of contagion. Capital regulation could play an important role.

7. How Will the Crisis Develop?

An important question is what will happen going forward. The 2007 crisis has often been compared to the Great Depression. While there are certainly analogies between the two crises, institutions, technologies, and many other aspects were very different 75 years ago. This limits the conclusions that can be drawn from this analogy.

The most similar recent crisis is the one that occurred in Japan in the 1990s. The reason is that Japan is the second biggest economy and had a large bubble in both stock and property prices. In the mid-1980s, the Nikkei was around 10,000 and it peaked at just under 40,000 in December 1989. Recently, the Nikkei has been trading in the range of 7,000 to 10,000. This means that it is still around a quarter to a fifth of where it was 20 years ago.

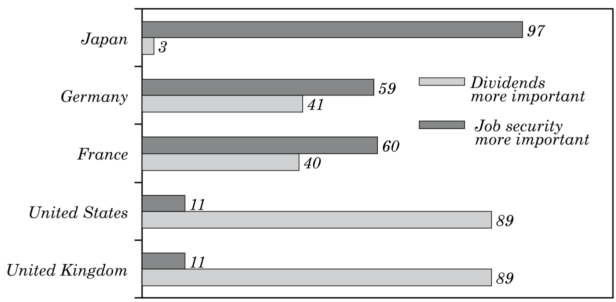
Similarly, property prices were very high. At the peak of the bubble, the value of the few hundred acres that the Imperial Palace stands on in Japan had the same value as all the land in Canada or California (see Ziemba and Schwartz, 1992, p. 109). Real estate prices fell 75 percent over 15 years. This caused enormous problems in the real economy and Japan went from having one of the most successful and fastest growing economies in the world to having one of the slowest.

The question is whether the bubble bursting in the United States will provoke similar effects as in Japan. Some argue that the U.S. bubble was smaller than Japan's, in the sense that asset and property prices had not risen as much. Concerning stocks, there was a reverse of the tech bubble in stock prices in 2001. Afterward, stock prices rose significantly from 2003 to 2007. Early in 2009, stock prices had fallen to around a half of what they were at their peak in 2007, and then rose by more than 50 percent by late 2009. Whether this is a long-lived phenomenon, as in Japan, or just a liquidity and mispricing problem such that prices are going to snap back fully in a year or two as they did after the crash of 1987, is too early to say. Many believe that prices will return to pre-crisis levels once the government has cleaned up the financial system.

On property prices in the United States, many experts argue that these were about 25 percent above trend. The Case-Shiller index in figure 1 shows that property prices were down about 30 percent in mid-2008. The adjustment since then may mean that price adjustment has ended and the economy will move back to normal, as it did eventually in Japan. However, this is not necessarily the case. The reason is that Japan has a very different kind of economy in terms of corporate governance. Japanese firms are much more stakeholder-oriented than their U.S. counterparts. This means that Japanese firms care more about their workers, suppliers and other stakeholders than about shareholders, so they react very differently to shocks and crises as compared to firms in the United States.

Evidence of this is provided by the answers to some surveys where the question asked is (for example, Yoshimori, 1995): "What's the prevalent view in your country? If times get bad, should firms maintain dividends and lay off workers or should firms cut dividends and keep stable employment?" Figure 4 shows that the answer to this question varies significantly across countries. In Japan, the answer is that firms should cut dividends and maintain employment. In the United States and the United Kingdom, it's the complete opposite. Firms should fire workers and keep dividends up.

Figure 4. Job Security versus Dividends[a]

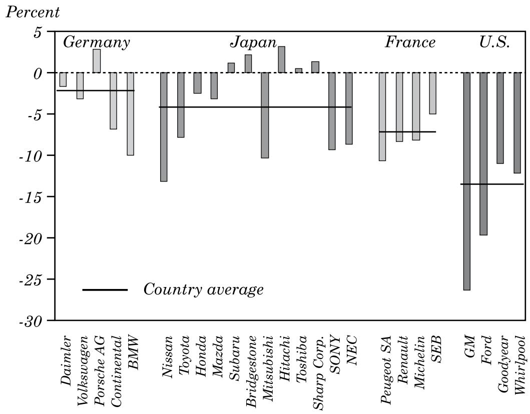


Source: Yoshimori (1995).
a. Number of firms surveyed: Japan, 68; United States, 83; United Kingdom, 75; Germany, 105; France, 68.

In the past 20 years, the focus on shareholders has been very beneficial to the United States and the United Kingdom, because it allowed resources in the economy to be reallocated very quickly. This fast reallocation was not possible in Japan in the 1990s and 2000s. However, the situation in the current crisis is very different. U.S. firms have been firing many workers since 2008, unemployment has gone up, and that may have dramatic macroeconomic consequences. The unemployment rate in the United States was 4.7 percent in July 2007 and had risen to around 10 percent by the end of 2009. In addition, unemployment can trigger fears of additional future unemployment.

Figure 5 points to further differences, in terms of unemployment, between the United States and other countries. The figure shows the layoffs in companies in the auto industry and in white goods (consumer durables) in different countries. Both industries were hit quite badly. As the figure shows, there have been many more layoffs in the United States compared to other countries. Germany experienced the lowest number of layoffs. In fact, Volkswagen is increasing employment.

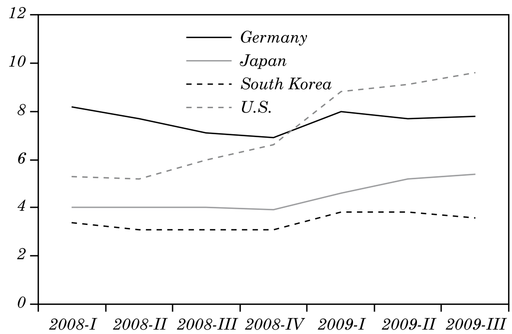
Figure 5. Country-Based Effect on Workforce Reduction per Company



Source: Company reports.

The aggregate statistics for unemployment in figure 6 confirms that U.S. unemployment has gone up dramatically. In contrast, for Germany the line is basically flat. This implies German workers do not feel threatened and can continue to consume. The different corporate governance structures across countries may also explain the different needs of the various countries to introduce stimulus packages during the crisis.

Figure 6. Unemployment Rates



Source: OECD.

To sum up, focusing on value creation for shareholders works well for economic efficiency in boom times, as it facilitates the reallocation of resources to their most efficient uses. However, in times of crisis, laying off workers may create macroeconomic instability. A soaring unemployment rate can cause significant feedback effects. A critical issue when comparing Japan's experience in the 1990s with U.S. experience now is how big these feedback effects will be in the United States. Japan had a lost decade with slow growth but did not see a large contraction in GDP and an increase in unemployment. How big the feedback effects in the United States will be in the long run remains to be measured.

8. Excessive Risk Taking in Private or Public Sectors?

Reforming financial regulation is certainly one of the most important priorities now. Other measures should, however, be adopted. People have laid a lot of blame on the private sector, in particular for the excessive risk taken by banks. In light of the view that there was a bubble and that central banks played a big role in creating it, however, it is also important to think about how to avoid such a problem in the future. In other words, it is also important to avoid the problem that the public sector will take risks again.

After the inflationary experiences of the 1970s, many countries made their central banks independent. The main rationale was that independent central banks were less likely to succumb to political pressure to cut interest rates and cause an inflationary boom at every election. This principle has worked very well for preventing inflation. However, this crisis has demonstrated that central bank independence is not good for financial stability. In essence there are very few checks and balances on central banks. In the Federal Reserve, for example, Alan Greenspan could basically decide on his own to cut interest rates to 1 percent in 2003. In those days, there wasn't much dissension within the Board of Governors. The low interest rates avoided a recession in the short run, but fueled the bubble and thus led to a much bigger recession after the crisis that started in 2007. Better governance mechanisms are needed to guarantee proper debates on decisions concerning interest rates. The current mechanism seems highly inappropriate.

Again, there has not been much discussion about the use of quantitative easing. This allows the Federal Reserve to effectively print money and buy back long-term government bonds. Although this may be beneficial in the short run, it may lead to excess liquidity and thus inflation in asset prices in the longer run. Quantitative easing has not been tried very much. It was used in Japan in the 1990s, but did not help cure the problem. It didn't lead to inflation in Japan either, but it probably did lead to a larger yen carry trade than would otherwise have occurred.

To illustrate the riskiness of quantitative easing, suppose that after increasing the money supply there is a burst of inflation. At that point, the Federal Reserve has to start soaking up liquidity again, by selling the bonds that they bought with the program of quantitative easing. However, buying is clearly much easier than selling. If, for example, the Chinese and other foreign holders of U.S. Treasuries decide to withdraw some of their money from the United States and start diversifying their investment into euros and yen, then there is likely to be a run on the dollar.

This is just an example to illustrate the problems that can originate from inappropriate policy and an inappropriate governance mechanism in the public sector.

9. Preventing Global Imbalances

As mentioned above, the IMF arguably helped cause the problem of global imbalances through its harsh policies in the 1997 Asian Crisis. At the time, there was no mechanism to stop this from happening, because the Asians were not as important politically and were underrepresented in the IMF governance process. Today, the Asian countries are among the most important economically. The Chinese have almost 2.5 trillion dollars, the Japanese another trillion, and South Korea several hundred billion.

Asian countries have also been quite resilient to the 2007 crisis. For example, South Korea cut interest rates and allowed the value of its currency to sink a long way. In contrast to the 1997 crisis, when unemployment rose to more than 9 percent, it has only increased slightly in the current crisis. The reason is that they could use their large reserves to pursue these policies, without any approach to the IMF.

While it is individually advantageous for countries to self-insure by accumulating reserves, this is a very inefficient mechanism from a global perspective. One possibility is that the countries accumulating reserves must lower their consumption to do so, and other countries must run deficits to offset these surpluses. In practice, the United States was the main deficit country. The resulting buildup of debt and its role in triggering the crisis shows that this was not desirable. Another possibility is that countries building up reserves borrow long term and invest short term. These alternatives raise the question of what the alternatives to self-insurance through reserve accumulation could be.

The first clear alternative is to reform the IMF to guarantee that countries hit by shocks are treated properly, if they need help. If countries can always rely on fair and equitable treatment and not being forced to implement harsh measures, they need not accumulate large levels of reserves. To achieve this change, the IMF needs to reform its governance structure, so that Asian countries play a much larger role. This should be accompanied by an increase in Asian staff at all levels. Unfortunately, current proposals do not go nearly far enough in this regard, and it seems unlikely that the IMF will apply sufficient reforms to make large reserves unnecessary in the short to medium run.

A number of Chinese officials have made proposals for a global currency to replace the dollar. This kind of approach has the great long-run advantage that reserves can be created initially, without large transfers of resources and the attendant risk of a crisis. All countries could be allocated sufficient reserves to survive shocks. The drawback of this proposal is that an institution like the IMF would be necessary to implement the currency and the issue of fair representation of Asian countries would arise again.

A more likely medium-term scenario is that the Chinese renminbi becomes fully convertible and joins the U.S. dollar and the euro as a third major reserve currency. With three reserve currencies there would be more scope for diversification of risks and China itself would have very little need for reserves, in just the same way that the United States and euro zone countries do not need significant reserves.

10. Other Key Reforms

So far we have suggested three important reforms. The first is that banking regulation should be based on a coherent intellectual framework of correcting market failures. The second is that the Federal Reserve and other central banks need to be subject to more checks and balances than is currently the case. The third is that the IMF needs to be reformed so that Asian countries can rely on being treated in the same way as European countries, so they do not need to build up enormous reserves. In this section we consider several other key reforms.

10.1 "Too Big to Fail" Is Not "Too Big to Liquidate"

One of the most important principles guiding policy during the current crisis has been that large institutions are "too big to fail." The notion is that if Citigroup, for example, is allowed to fail, this is going to cause many other institutions to fail throughout the financial system. This is the contagion problem discussed earlier. The way that this policy has been implemented is that governments have bought preferred shares in many institutions that would otherwise have failed. They have made clear that these institutions will be provided with the capital that they need in order to survive.

We would argue that this is the wrong way to deal with the "too big to fail" problem. As Lehman Brothers' demise illustrated, contagion is a very real problem and large banks should not be allowed to simply go bankrupt. However, "too big to fail" doesn't mean that we should allow these institutions to survive. It's a very bad precedent to provide failing banks with the funds they need to survive. In the future, banks and other financial institutions will grow and become large. They know they will then be "too big to fail," and everything will be fine for most of their employees and customers. Firms that form a business relationship with them know they are going to be able to continue. The banks will then be willing to take large risks, since they receive the payoffs if gambles are successful, while the government bears any losses.

However, "too big to fail" does not mean "too big to liquidate." Financial institutions should be prevented from failing in a chaotic way. The government should step in and take them over, to prevent contagion. But rather than allowing them to continue, these institutions should be liquidated in an orderly manner and possibly over a long period of time. That would allow other institutions that didn't fail and are well run to expand and take their business. Propping up the weak ones that did badly is not a good idea in the long term. It rewards risk taking and perhaps more importantly it prevents prudence from being rewarded. Well-run banks that survive should benefit.

An important aspect of such a scheme for allowing the government to prevent contagion by taking over failing institutions is to have bankruptcy rules for non-bank financial institutions that allow the equivalent of prompt corrective action for banks. With a bank, the government can step in before it goes bankrupt and take control. There doesn't have to be a shareholder vote. This is necessary for all financial institutions. That's what the government should have been able to do with Bear Stearns and Lehman Brothers. This would have prevented the great uncertainty that occurred when they failed.

10.2 Resolution of Large Complex Cross-border Financial Institutions

A major difficulty in designing a framework that allows financial institutions to be liquidated is how to deal with large, complex, cross-border institutions. In particular, there is the problem of which countries should bear any losses from an international mismatch of assets and liabilities. This has proved a thorny problem for the European Union in designing a cross-border regime to support its desire for a single market in financial services. For countries without political ties like the E.U., the problem is even more difficult. Designing such a system is one of the most urgent tasks facing governments.

One possible way to proceed would be to eliminate cross-border branching. Then, the host country would regulate any subsidiaries. These regulators would be charged with ensuring that they were comfortable with any imbalances between assets and liabilities in their country. They would be responsible for intervening, should a foreign subsidiary or home institution come close to failing, and would be responsible for covering any shortfalls of cross-border assets and liabilities resulting from failure.

The issue of cross-border resolution is one of the most important and urgently needs to be addressed. Current proposals have made very little progress on this issue.

10.3 Limited Government Debt Guarantees for Financial Institutions

In the current crisis, bank bondholders have effectively had a government guarantee. There is an important issue of whether this is desirable. Such a guarantee prevents disorderly wholesale runs. However, this again provides undesirable long-term precedents. Going forward, holders of bank debt will know it is guaranteed and will not have any incentive to exert market discipline. If failing banks are nationalized and liquidated in an orderly manner as discussed above, it should be possible to impose losses on long-term bond and other debt holders. This should provide incentives for market discipline by bondholders.

10.4 Removal of Tax Subsidies for Debt

The tax system in many countries subsidizes the use of debt in many ways. For example, in the United States, mortgage interest is tax deductible. These kinds of incentives to use debt are not desirable in a financial stability context. They should be removed.

10.5 Capital Adequacy Regulation Should Be Based on Market Capital as Well as Accounting Capital

Capital adequacy rules have an important role to play in preventing contagion and other problems. However, one aspect of their current implementation is that they are based on accounting capital. When Wachovia effectively failed, its accounting capital was well above regulatory limits, even though the market was no longer willing to provide funds. This example underlines the importance of using market capital in regulation, in addition to accounting capital.

10.6 Mark-to-Market, Historic Cost Accounting or Something Else?

Financial institutions have traditionally used historic cost accounting for many of their assets. This is problematic if assets fall in value as they are able to hide this fact for significant periods of time. A good example is the savings and loan crisis in the United States in the 1980s. This kind of episode encouraged a move to mark-to-market accounting by the International Accounting Standards Board and the U.S. Financial Account Standards Board (FASB) (see, for example, Plantin, Sapra, and Shin, 2008; Allen and Carletti, 2008a). During the current crisis, it is not at all clear that market prices have reflected fundamental values. Mark-to-market accounting has come under severe criticism by financial institutions, and has been relaxed by the FASB under political pressure from Congress.

How should the advantages and disadvantages of mark-to-market accounting be balanced? As long as markets are efficient, mark-to-market accounting dominates. However, if, as during times of crisis, they cease to be efficient, market prices do not provide a good guide for regulators and investors. The key issue then becomes how to identify whether financial markets are working properly or not. Allen and Carletti (2008b) suggest that when market prices and model-based prices diverge significantly (more than 2 percent, say), financial institutions should publish both. If regulators and investors see many financial institutions independently publishing different valuations they can deduce that financial markets may no longer be efficient and can act accordingly.

10.7 A Role for Public Sector Banks in a Mixed System

Some countries have a publicly owned commercial bank that competes with private sector banks, such as Chile with its *BancoEstado*. In times of crisis, such a bank can expand and help stabilize the market, as all market participants know that it is backed by the state and will not fail. During the 2007 crisis, that is what the Federal Reserve was effectively doing. It became one of the biggest commercial banks in the world. But the people in the Fed did not have much expertise in running a commercial bank. They didn't know much about credit risk. It would be better to have expertise in the public sector, which allows the state to perform commercial banking functions during times of crisis.

11. Concluding Remarks

If our hypothesis, that the most recent crisis similar to the one starting in 2007 was Japan's in the 1990s, is correct, this implies that the after effects of the current crisis will be long lived. The problem is that when bubbles burst more than the financial system gets damaged. Prices have been wrong and finding the correct new prices can take a long time, particularly if the bubble was largely in real estate. During the adjustment period economic activity can be badly affected.

In the current crisis, both residential and commercial property prices have fallen significantly. That may well cause the same kind of problems in commercial-backed securitizations as with subprime securitizations. The other major problem is corporate defaults.

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The Great Recession and the Great Depression: Reflections and Lessons

Barry Eichengreen
University of California at Berkeley

My Economics Department colleagues are fond of telling me that, as an economic historian, I have the advantage that I don't have to update my lectures in response to events. My history lectures don't become outdated as quickly as their lectures on, say, the Great Moderation. The fallacy of this view is that while the so-called "facts" don't change, their interpretation does. To take the obvious example, in light of recent events I have had to revise everything I say about the Great Depression. This is the case with regard to the causes of the 1929 crisis, which included the Florida real estate bubble, global imbalances (referred to then as "the transfer problem"), and lax supervision and regulation. And this is the case with regard to the debate over the effectiveness of monetary and fiscal stimulus in the 1930s. It is certainly the case when we ask whether "it" could happen again.

Be this as it may, it remains true that the conventional account of this earlier period powerfully shapes the outlook of current policy makers. Their views are informed by the Federal Reserve's failure to make decisive use of monetary policy and its choosing, instead, to allow the entrenchment of deflationary expectations. They are informed by the Federal Reserve's failure to execute its responsibilities as a lender of last resort, instead allowing the banking system to collapse. They are informed by historical analyses of the actions of the Hoover administration and Congress, which

Revision of a keynote address presented at the Thirteenth Annual Conference of the Central Bank of Chile. This talk has been evolving for some time. Earlier versions of the material, or portions thereof, appeared in *Current History* (January 2009) and were presented at the annual conference of the Central Bank of Argentina (August 2009).

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raised taxes in the early 1930s in a futile effort to balance the budget, but only reinforced the collapse of private demand. They are informed by memories of how, although the economic downturn was fully underway already in the second half of 1929, no effective steps to halt the fall in prices, stabilize the banking system, and restart investment spending were taken until 1933.

This time, of course, reflecting these "lessons of history," U.S. policy makers did not hesitate to act. No sooner did the crisis erupt than the Fed flooded financial markets with liquidity. When the economy continued to weaken, it cut interest rates to zero. It intervened in markets for securitized investments of all kinds. In early 2009, it moved to quantitative easing, purchasing treasury bonds.

On the fiscal front, a first dose of stimulus was administered in early 2008, and the Obama administration and Congress followed in 2009 with their $787 billion stimulus. They clearly took to heart a further lesson from the 1930s: that when interest rates are cut to low levels, fiscal policy becomes even more important for stabilizing the economy.

Through these actions, both in the United States and elsewhere, we prevented the Great Recession from turning into a second Great Depression. But as for how we got into this mess in the first place and why policy was not more successful in containing the crisis, part of the problem may, ironically, be the tendency to take history too literally. While Black Thursday (24 October 1929) and, more generally, the 1929 stock market crash feature prominently in popular accounts of the Depression, scholarly analyses typically treat the crash as a sideshow and emphasize the crisis in the banking system. Such analyses are organized around the First, Second and Third Banking Crises in 1930, 1931 and 1933. Appropriately so, one might argue, since the U.S. economy was heavily bank-based in the 1930s. But with the passage of time, nonbank financial institutions became more important, reflecting the progress of disintermediation and securitization. The current crisis has been a crisis not just for banks but for insurance companies like the American International Group (AIG), for the hedge funds whose distress sales of securities created problems for other investors, and for the securities markets themselves.

Ironically, memories of the financial crisis of the 1930s, which was first and foremost a banking crisis, may have led policy makers to focus on this segment of the financial system to the neglect of others. At first they lent freely to commercial banks but not to other institutions, reflecting the "lesson of the 1930s" that banks are the weak link in the financial chain. But in the recent crisis, problems were equally pervasive in the "shadow banking system:" that is, among the conduits and special purpose vehicles of investment banks, which did not initially have access to the Federal Reserve's discount window, and hedge funds and insurance companies such as AIG. Initially, the Federal Reserve hesitated to support this segment of the financial system. I would suggest that this reflected the power of historical narrative—that there existed in the 1930s no shadow banking system for historians to examine. And it reflected the difficulty of realizing that, while history repeats itself, it never repeats itself in the same way.

One can make the same argument about the tendency for authorities to underestimate the importance of credit default swaps (CDSs) and of the CDS-related financial seizure that would follow from the decision to allow Lehman Brothers to fail. The fact that in the 1930s there was no equivalent to CDSs and other complex derivatives may have meant that our policy makers failed to appreciate their importance. Once again, I am suggesting that, while the policy response was positively shaped by historical narrative, that narrative also distorted the response in unfortunate ways.

None of this is to deny that policy makers have done better this time. Of course it would have been hard to do worse.

Our central bankers have also been in constant communication, which of course they were in the 1930s too. But in contrast to the 1930s, the result has been a good deal of actual cooperation. The importance of cooperation is another "lesson of history." There have been currency swaps between the Federal Reserve System, European Central Bank, and Bank of England. The European Central Bank (ECB) extended euro and dollar swap lines to European countries outside the euro area and the Federal Reserve did likewise with Mexico, Brazil, South Korea and Singapore. These swap facilities did not magically solve the financial problems of receiving countries, but they alleviated the immediate problem of dollar and euro shortages caused by U.S. hedge funds and European banks liquidating investments. This is quite unlike the situation in the 1930s, when France blocked the extension of credits to Austria through the Bank for International Settlements, due to objections to the formation of an Austrian-German customs union and Germany's decision to build pocket battle ships in violation of the terms of the Versailles Treaty. This proved a fateful decision that allowed the financial crisis to spiral out of control.

Asia is the one place where I detect echoes of the interwar tangle between France and Germany. While Asian countries created a regional system of financial supports, the Chiang Mai Initiative (now referred to, less elegantly, as the Chiang Mai Initiative Multilateralization, or CMIM), they were unwilling to activate it, even in September–November 2008 in response to the most serious global financial crisis in 80 years. The reason is clear: delicate political relations make it hard for Asian countries to demand policy adjustments of their neighbors, and in the absence of such adjustments they are reluctant to put money on the barrelhead.

To finesse this problem, disbursing credits through the CMIM, after the first 20 percent, requires the recipient to negotiate a program with the International Monetary Fund. But with memories of the 1997–98 financial crisis still raw, governments are unwilling to approach the Fund. Beijing prefers to see the creation of a more extensive financial support system within the region, while Tokyo resists this on the grounds that China would eventually become the dominant party in such a system. The Japanese government would prefer recycling Asian reserves through the IMF, where it has twice the voting power of China and designates one of the deputy managing directors, whereas China, whose voting power in the Fund is roughly equivalent to Belgium's, is understandably reluctant to go this route. China is also reluctant to see its currency appreciate against the dollar, a policy that is creating other problems, described below.

It is tempting to draw a parallel with Charles Kindleberger's (1973) interpretation of the interwar depression: that the Depression resulted from the inability of the declining power, Great Britain, to display leadership and the unwillingness of the rising power, the United States, to do so. This time the United States is declining and China is on the rise. I would argue, however, that the parallel is overdrawn. There is no question that a Chinese contribution would be helpful for solving current problems. But China is not yet capable of exercising the kind of leadership that could reasonably be expected of the United States in 1929. In 1929 the rising power, the United States, was already three times the size of the declining power, Britain. Today, in contrast, the United States is still three times the size of China. This is worth bearing in mind when one hears calls for China to boost consumption by enough to offset the decline in U.S. consumption, as U.S. households seek to rebuild their retirement accounts. If there is going to be a decline in U.S. spending, then we will need more than just China to take up the slack.

The other place where we have done a reasonably good job—and here I need to emphasize the qualifier "reasonably"—is in avoiding protectionism. I am aware of the U.S. stimulus bill's "Buy America" provisions and their unfortunate counterparts in other countries. I am aware of the scorecard kept by the World Bank, showing some 46 new trade restricting measures worldwide in the five months following Lehman Brothers alone. That said, it is still true that we have done better, this time, at resisting protectionism. There has been no wholesale recourse to tariffs and quotas, as there was in the 1930s.[1]

The difference is attributable, once again, to the "lessons of history." Here, however, we have an instance of bad history ironically producing good policy. The bad history is the belief that the Smoot-Hawley tariff significantly worsened the Depression and provoked widespread retaliation. Smoot-Hawley is entry number 17 on my list of factors contributing to the Depression, organized in descending order of importance. U.S. tariffs were already high as a result of the Fordney-McCumber "skyscraper" tariff of 1922; Smoot-Hawley raised them only a bit further. Monetary, fiscal, financial, and even competition and labor-market policies were all much more important factors in the slump.[2]

Similarly, the fact is that retaliation against Smoot-Hawley was minimal. The measure that set off a wave of retaliation was the British general tariff of 1932, not Smoot-Hawley.[3] But bad history in the service of good policy has its merits. The very phrase "Smoot-Hawley" was enough to restrain our policy makers from their worst protectionist impulses this time.

The other reason we avoided protectionism this time, as I have argued in work with Doug Irwin, is that we deployed appropriate monetary and fiscal measures. In the 1930s, countries resorted to tariffs in a desperate effort to bottle up the available demand, to ensure that whatever spending occurred was on domestic goods. They resorted to tariffs because the case for fiscal stimulus was not understood, and because monetary stimulus was not possible as long as central banks were constrained by the gold standard. Starting in 1931, all things being equal, countries that went off the

1. See Kee, Neagu, and Nicita (2010).

2. One can even make the argument that Smoot-Hawley had a positive impact by putting upward pressure on prices in a deflationary environment. For the conditions under which this result holds, see Eichengreen (1989).

3. See Eichengreen and Irwin (2009).

gold standard and were therefore able to apply first-best monetary stimulus were less inclined to resort to protection. Able to counter unemployment by other means, they did not invoke the fixed-lump-of-spending hypothesis and resort to protectionism. This is where good history has helped to avert a lapse into protectionism. Insofar as our policy makers understood the need to mount a concerted monetary and fiscal response to a Depression-like threat, their protectionism temptation was less.

Let me now switch gears a bit, although the way I am trying to use history in an effort to shed light on recent events will not go away. Given how the Great Recession was a crisis of the international system, one increasingly hears the question of whether globalization might now be rolled back. Here I would distinguish financial globalization from other aspects of globalization. It is possible to argue that the golden age of financial globalization has already passed. In the future, national financial systems will be more tightly regulated (although how much more tightly we will see). Capital requirements will be raised (although how high, once again we will have to wait and see). Given the urgency attached to creating orderly resolution regimes for nondepository financial institutions (something that can be done at this stage only at the national level, given lack of international agreement on how to structure them), pressure will increase to ensure that the domain of such institutions coincides more closely with the domain of regulation. All this will mean that somewhat less capital will flow across national borders. (I emphasize the “somewhat” in that last sentence, to remind you that I am not getting carried away.)

On the recipient side, emerging markets are keenly aware that countries that relied most heavily on capital inflows suffered the greatest dislocations when the crisis hit and deleveraging occurred. Countries such as South Korea, where half of all domestic stock market capitalization was in the hands of foreign institutional investors, saw their markets crash as these foreign investors liquidated holdings in a desperate effort to repair damaged balance sheets. In contrast, the countries that had internationalized their financial markets more slowly suffered less serious disruption. Governments are therefore likely to do more to limit inflows in the future. We have seen the Brazilian authorities impose a 6 percent tax on some forms of portfolio capital inflow. Korea’s Financial Supervisory Agency has announced it intends to impose additional capital charges on banks borrowing offshore. One can question the effectiveness of these measures: will Brazil's measures be evaded via offshore markets or Korea's via shifting transactions from bank to nonbank financial institutions, for example? To answer these questions, people will almost certainly return, yet again, to another historical episode, namely, Chile's experience in the 1990s.[4]

The other thing needed to deal with capital flows—you will not be surprised to hear this from me—is exchange rate flexibility sufficient to create two-way bets. The absence of this flexibility is fueling the carry trade, which in turn is giving rise to frothy property and asset markets, especially in Asia. Given expectations that the dollar can only decline and that Asian currencies can only rise, there is an irresistible temptation to use dollar funding, at what are effectively negative real interest rates, to invest in Asia, where values can only rise with currency appreciation. Letting currencies adjust now, so that there is no longer the prospect of a one-way bet, would help to relieve this pressure. Latin America is by no means immune to the carry trade, but the fact that the major countries, not least this one, allow their currencies to fluctuate relatively freely means that this tendency has affected local markets less. To put it another way, the point is that U.S. monetary conditions, which remain loose for good reason, are not appropriate for emerging markets, whose problems are, if anything, incipient inflationary pressure and strong economic growth. And capital flows are the vehicle through which pegging to the dollar causes these countries to import U.S. monetary conditions.

I could cite various historical illustrations of the danger. The locus classicus again is the Great Depression. The carry trade contributed to the unstable equilibrium of the 1920s, as investors funded themselves at 3 percent in New York to lend to Germany at 8 percent. Then as now, the migration of capital from low- to high-interest-rate countries was predicated on the mirage of stable exchange rates.

Another example is the 1960s, when Germany was in the position China is in now. Everyone understood that the deutschemark would rise against the dollar. Everyone who could get their hands on dollars poured them into German assets, since exchange rate policy offered a one-way bet. As a result the Bundesbank was forced to wage a continuous battle against imported inflation. One might object: if this

4. The IMF has already done this, in its assessment of capital controls: see Ostry and others (2010).

problem was so serious, why didn't it result in a dangerous bubble followed by a devastating crash? The answer is that the German authorities limited the impact on the economy. They revalued in 1961 and 1969, and they imposed Brazilian-style capital controls in April of 1970 and May of 1971.[5] But it was only when they allowed the deutschemark to float, first in 1971 but especially in 1973, that they finally got a handle on the problem.

Let me turn finally to other aspects of globalization. I want to argue that what is true of finance—that the golden age of globalization is past—is less obviously true of other aspects of globalization. There is little likelihood that we will see this rolled back. U.S. appliance manufacturers continue to do assembly in Mexico, global credit crisis notwithstanding. German auto companies continue to source parts and components in Eastern Europe. East Asia is of course the prime case in point. Trade there, in parts and components, has been growing exponentially. China is effectively serving as a gigantic assembly platform for the region and the world.

Moreover, the logic for these global supply chains and production networks remains intact. The cost of air transport has fallen by two-thirds since 1950. Ocean freight rates have fallen by a quarter as a result of containerization and other advances in logistics. And what is true of transportation is true of communication: the cost of satellite communications is barely 5 percent what it was in the 1970s. Then there is the cost of communicating via the Internet, a medium that didn't exist four decades ago. The outsourcing of back office services, transcription, data entry, and now software engineering and financial analysis to developing economies reflects these same advances in communications technology, which are not going to be rolled back.

To be sure, one can imagine channels through which the backlash against financial globalization could spread. Trade grows more quickly when there is easy access to trade finance. At the height of the crisis the difficulty of securing letters of credit, which are important for financing export transactions and giving exporters confidence that they will be paid, had a profoundly depressing impact on export and import transactions. HSBC, a leading supplier of trade finance, reported in November 2008 that the cost of insuring letters of credit had doubled in little more than a month.[6] In response, however, there were a variety of concerted interventions by multinationals and national import-export banks. The volume of trade has recovered.

5. See Bakker (1996).
6. See Mortished (2008).

And even if financial de-globalization is permanent, it will still be possible for importers and exporters to obtain trade credit from national sources. That is, even if cross-border financial transactions remain more limited than in the past, it will still be possible for U.S. exporters to get trade credit from U.S. banks and for Korean exporters to get trade credit from Korean banks. When only a handful of countries had well developed financial markets and banking systems, this would have been a problem. It would no longer be a problem today.

There may also be a destructive interplay between the politics of domestic economic liberalization and the politics of globalization. Insofar as a legacy of the crisis is an extended period of high unemployment, the voting public may grow disenchanted with liberalization. The end-August 2009 Japanese elections are consistent with this view. The voting public may grow disaffected with globalization since it has failed to deliver the goods.

Here it will be important for our leaders to make the case for free and open trade. They will have to draw a firm distinction between financial and other aspects of globalization. It will be important for them to distinguish between the need for tighter regulation of financial markets, where the justification is clear on the grounds of consumer protection, market integrity and systemic stability, on one hand, and tighter regulation of other markets, on the other, where the need is less evident and the response should be on a case-by-case basis.

These distinctions were not drawn in the 1930s, when there was a backlash against both trade and finance and when governments intervened equally in domestic and international markets. Experience after World War II is more reassuring. In the third quarter of the twentieth century, global trade expanded vigorously, despite the fact that international financial transactions remained heavily controlled. And notwithstanding enduring hostility to the deregulation of financial markets and liberalization of international financial flows, political consensus favoring trade liberalization was successfully maintained through successive General Agreement on Tariffs and Trade rounds over fully half a century. This experience offers at least cautious grounds for hoping that the same will again be possible. I for one am hopeful.

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Recessions and Financial Disruptions in Emerging Markets: A Bird's Eye View

Stijn Claessens
International Monetary Fund, University of Amsterdam, and Centre for Economic Policy Research

M. Ayhan Kose
International Monetary Fund

Marco E. Terrones
International Monetary Fund

The global financial crisis of 2008–09 led to massive interruptions in cross-border financial and trade flows. As a result of the crisis, virtually all of the advanced economies and many emerging market countries experienced recessions over the past two years. These recessions coincided with various forms of financial disruptions, such as severe contractions in the supply of credit and sharp declines in asset prices. Understanding the linkages between recessions and periods of financial disruptions has become a new challenge for macroeconomic research.

This paper provides a brief overview of the linkages between recessions and financial disruptions for a large group of emerging market economies. In particular, we explore the following questions. First, what are the main features of recessions and financial disruptions in emerging markets? Second, how synchronized are these events across emerging markets? Third, how does the coincidence between recessions and financial disruptions affect

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macroeconomic outcomes? For each of these questions, we contrast the experience of emerging market economies with that of a group of advanced countries. We also provide a brief case study analysis of recessions and financial disruptions in Chile and consider how the Chilean case compares to other emerging markets.

To address these questions, we construct a comprehensive dataset of key macroeconomic and financial variables covering 23 emerging market countries over the period 1978:1 to 2007:4. Using a standard business cycle dating algorithm, we first document turning points in our main variables of interest, including output, credit, and equity prices. We identify 84 recessions, 102 credit contractions, and 139 equity price declines for these countries over this period. When recessions, credit contractions, and equity price declines fall into the top quartiles of all recessions, contractions, and declines, we define them as severe recessions, credit crunches, and equity price busts. We also identify 20 recessions associated with episodes of financial crises in emerging markets.

Armed with this rich set of events, we conduct a number of exercises. First, we examine the main characteristics of these recessions and financial market disruptions—in terms of duration and severity—and the behavior of major macroeconomic and financial variables around these events. Next, we document the coincidence of recessions and credit crunches, equity price busts, and financial crises, and analyze the implications of recessions for key macroeconomic aggregates. We also examine how these features vary across regions, and we consider how episodes of recessions and financial disruptions in emerging markets are different from those in advanced economies.

In light of the facts we document for the broader set of emerging markets, we next explore the main features of recessions and financial disruptions in Chile. We focus on the Chilean case for a few reasons. First, the growth performance of the Chilean economy has been a major success story over the past three decades. Second, Chile's macroeconomic and financial sector policies were instrumental in moderating business and financial cycles in this period. Third, the relative success of Chile in managing the adverse effects of the recent global financial crisis makes it an interesting case study. We briefly review the three recession episodes Chile experienced prior to the recent crisis and examine the macroeconomic implications of disruptions in its credit and equity markets. We put our findings into context by providing a review of the related literature regarding business cycles in Chile.

Our study contributes to a large body of research on business cycles and growing research analyzing the interactions between macroeconomic and financial variables over the business cycle. While most empirical work focuses on advanced countries, there is a rich set of theoretical studies examining the implications of financial disruptions for the real economy in the context of emerging market countries. Krugman (1999) and Aghion, Bacchetta, and Banerjee (2001), for example, show how a combination of financial market imperfections and currency mismatches can translate into highly volatile business cycle fluctuations in emerging markets. Using the financial accelerator construct, Céspedes, Chang, and Velasco (2004) study how linkages between exchange rates and corporate balance sheets affect macroeconomic outcomes in small open economies.[1] Caballero and Krishnamurthy (1998) and Schneider and Tornell (2004) model how, also because of balance sheet constraints, fluctuations in credit and asset markets can translate into boom-bust cycles in emerging market economies.[2]

Several empirical studies provide evidence of these interactions in the context of advanced countries. For example, there is a large empirical literature for advanced countries analyzing the dynamics of business cycles, asset price fluctuations, and credit cycles (see Bernanke and Gertler, 1989; Borio, Furfine, and Lowe, 2001), including studies using microeconomic data (banks or corporations) (see Bernanke, Gertler, and Gilchrist, 1996; Kashyap and Stein, 2000). Recent research also considers how interactions between financial and real activity variables can vary during recessions in advanced countries. For example, Claessens, Kose, and Terrones (2009) report that recessions in advanced countries associated with episodes of sharp declines in credit or asset prices are typically longer and deeper than normal recessions. However, studies of interactions

1. In particular, Céspedes, Chang, and Velasco (2004) extend the model of Bernanke, Gertler, and Gilchrist (1999) and show that negative external shocks can have a magnified impact on output because of the balance sheet effects stemming from a (real) devaluation in emerging markets.

2. Recent research also considers how fluctuations in asset prices affect the value of collateral required for international funding. Mendoza (2010) shows that when borrowing levels are high relative to asset values, shocks to collateral constraints can generate an amplification mechanism, like Fisher's (1933) debt-deflation mechanism, and can result in a large impact on output.

between real and financial sectors during periods of downturns in emerging markets are rather limited.

We also contribute to a branch of the literature on business cycles that aims to identify the turning points in macroeconomic and financial variables using various methodologies. The classical methodology of dating business cycles, applied here as well, goes back to Burns and Mitchell (1946). It has been widely used over the years to study recessions in advanced countries. Only a few studies use this methodology to analyze the turning points of business cycles in emerging markets with quarterly data.[3] These studies focus mostly on the behavior of output or employ small samples of countries over relatively short time periods.

There is, of course, a large literature analyzing various aspects of business cycles in emerging economies using a variety of methods. For example, Kose (2002) and Neumeyer and Perri (2005) use stochastic dynamic models to consider the implications of various shocks for business cycles in emerging markets. Chang, Kaltani, and Loayza (2009) and Kose, Prasad, and Terrones (2006) analyze empirically the linkages between long-term growth and short-term business cycle volatility using panel regressions. Kose, Prasad, and Terrones (2003) examine the synchronization of cycles across emerging and advanced countries using various methods, including dynamic factor models. However, none of these papers consider the dynamics of financial cycles in emerging markets.

Importantly, the links between real and financial variables during recessions have yet to be analyzed using a comprehensive dataset of a large number of emerging market countries over a long period.[4] Most studies are limited to a small number of countries or present case studies of individual episodes. Others focus specifically on the behavior of real and financial variables surrounding financial crises, notably Reinhart and Rogoff (2009). Building on earlier work in the context of advanced economies (Claessens, Kose, and Terrones,

3. Calderón and Fuentes (2006) consider a sample of 14 emerging market economies over 1980–2005. Gupta and Miniane (2009) analyze recessions and recoveries using quarterly data on eight emerging countries for the 1980–2008 period. Du Plessis (2006) studies seven emerging economies using a data sample mostly covering the period 1980–2004. Using annual data, Hong, Lee, and Tang (2010) examine the links between macroeconomic fluctuations and financial crises in 21 Asian emerging and developing economies.

4. Claessens, Kose, and Terrones (forthcoming) provide a detailed analysis of business and financial cycles in advanced countries and emerging markets.

2009), this paper documents the basic stylized facts of recessions and financial market disruptions in emerging markets.

The paper is structured as follows. Section 1 presents our dataset and methodology. Section 2 examines the basic characteristics of recessions and episodes of credit contractions and equity price declines in emerging markets and compares these with the experiences of advanced countries. This section also studies the implications of recessions associated with credit crunches, equity price busts, and financial crises. In section 3, we provide a brief discussion of recessions and financial disruptions in Chile and compare the Chilean episodes with those in other emerging markets. Section 4 concludes.

1. Database and Methodology

We employ a comprehensive database covering 23 emerging market countries and 21 Organization for Economic Cooperation and Development (OECD) countries over the period 1978:1 to 2007:4. The emerging market countries in our sample are Argentina, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Hong Kong, India, Indonesia, Israel, Malaysia, Mexico, Peru, Philippines, Singapore, South Africa, South Korea, Taiwan, Thailand, Turkey, Uruguay, and Venezuela.[5] We compare the features of recessions and financial disruptions in emerging economies with those of advanced OECD countries. The advanced countries in our sample are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.[6]

The emerging and advanced countries in our sample account collectively for more than 90 percent of global output. However, there are significant differences between the two groups. For example, per capita income level is typically about one-third lower in emerging

5. The emerging markets roughly correspond to those included in the MSCI Emerging Markets Index. The main differences are that we drop some countries because of data limitations (Czech Republic, Egypt, Hungary, Jordan, Morocco, Pakistan, Poland, and Russia), while we include a number of other emerging markets (Costa Rica, Ecuador, Hong Kong, Singapore, and Venezuela). We provide detailed information about the database in Claessens, Kose, and Terrones (forthcoming).

6. In Claessens, Kose, and Terrones (forthcoming), we study business and financial cycles in advanced countries for the period 1960:1 to 2007:4.

markets than in the typical advanced country. In terms of overall economic size, total GDP (in U.S. dollars) is also lower for the typical emerging market. Relative to its size, however, the typical emerging market country in the sample trades more with the rest of the world than the typical advanced economy. Specifically, in 2005, the standard trade openness ratio (exports plus imports as a share of GDP) is close to 80 percent for the emerging market group, while it is about 50 percent for the advanced countries group. In terms of financial linkages with the rest of the world, the advanced economies are definitely more integrated with the global financial markets than emerging countries are.

1.1 Macroeconomic and Financial Variables

Our analysis focuses on recessions and financial market disruptions, which dictates our data choices. Although our main database contains a large number of macroeconomic aggregates, we provide statistics here for only a smaller set for the sake of brevity. The quarterly time series of macroeconomic variables are seasonally adjusted, whenever necessary, and in constant prices. These series are collected from various sources, including the International Monetary Fund's *International Financial Statistics* (IFS) and the OECD. The financial variables we consider are credit and equity prices. Credit series are obtained from IFS and defined as claims on the private sector by deposit money banks. These are also the series used in earlier cross-country studies on credit dynamics (for example, Mendoza and Terrones, 2008).[7] Equity price indexes are also from IFS and generally cover the main local stock exchanges. All financial variables are converted into real terms using their country's respective consumer price indexes (CPI).[8]

7. Many papers examine the behavior of aggregate credit measures during recessions or financial crises. Chari, Christiano, and Kehoe (2008) and Cohen-Cole and others (2008) highlight that it is important to go beyond aggregate measures (for example, differentiating credit to corporations from credit to households) to study the dynamics of credit markets especially in the context of the latest financial crisis in the United States. However, this is extremely difficult, if not impossible, to do in the context of our large cross-country coverage.

8. Another major financial variable is the house price, but house prices are available for only a small number of emerging market economies. Claessens, Kose, and Terrones (2009) provide an analysis of disruptions in housing markets using the data for advanced countries.

1.2 Identifying Turning Points

Before analyzing recessions and their interactions with periods of financial stress, it is necessary to determine the dates of these various events. The methodology we employ focuses on changes in the levels of variables to identify cycles. This is consistent with the guiding principles of the National Bureau of Economic Research (NBER), which is the unofficial arbiter of U.S. business cycles. This methodology assumes that a recession begins just after the economy reaches a peak and ends as the economy reaches a trough. The methodology determines the peaks and troughs of any given series by first searching for maxima and minima over a given period of time. It then selects pairs of adjacent, locally absolute maxima and minima that meet certain censoring rules requiring a certain minimal duration of cycles and phases.

In particular, we employ the algorithm introduced by Harding and Pagan (2002b), which extends the so called BB algorithm developed by Bry and Boschan (1971) to identify the cyclical turning points in the log-level of a series.[9] We search for maxima and minima over a given period of time and then select pairs of adjacent, local maxima and minima that meet certain censoring rules, that is, a certain minimal duration for cycles and phases. In particular, the algorithm requires the durations of a complete cycle and of each phase to be at least five quarters and two quarters, respectively. Specifically, a peak in a quarterly series y_t occurs at time t if

$$\left\{\left[(y_t - y_{t\text{-}2})>0,(y_t - y_{t\text{-}1})>0\right] \text{ and } \left[(y_{t+2} - y_t)<0,(y_{t+1} - y_t)<0\right]\right\}.$$

Similarly, a cyclical trough occurs at time t if

$$\left\{\left[(y_t - y_{t\text{-}2})<0,(y_t - y_{t\text{-}1})<0\right] \text{ and } \left[(y_{t+2} - y_t)>0,(y_{t+1} - y_t)>0\right]\right\}.$$

9. The algorithm we employ is known as the BBQ algorithm since it is applied to quarterly data. It is possible to use a different algorithm, such as a Markov switching (MS) model (Hamilton, 2003). Harding and Pagan (2002a) compare the MS and BBQ algorithms and conclude that the BBQ is preferable because the MS model depends on the validity of the underlying statistical framework. Artis, Kontolemis, and Osborn (1997) and Harding and Pagan (2002b) also use the BBQ methodology.

We then define a complete cycle from one peak to the next with two phases, the contraction phase (from peak to trough) and the expansion phase (from trough to peak). Our main macroeconomic variable is output (GDP), which provides the broadest measure of economic activity.

We use the same approach to identify the turning points in our financial series.[10] In terms of financial variables, we consider cycles in real credit and equity prices. We are especially interested in what happens when recessions and financial disruptions coincide. To investigate these coincidences, we apply a simple dating rule for whether or not a specific recession is associated with a credit crunch or an equity price bust. If a recession episode starts at the same time as or after the start of an ongoing credit crunch or equity price bust, then we consider the recession to be associated with the respective crunch or bust. By definition, this rule describes a timing association (or coincidence) between the two events, but does not imply a causal link.

The main characteristics of cyclical phases are their duration and amplitude. Since we are mainly interested in examining contractions (recessions in output and declines in financial variables), we study these characteristics for contractions only. The duration of a contraction, D^c, is the number of quarters, *k,* between a peak and the next trough. The amplitude of a contraction, A^c, measures the change in y_t from a peak (y_0) to the next trough (y_k), that is, $A^c = y_k - y_0$. For output, we consider another widely used measure, cumulative loss, which combines information on duration and amplitude to proxy for the overall cost of a contraction. The cumulative loss, F^c, during a contraction with duration k is defined as

$$F^c = \sum_{j=1}^{k} (y_j - y_0) - \frac{A^c}{2}.$$

We further classify recessions based on the extent of decline in output. In particular, we call recessions mild or severe if the peak-to-trough output drop falls within the bottom or top quartile, respectively, of all output drops in each group of countries we

10. In the case of equity prices, the constraint that the contraction phase must last at least two quarters is ignored if the quarterly decline exceeds 20 percent because equity prices can display much intraquarter variation leading to large differences between peaks and troughs.

study. Similarly, a credit crunch is defined as a peak-to-trough contraction in credit that falls within the top quartile of all credit contractions.[11] An equity price bust is defined as a peak-to-trough decline that falls within the worst quartile of all price declines. A severe credit crunch or equity price bust is defined as the top one-eighth of all credit contractions or equity price busts.

How successful is our algorithm in replicating the well-known turning points of U.S. business cycles as determined by the NBER? Our algorithm replicates the dates of the NBER very well. According to the NBER, the United States experienced seven recessions over the 1960–2007 period. Our algorithm provides exact matches for four of these seven peak and trough dates and is only a quarter early in dating the remaining peaks and troughs.[12] The main features of our business cycles are quite similar to those of the NBER, as well. For example, the average duration of U.S. business cycles based on our turning points is the same as that reported by the NBER. In addition, the average peak-to-trough decline in output during U.S. recessions is about 1.7 percent based on our dating and 1.4 percent based on NBER dating.

2. Exploring the Downside of Fluctuations

We start by measuring the frequency of recessions and their coincidence with financial disruptions. We then describe the basic features of recessions and their dynamics. Next, we take a look at the implications of credit contractions and equity price declines in financial markets. Finally, we explore the effects of recessions in emerging markets when they are accompanied by credit crunches, equity price busts, or financial crises.

11. To determine the credit crunch episodes, we use changes in the volume of (real) credit. In the literature, crunches are typically defined as excessive declines in the supply of credit that cannot be explained by cyclical changes in demand (see Bernanke and Lown, 1991). It is very difficult, however, to separate the roles played by demand and supply factors in the actual volume of credit extended. An alternative methodology to identify credit crunch episodes would be to consider price measures, that is, to track changes in interest rates over time, but data limitations do not allow us to employ such measures for our large sample of countries.

12. The differences between our turning points and those of the NBER are due to the fact that the NBER uses monthly data for various activity indicators (including industrial production, employment, personal income net of transfer payments, and volume of sales from the manufacturing and wholesale retail sectors), whereas we use only quarterly output series to identify cyclical turning points.

2.1 Frequency and Synchronization of Recessions and Financial Disruptions

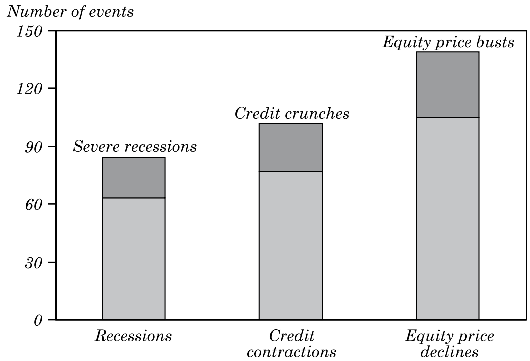
How many recessions and financial market disruptions did the emerging market and advanced economies experience over 1978–2007? In emerging market countries, we identify 84 output recessions (21 of which are severe), 102 credit contractions (25 crunches), and 139 declines in equity prices (34 busts) (see figure 1). For the sample of advanced countries, we identify 81 output recessions (20 of which are severe), 71 credit contractions (17 crunches), and 152 declines in equity prices (38 busts). Although the samples of events appear to be similar in terms of numbers, our data set for emerging markets often includes countries with shorter time series than those for advanced countries, which are typically for the full period.

In terms of recessions and financial market disruptions, the events we analyze display a considerable overlap: 14 and 25 recession episodes in emerging markets are associated with credit crunches and equity price busts, respectively. In other words, in about one out of six recessions, a credit crunch was also underway, and in about one in three recessions, an equity price bust was occurring. In terms of financial crises, of the 84 recessions, 20 are associated with crises dated by Laeven and Valencia (2008). Of these 20, five were also credit crunches and ten were equity price busts, and of these, four were both credit crunches and equity price busts.

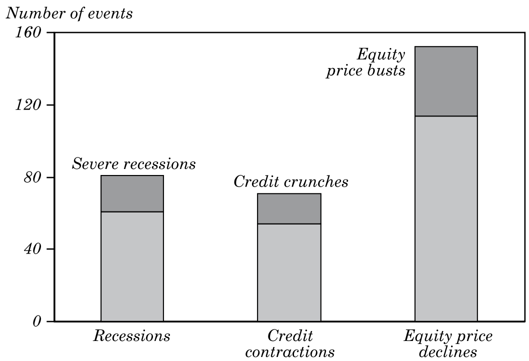
We next examine the synchronization of recessions, credit contractions, and equity price declines across countries. Our synchronization measure is simply the fraction of countries experiencing the same event at about the same time. For recessions, panel A in figure 2 shows the fraction over the period 1978:1 to 2007:4. Recessions in emerging markets do occur in bunches. The first synchronized recession episode is related to the debt crisis of the 1980s, with the frequency of recessions increasing first in 1982 and then again in the mid-1980s. Following this period, recessions are less common across emerging market countries until the Asian crisis of 1998–99, when a relatively larger fraction of countries (about 40 percent) suffered recessions. Another increase of recessions in emerging markets coincides with the 2001 U.S. recession.

Figure 1. Number of Recessions and Financial Disruptions[a]

A. Emerging markets



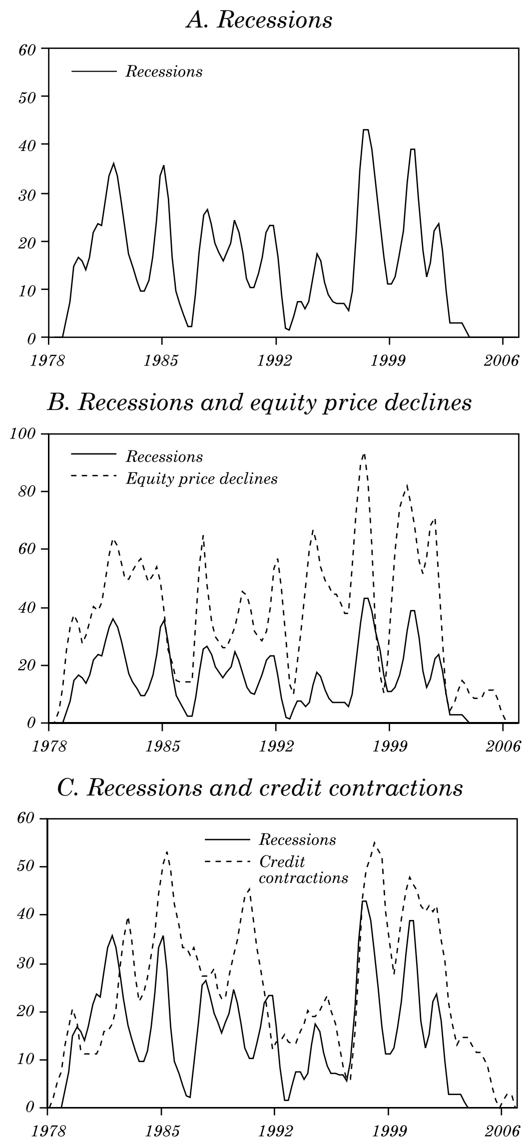
B. Advanced countries



Source: Authors' calculations.

a. Each bar refers to the total number of the respective events. Severe recessions are those in which the peak-to-trough decline in output is in the top 25 percent of all recession-related output declines in the respective group. Credit crunches and asset price busts correspond to peak-to-trough declines in credit and asset prices that are in the top 25 percent of all episodes of credit contractions and asset price declines, respectively.

Figure 2. Synchronization of Recessions and Financial Disruptions[a]



Source: Authors' calculations.

a. Each line represents the share of emerging market countries experiencing recessions, credit contractions, or equity price declines.

We also consider the coincidence of contraction episodes in financial markets and their overlap with recessions (figure 2, panels B and C). Equity prices exhibit the highest degree of synchronization, reflecting the extensive integration of stock markets around the world. More than half of the emerging markets experienced a sustained decline in equity prices during the highly synchronized episodes of equity market turbulence. Credit contractions are somewhat less synchronized across countries, but still there are eight years in which more than 40 percent of countries experienced credit contractions.

In emerging market economies, recessions tend to coincide most closely with contractions in domestic credit and somewhat less with declines in equity prices. This is evident in the fact that the fractions of countries experiencing recessions is more highly correlated with the fractions suffering credit contractions than with those suffering bear equity markets. While credit contractions are particularly closely associated with recessions, we cannot infer causality here—nor for any other relationship we depicted: credit could be declining because of the recession or a decline in credit could be leading to the recession episode.

These findings echo the results reported by Claessens, Kose, and Terrones (2009) in the context of advanced countries. In that paper, we document that recessions in advanced countries are also highly synchronized events. They are bunched in four periods over the past 40 years—namely, the mid-1970s, the early 1980s, the early 1990s, and the early 2000s—and often coincide with global shocks. Importantly, these findings suggest that globally synchronized recessions are longer and deeper than other recessions. Advanced countries also go through simultaneous episodes of credit contractions and declines in equity prices. Recessions tend to coincide with contractions in domestic credit and declines in equity prices in most advanced countries. Credit contractions, in particular, are closely associated with recessions. Equity prices exhibit the highest degree of synchronization, reflecting the extensive integration of equity markets across advanced economies.

2.2 Basic Features of Recessions

Recessions can be characterized according to their intensity, duration, cost, and severity. This section addresses each of these features in turn.

2.2.1 Intensity of recessions

Table 1 presents the main characteristics of the recessions in our sample of emerging markets and advanced countries. Since we are interested in the experience of the typical country, we most often focus on medians, as they are less affected by the presence of outliers. However, we also report the averages and standard deviations measuring the dispersion in our sample. A typical emerging market country experienced about four recessions. There is no apparent pattern to the number of recessions across countries, although some regions do stand out. For example, the Asian emerging markets experienced just two recessions, on average, whereas the emerging economies in Latin America witnessed close to five episodes. The median number of recessions in a typical advanced economy is three, but the average is close to four. Since the length of available data series differs slightly across the emerging countries in our sample, it is difficult to compare the absolute number of recessions across country groups and regions.

A better metric for analyzing the incidence of recessions is the proportion of time a country has been in a recession, simply defined as the fraction of quarters the economy is in a recession over the full sample period. According to this metric, the typical emerging market went through a period of contraction for less than 20 percent of the sample duration. Since this metric adjusts for the length of data series, we can compare groups by region and level of development. The fraction of time spent in recession is typically 50 percent longer for Latin American emerging economies than for Asian emerging markets. In the case of advanced countries, the intensity measure is around 13 percent, on average, which is much less than that of emerging markets.

2.2.2 Duration of recessions

There is no noticeable difference across emerging and advanced countries in terms of the average duration of recessions. In emerging markets, an average recession lasts about four quarters (3.92), while in advanced countries, the average recession lasts slightly less (3.73 quarters). In emerging markets, the shortest recession is (by definition) two quarters and the longest 13 quarters (in South Africa over the period 1989:3–1992:4). Roughly 35 percent of all recessions are short-lived, meaning only two quarters of output decline. The average duration of recessions does not differ much between emerging markets in Asia and Latin America.

Table 1. Basic Features of Recessions[a]

Country group	*Number of recessions*	*Duration*	*Proportion of time in recession*	*Amplitude*	*Slope*	*Cumulative loss*
Emerging market countries						
Total						
Median	4.00	3.00	0.19	−4.81	−1.24	−8.93
Mean	4.00	3.92	0.19	−6.54	−1.69	−17.08
Std. deviation	2.18	2.10	0.08	6.46	1.60	27.88
Asia						
Median	2.00	3.00	0.12	−2.73	−1.12	−4.22
Mean	2.88	3.65	0.12	−5.27	−1.33	−13.85
Std. deviation	1.54	2.01	0.05	5.37	1.02	21.35
Latin America						
Median	4.50	3.00	0.25	−5.41	−1.59	−9.26
Mean	4.80	3.79	0.23	−7.13	−1.89	−16.37
Std. deviation	2.48	1.77	0.08	6.90	1.78	21.73
Other						
Median	5.00	5.00	0.21	−4.88	−1.07	−11.17
Mean	4.33	4.85	0.20	−6.57	−1.60	−25.42
Std. deviation	0.94	3.08	0.03	6.68	1.71	50.92
Advanced countries						
Median	3.00	3.00	0.13	−1.72	−0.43	−2.74
Mean	3.86	3.73	0.13	−2.22	−0.60	−6.12
Std. deviation	1.52	2.09	0.04	2.23	0.62	12.59

Source: Authors' calculations.

a. Duration is the number of quarters between a peak and the next trough of a recession. Proportion of time in recession refers to the ratio of the number of quarters in which the economy is in recession over the full cycle period. Amplitude is the percent change in output from a peak to the next trough of a recession. Slope is the ratio of amplitude to duration. Cumulative loss combines information about the duration and amplitude to measure the overall cost of a recession and is expressed in percent.

2.2.3 Cost and violence of recessions

The median (average) decline in output from peak to trough, or the recession's amplitude, is about 4.8 percent (6.5 percent) in emerging markets. It ranges from about 1.7 percent for the typical recession in Costa Rica to more than 10 percent for recessions in Peru, Thailand, and Venezuela. The typical recession in Asian emerging markets is two times less costly than that in Latin American countries. However, the amplitude of a typical emerging country recession is about three times larger than that of an advanced country.

The slope (violence) of a recession, defined as the ratio of its amplitude to duration, is typically also much larger in emerging economies than advanced countries, at –1.2 versus –0.4. This suggests that recessions in emerging market countries are more violent macroeconomic events. Consistent with the findings for amplitudes, recessions in Asian emerging markets tend to be less violent than those in Latin America.

Recessions in emerging market countries lead to much larger cumulative losses than those in advanced economies. In particular, a typical recession is associated with more than three times larger cumulative loss in an emerging market country than it is for an advanced economy (9 percent versus 3 percent). While the cumulative loss for a typical (median) recession is about 9 percent in emerging markets, the average loss is about 17 percent, showing that the distribution is very skewed to the right. The cumulative loss of a recession in Latin American emerging markets is two times larger than that in emerging Asia.

These findings are consistent with the widely documented result that macroeconomic fluctuations in emerging markets are typically more pronounced than those in advanced economies (Kose, Prasad, and Terrones, 2006 and 2009). More importantly, they indicate that the downside of macroeconomic fluctuations in emerging market economies tends to be much sharper than those in advanced countries. While recessions in emerging markets are typically not much more frequent and not longer than those in advanced countries, when recessions occur in emerging markets, they tend to worsen at a more rapid pace and become deeper than those in advanced countries. This is, in part, due to many recessions in emerging markets being accompanied by financial market disruptions.

2.2.4 Severity of recessions

A recession is classified as severe when the peak-to-trough decline in output is in the top one-quarter, or greater than 8.4 percent. We present the main features of such episodes in table 2. While a number of emerging market countries did not experience severe recessions in the sample period, Argentina went through four such episodes, and Venezuela, Peru, and Turkey experienced two of them. The 21 such recessions in our sample typically lasted for five quarters, a quarter longer than the average recession. By construction, severe recessions are much more costly than other recessions, with a median decline of about 13 percent and a cumulative loss of about 27 percent, the latter over three times more costly than that of other recessions. These recessions are also more virulent, with a slope coefficient three times greater than that of other recessions. Tables 1 and 2 together suggest that, compared with advanced countries, the typical recession in emerging economies is equivalent to a severe recession in advanced countries in terms of its amplitude and cumulative loss.

A further illustration of the distribution of recessions is provided in figure 3. Most recessions in emerging markets lasted four quarters or less, and the overwhelming majority of these were mild to moderate in depth. Specifically, roughly 30 percent of all recessions lasted two quarters, 40 percent lasted three-four quarters, and 30 percent lasted five quarters or more. This figure also shows that the shorter recessions tended to be milder. Of the severe recessions, however, most lasted more than five quarters. To examine the changes in these features over time, we split our sample into two subperiods: 1978–92 and 1993–2007. Comparing the two subperiods shows that, unlike the well-documented pattern of the Great Moderation of cycles in advanced countries up until the latest crisis, the depth and duration of recessions in emerging markets have not moderated over time.

2.3 Dynamics of Recessions

The dynamics of adjustment around recessions in emerging markets differ substantially from those in advanced countries. Figure 4 presents a comparison of the typical behavior of some macroeconomic and financial variables during recessions in emerging markets and advanced countries. The typical decline in the year-over-year growth rate of output in emerging markets from the peak to the trough of

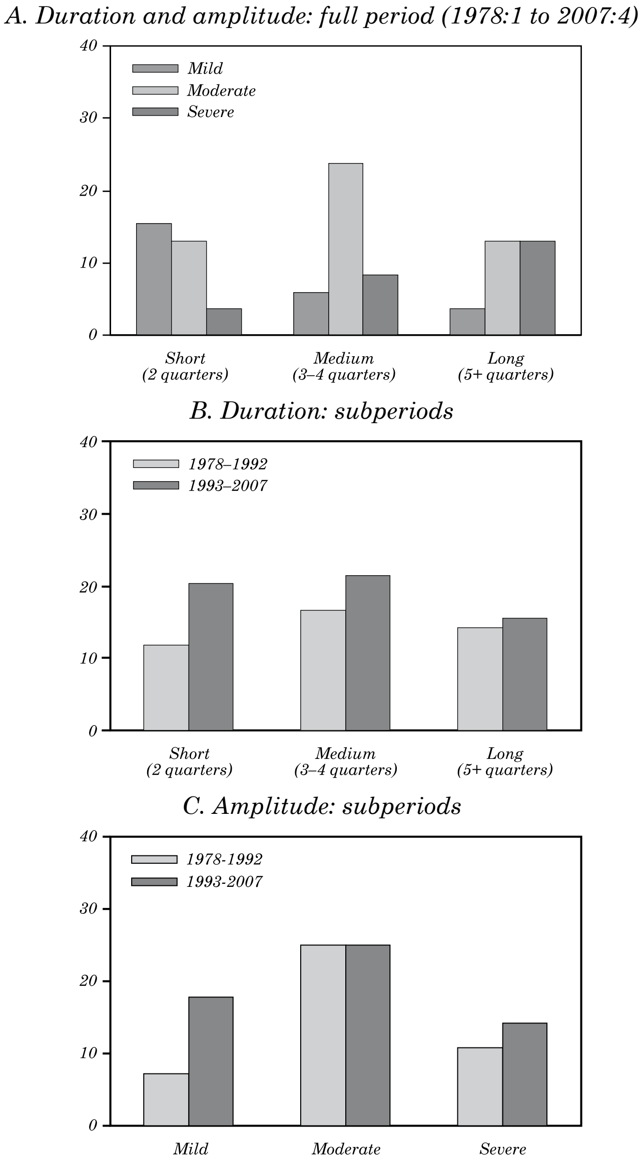
Table 2. Basic Features of Severe Recessions[a]

Country group	*Number of severe recessions*	*Duration*	*Amplitude*	*Slope*	*Cumulative loss*
Emerging market countries					
Total					
Median	1.00	5.00	–12.73	–3.70	–27.16
Mean	1.40	4.86	–15.64	–3.67	–46.67
Std. deviation	0.83	2.13	6.43	1.97	42.81
Asia					
Median	1.00	5.00	–13.14	–2.43	–38.24
Mean	1.00	5.50	–13.16	–2.63	–41.60
Std. deviation	0.00	2.51	4.07	0.89	26.62
Latin America					
Median	1.00	4.50	–13.93	–3.76	–30.57
Mean	1.71	4.67	–16.79	–4.07	–41.91
Std. deviation	1.11	1.97	6.98	2.26	29.54
Other					
Median	1.50	4.00	–12.73	–3.70	–25.32
Mean	1.50	4.33	–15.98	–4.13	–75.85
Std. deviation	0.71	2.52	8.78	2.05	101.31
Advanced countries					
Median	1.50	5.00	–4.54	–0.74	–11.07
Mean	2.00	5.45	–5.19	–1.22	–17.65
Std. deviation	1.41	3.03	2.61	0.96	21.65

Source: Authors' calculations.

a. Severe recessions are those in which the peak-to-trough decline in output is in the top 25 percent of all recession-related output declines. Duration is the number of quarters between a peak and the next trough of a recession. Amplitude is the percent change in output from a peak to the next trough of a recession. Slope is the ratio of amplitude to duration. Cumulative loss combines information about the duration and amplitude to measure the overall cost of a recession and is expressed in percent.

Figure 3. Recessions in Emerging Markets: Duration and Amplitude[a]

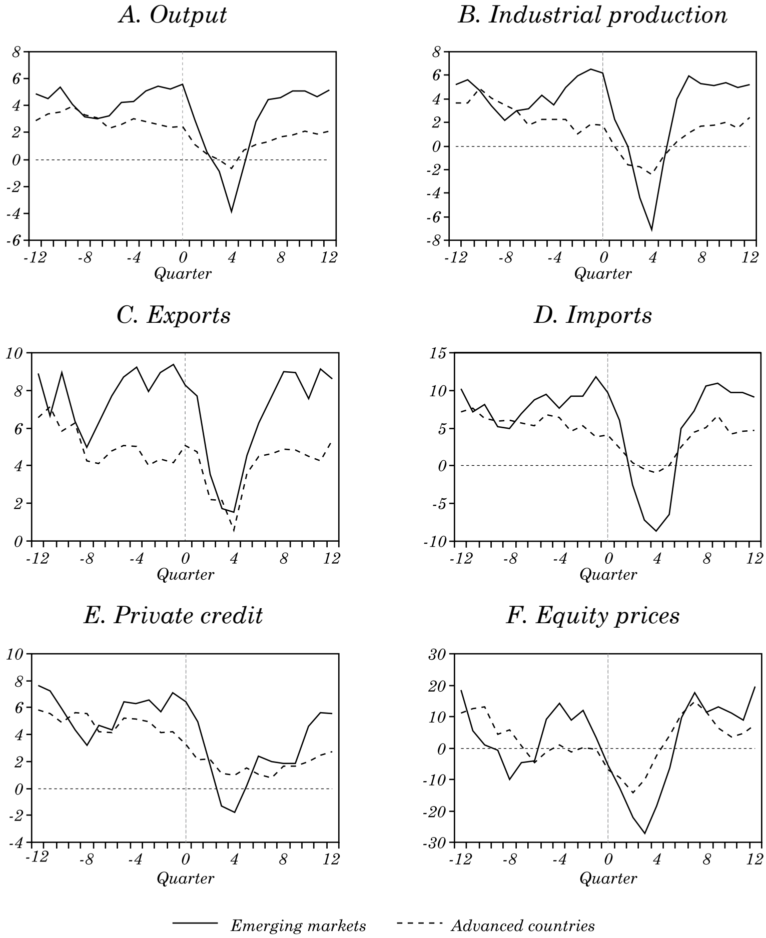


Source: Authors' calculations.

a. Each bar represents the share of total recessions in a particular category. Duration is the number of quarters from peak to trough in a recession. Amplitude is the percent change in output from peak to trough in a recession.

a recession is three times larger than in advanced countries (10 percentage points versus 3 percentage points). Industrial production also displays a much sharper decline in emerging markets relative to advanced countries.

Figure 4. Recession Dynamics: Emerging Markets and Advanced Countries[a]
Annual percent change



Source: Authors' calculations.
a. The solid line denotes the median of all observations for emerging market countries, while the dashed line corresponds to the median of all observations for advanced countries. Zero is the quarter after which the recssion begins (the peak in the level of output).

There are also some differences in the behavior of trade and financial variables. In emerging markets, the growth rate of exports slows down sharply, but still stays above that of advanced countries after the beginning of recessions. In contrast, the import sector goes through a much sharper adjustment in emerging markets than in advanced countries, and it actually registers several quarters of negative growth. Credit slows down in advanced countries during recessions, but it contracts in emerging markets. Finally, equity prices tend to exhibit a much sharper decline in emerging markets than in advanced countries during recessions. Almost all macroeconomic and financial variables thus exhibit much sharper adjustments during recessions in emerging markets than in advanced countries.

2.4 Downside of Fluctuations in Financial Markets

Next, we provide summary statistics about the episodes of credit contractions and equity price declines in emerging markets (table 3). In terms of duration, episodes of credit contractions last longer than recessions, slightly less than seven quarters. Equity price declines are slightly shorter, but they are also longer than the typical recession, with a median duration of six quarters. As we noted above, a credit crunch (equity price bust) is defined as a peak-to-trough contraction (decline) in credit (equity) that falls within the top quartile of all credit contractions (equity price declines). In terms of amplitude, a typical credit crunch is associated with a decline in credit of almost 50 percent, while a credit contraction episode leads to about a 12 percent decline. An episode of equity price decline (bust) tends to result in a fall of 37 percent (70 percent) in equity prices. Credit crunches and equity price busts not only have greater amplitudes—by definition—but they also last longer than other credit contractions and equity price declines do, eleven versus five quarters and nine versus five quarters, respectively.

Although the duration of credit crunches in advanced countries is longer than that in emerging countries, crunches in advanced countries are much less intense than those in emerging markets. The periods of equity busts in advanced countries last as long as those in emerging markets, but they lead to smaller declines in equity valuations. Consistent with the highly volatile nature of credit and equity markets in emerging economies, the slopes of credit contractions and equity price declines in these countries are much larger than those in advanced countries.

Table 3. Credit Contractions and Equity Price Declines[a]
Percent change (unless otherwise indicated)

Country group and event	*Duration (mean)*	*Amplitude (median)*	*Slope (median)*	*Output (median)*
Emerging market countries				
Credit contraction	6.48	–11.62	–1.86	1.93
Credit crunch	11.32 ***	–49.98 ***	–5.55 ***	–0.62 *
Other credit contraction	4.91	–7.29	–1.51	2.94
Equity price decline	5.93	–36.63	–6.29	3.47
Equity price bust	9.44 ***	–68.79 ***	–9.03 ***	1.91
Other equity price decline	4.79	–30.15	6.03	3.48
Advanced countries				
Credit contraction	6.03	–3.64	–0.85	1.42
Credit crunch	12.29 ***	–13.06 ***	–1.39 ***	4.18 ***
Other credit contraction	4.06	–2.74	–0.64	1.13
Equity price decline	5.38	–22.54	–4.55	2.71
Equity price bust	8.68 ***	–45.81 ***	–5.6 ***	2.89
Other equity price decline	4.27	–17.96	–3.85	2.47

Source: Authors' calculations.
* The difference between means (medians) of crunches/busts and other contractions/declines is statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.
a. Duration is the number of quarters between a peak and the next trough of a credit contraction, or an equity price decline. Amplitude is the percent change in credit from a peak to the next trough of a credit contraction, or an equity price decline. Slope is the ratio of amplitude to duration. Credit crunches and equity price busts correspond to peak-to-trough declines in credit and equity prices that are in the top 25 percent of all episodes of credit contractions and equity price declines, respectively within the respective group. In each cell, the mean (median) change in the respective variable from peak to trough of the episodes of credit declines/crunches, and equity price declines/busts is reported, unless otherwise indicated.

Episodes of credit contractions and equity price declines are typically not associated with a drop in output. However, they do coincide with a significant decline in activity when they take the form of a credit crunch. For example, output typically falls around 0.6 percent over the period of a crunch episode in emerging markets, while even during equity busts output registers positive growth. Compared to emerging markets, financial market disruptions in advanced countries are associated with less adverse outcomes in the real economy.

2.5 Recessions and Financial Disruptions

What are the implications of recessions in emerging markets when they are accompanied by (severe) credit crunches, equity price busts, or financial crises? We now answer this question with a set of summary statistics reported in table 4. When recessions are accompanied with disruptions in financial markets, they tend to be longer and deeper. To provide a sense of their distribution, we examine separately the features of recessions coinciding with severe episodes, that is, the top 12.5 percent of all financial market disruptions. We also provide the summary statistics for these types of events in advanced countries to allow for comparisons.

Output declines significantly more in recessions associated with a credit crunch than in other recessions, 8.5 percent versus 4.7 percent. The cumulative output loss in recessions associated with (severe) crunches is often larger than in recessions without crunches. There are a number of statistically significant differences between recessions coinciding with equity price busts and those without. While differences are not noticeable in duration, they are in some other aspects of recessions. In particular, declines in output (and corresponding cumulative losses) are typically much greater in recessions with busts, 6.8 (13.6) percent versus 3.3 (4.6) percent without busts.

With respect to their duration, recessions with financial crises are generally as long as those associated with credit crunches and equity price busts. In terms of their amplitude, recessions associated with credit crunches appear to be more costly than recessions with equity price busts, while recessions associated with financial crises are about as costly. If we use the cumulative loss measure as the relevant metric, then recessions associated with equity busts are slightly more costly than those associated with credit crunches (13.6

Table 4. Recessions Associated with Financial Disruptions[a]
Percent change (unless otherwise indicated)

Event	*Duration (mean)*	*Amplitude (median)*	*Cumulative loss (median)*
A. Recession	3.92	−4.81	−8.93
Severe recession	4.86 **	−12.73 ***	−27.16 ***
Other recession	3.60	−3.11	−4.34
B. Recession without credit crunch	4.03	−4.67	−8.78
Recession with credit crunch	3.64	−8.48 *	−11.12
Recession with severe credit crunch	3.57	−11.15 **	−15.99
C. Recession without equity price bust	3.62	−3.25	−4.62
Recession with equity price bust	4.04	−6.82 *	−13.56 *
Recession with severe equity price bust	4.58	−10.27 ***	−23.51 ***
D. Recession without financial crisis	3.86	−4.33	−7.03
Recession with financial crisis	4.10	−8.27 ***	−16.55 ***
Recession with severe financial crisis	4.60	−12.51 ***	−30.12 ***

Source: Authors' calculations.
* The difference between means (medians) of recessions with and without a bust or crunch is statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.
a. Duration is the number of quarters between a peak and the next trough of a recession. Amplitude is the percent change in output from a peak to the next trough of a recession. Cumulative loss combines information about the duration and amplitude to measure the overall cost of a recession and is expressed in percent. Severe credit crunches and equity price busts are in the top half of all crunch and bust episodes. Each cell reports the mean (median) change in the respective variable from peak to trough of recessions.

percent versus 11.1 percent). The cumulative losses stemming from the recessions associated with crises are typically larger than those in recessions accompanied with either credit crunches or equity price busts. These differences are even starker for the recessions associated with severe credit crunches or equity price busts and for the severe recessions accompanied by financial crises.

Recessions associated with equity price busts are much more costly events than those without equity busts for the sample of emerging markets. This is unlike the results for advanced countries. For example, Claessens, Kose, and Terrones (2009) report that although recessions associated with equity price busts tend to be longer and deeper than those without equity busts in advanced countries, many of these differences are not statistically significant. This might reflect the fact that the link between equity price busts and developments in the real economy in advanced countries are weaker compared to that of credit crunches. In emerging market economies, gyrations in equity markets are often associated with large swings in the direction and volume of capital flows, which suggests that recessions associated with equity price busts probably coincide with severe disruptions in the real economy as well as the balance of payments.

3. Recessions and Financial Disruptions: The Case of Chile

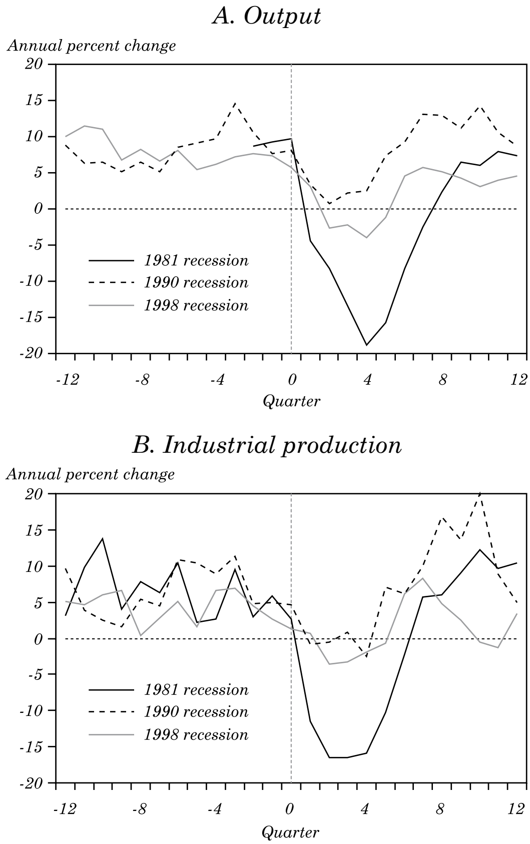
In light of the lessons from our broader analysis of the episodes of recessions and financial disruptions in emerging markets, we now turn our attention to the Chilean case. The broad overview of these episodes generally paints a grim picture about their adverse impact on the dynamics of growth and stability in emerging economies, especially when contrasted with the experiences of advanced countries. Some emerging markets have been quite successful, however, in either largely avoiding recessions and financial disruptions or managing their harmful effects when they nevertheless occur. These countries have been able to deliver persistently high growth while maintaining a stable economic environment. Chile occupies a special place among this elite group of emerging markets, but it has experienced its own recessions and financial market disruptions, as well. How do the episodes in Chile compare with those in other emerging markets?

We first present our findings with respect to the main properties of Chilean recessions. We then discuss how the dynamics of recessions in Chile compare with those in other emerging market economies. We conclude the section with a brief summary of the episodes of credit contractions and equity market declines in Chile.

3.1 A Brief Review of the Chilean Recessions

Using quarterly data, we identify three recessions over the period from 1980:1 to 2007:4 in Chile: 1981:3 to 1982:4, 1990:1 to 1990:3, and 1998:2 to 1999:1 (table 5 and figure 5). The longest and

Figure 5. Recessions in Chile: Output and Industrial Production[a]



Source: Authors' calculations.

a. Zero is the quarter after which a recession begins (the peak in the level of output).

Table 5. Recessions in Chile[a]
Percent change (unless otherwise indicated)

	Peak to trough			Chile		Emerging markets	
Indicator	*1981:3–1982:4*	*1990:1–1990:3*	*1998:2–1999:1*	*Mean*	*Median*	*Mean*	*Median*
A. Output							
Duration	5.00	2.00	3.00	3.33	3.00	3.92	3.00
Amplitude	−20.22	−2.46	−4.59	−9.09	−4.59	−6.54	−4.81
Slope	−4.04	−1.23	−1.53	−2.27	−1.53	−1.69	−1.24
Cumulative loss	−66.14	−2.66	−7.02	−25.27	−7.02	−17.08	−8.93
B. Components of output							
Consumption			−6.23	−6.23	−6.23	−2.80	−2.78
Investment		−3.61	−25.87	−14.74	−14.74	−17.09	−13.13
Exports		−11.90	−12.61	−12.25	−12.25	−0.29	0.76
Imports		7.48	2.40	4.94	4.94	−11.91	−10.18
Net exports (percent of GDP)		4.64	4.98	4.81	4.81	3.87	1.63
C. Other macroeconomic variables							
Industrial production	−16.87	−2.58	−3.33	−7.60	−3.33	−6.94	−8.21
Unemployment rate		0.24	2.94	1.59	1.59	1.53	1.06
Inflation rate	0.62	2.90	−1.49	0.68	0.62	1.04	0.62
D. Financial variables							
Equity prices	−24.50	−8.75	−16.20	−16.48	−16.20	−11.08	−17.45
Credit	15.87	−5.40	0.17	3.55	0.17	−4.10	−1.93

Source: Authors' calculations.
a. Duration is the number of quarters between a peak and the next trough of a recession. Amplitude is the percent change in output from a peak to the next trough of a recession. Slope is the ratio of amplitude to duration. Cumulative loss combines information about the duration and amplitude to measure the overall cost of a recession and is expressed in percent. Empty cells indicate that the corresponding observations are not available due to the lack of data.

deepest recession in Chile took place in the early 1980s and resulted in a significant decline in output over five quarters. The recession in the early 1990s was the shortest and mildest one, with decline in output of about 2.5 percent over two quarters. The recession in the late 1990s lasted three quarters and led to an output decline of roughly 4.6 percent.

The number and the dates of the Chilean recessions we document are mostly consistent with those in other studies using quarterly data. For example, Calderón and Fuentes (2006) also report that the Chilean economy witnessed three recessions over their sample of 1980–2005. Our findings with respect to the dates of recessions are also similar to some of the turning points identified in Mejía-Reyes (1999, 2004).[13]

Although the use of annual data can allow one to study the evolution of Chilean recessions over a longer period, this is not advisable for at least a couple of reasons. First, by construction, the use of annual data makes it impossible to identify recessions that are shorter than four quarters, unless these recessions are characterized by large enough quarterly declines in output that in turn lead to an outright contraction in annual series. In the case of Chile, for example, it is not possible to detect the early 1990s recession in annual data. In our broader sample of emerging markets, the number of recessions falls to 67 (from 84) if we simply define recessions as contractions in yearly output. Second, the use of annual data can distort the dating of recessions, even if the annual growth rate is negative in a particular year.[14]

Even with quarterly data, differences can arise because of varying data sources and frequency of data. Our main data source for the quarterly series of the Chilean macroeconomic and financial variables is the IMF's IFS. We compare our cyclical turning points with those computed using data series from other sources, such as the Global Data Source and the Central Bank of Chile. We conclude that our findings are robust to the use of these alternative data sources. We

13. The former study uses annual data and documents three recessions (1953–56, 1971–76, and 1981–83) over the period 1950–95. The latter study considers the turning points in the monthly industrial (or manufacturing) production index between 1960 and 2001 and identifies four recession episodes: 1971.9 to 1975.8, 1980.12 to 1982.10, 1984.6 to 1985.5, and 1989.12 to 1990.5.

14. For instance, the third recession in Chile begins in 1998:2 and ends in 1999:1. Since the growth rate of output is positive in 1998 and negative in 1999 in annual series, the date of the recession is incorrectly identified as 1999 using the annual data.

also check whether there is contraction not only in GDP, but also in other main indicators of activity, including industrial production, consumption, and investment, during the recessionary periods we identified. All of these variables also register negative growth rates during the recessions we determined, indicating that the dates we identify are true recessions reflecting significant decline in activity spread across multiple segments of the Chilean economy.[15]

Recessions can be driven by a number of factors. Moreover, it can be hard to identify conclusively the most important causes for specific recession episodes, as the voluminous literature on the sources of business cycles has made clear. This observation also applies to the recessions experienced by Chile. Nevertheless, a review of the individual recession episodes along with the related literature can help clarify what factors may have been at play during these events.

The first Chilean recession we identify (1981:3–1982:4) coincided with the 1982 global recession, in which the world per capita GDP fell by around 1 percent (see Kose, Loungani, and Terrones, 2009). The recession in Chile resulted in a significant decline in both output (20 percent) and industrial production (17 percent). This episode was also accompanied by an equity price bust and a disruption in credit markets. Although credit did expand over the course of the recession, it began contracting in 1982:2, as a major financial crisis occurred during that year.

Reflecting the simultaneously ongoing global recession, decline in demand was an important factor during the 1981–82 recession. This meant a significant fall in demand for Chile's exports, given that the economy is dependent on commodity exports.[16] There were other external factors, as well: the tight monetary policies in several advanced economies, the rapid increase in oil prices, and the debt crisis experienced by a number of Latin American countries

15. Some other studies examine the stylized facts of the Chilean business cycles using filtered time series. For example, Belaisch and Soto (1998) study the characteristics of business cycles in Chile for 1986–97 using the HP-filtered data. They report that the average business cycle in Chile lasts three years, half of it in the recession phase, and the other half in the expansion phase. Their findings indicate that the amplitude of the cycle is about 3 percent. Given the time-varying nature of the trends computed by the HP filter, it is hard to contrast their findings with those coming from the studies employing the classical methodology, such as ours.

16. Copper exports constitute a significant source of revenue for the Chilean economy. Spilimbergo (1999) and Caballero (2001) find a strong association between the price of copper and business cycles in Chile, while De Gregorio (2009) claims that Chile does not share the curse of rich natural resources that often stunts the long-term economic growth in commodity-dependent countries.

reduced the supply of external financing. Indeed, net private capital inflows to Chile registered a decline during this period (see IMF, 1983). Franken, Le Fort, and Parrado (2005) consequently argue that the recession resulted from a sudden stop in capital inflows coinciding with a deterioration of the terms of trade, a jump in the world interest rates, and the sharp adjustment in the real exchange rate.

As documented in the literature, there were also various Chile-specific factors associated with this episode. First, in addition to the problems in international capital markets, the Chilean financial system was under stress as banks had taken excessive risk, leading to a deterioration of their loan portfolios and eventually resulting in a full-blown banking crisis (see Larraín, 1989; Barandiaran and Hernández, 1999). Second, as Edwards (1983) notes, the fixed exchange rate regime combined with the rigid wage rate policy precluded any downward adjustment in real wages.[17]

The 1990:1–1990:3 recession also coincided with a worldwide slowdown in activity, ahead of the 1991 global recession. The global recession reflected problems in various parts of the world: difficulties in the U.S. saving and loan industry, banking crises in several Scandinavian economies, an exchange rate crisis in a large number of European countries, the challenges faced by East European transition economies, and the uncertainty stemming from the Gulf War and the subsequent increase in the oil price. In Chile, the recession meant declines in investment, exports, and industrial production and a slight increase in the unemployment rate. The Chilean financial markets went through a rough period as credit fell by 5 percent and the equity market declined by 9 percent.[18]

After the brief recession of the early 1990s, Chile registered strong economic growth until 1998. In fact, growth averaged around 7 percent per year and per capita income doubled over the period

17. For an extensive discussion of the developments prior to this episode and the associated banking crisis, see IMF (1982), Edwards (1983), Barandiaran and Hernández (1999), and Franken, Le Fort, and Parrado (2005). Franken, Le Fort, and Parrado (2005) argue that the rapid increase in bank credit in the late 1970s and the early 1980s resulted in a severe deterioration of the quality of the loan portfolio and increased exposure to exchange rate movements. In a related paper, Barajas, Luna, and Restrepo (2007) investigate macroeconomic fluctuations and bank behavior in Chile between 1989 and 2006.

18. As De Gregorio (2009) notes, there was political uncertainty in the early 1990s, as it was a period of transition to democracy after the 1989 elections following 16 years of military regime.

1985–98.[19] The recession of 1998:2 to 1999:1 marked the end of Chile's "golden period" of growth, however (see De Gregorio, 2004). The main driving forces behind the 1998–99 recession were external developments, notably the Asian crisis in 1997 and the Russian crisis in 1998. The accompanying decline in copper prices led to a significant deterioration of Chile's terms of trade and a substantial decline in exports. The recession resulted in a GDP contraction of 4.6 percent, along with sharp reductions in consumption and investment. Industrial production contracted, and the unemployment rate increased. The equity market registered a substantial decline. Credit growth was muted over the course of the recession, in part because of an increase in the policy rates to stem the depreciation of the currency.[20]

The brief review we present here thus consistently emphasizes the importance of external, and to a lesser degree domestic, factors in explaining the recessions in Chile. This confirms the findings of some earlier studies employing different methodologies to study the determinants of macroeconomic fluctuations for Chile. Franken, Le Fort, and Parrado (2005), for example, use a vector autoregression model over the 1950–2003 period to examine how Chilean business cycles respond to various shocks. They report that external shocks constitute the main source of business cycle fluctuations in Chile. In a related paper, Medina and Soto (2007) analyze the sources of business cycle fluctuations in Chile for the period 1987–2005 using a dynamic stochastic general equilibrium model. They conclude that both foreign and domestic supply shocks play important roles in accounting for output fluctuations, whereas domestic demand shocks and terms-of-trade shocks tend to have relatively minor effects.

We conclude this subsection with a brief look at how the Chilean recessions compare with those in other emerging market economies. In terms of the number of episodes, Chile witnessed only three

19. For a detailed analysis of the "golden period" of growth in Chile, see Gallego and Loayza (2002). They document that a significant part of growth was explained by the growth of total factor productivity after 1985, whereas before 1985, it was mostly due to labor growth.

20. Franken, Le Fort, and Parrado (2005) argue that this recession could have been avoided if monetary policy did not overreact to limit the currency depreciation by narrowing the exchange rate band. At the end of the 1998, the copper price started to rise again, and with expansionary monetary and fiscal policies, the Chilean economy started to recover (IMF, 2000). Simonovska and Soderling (2008) examine the sources of business cycles in Chile using a dynamic stochastic general equilibrium (DSGE) model with time-varying frictions over 1998–2007. They conclude that changes in productivity and labor markets played important roles in explaining the 1998–99 crisis.

recessions, whereas a typical emerging economy experienced four over the sample period. However, the features of a typical Chilean recession are quite similar to those of emerging markets, as the median amplitude of the three recessions is about 4.6 percent and the median duration about three quarters (figure 6). The median decline in industrial production during the Chilean recessions, however, is roughly three times smaller than that in recessions in other emerging markets. The recession of the early 1980s in Chile was a severe one, though, and it was deeper than the typical severe recession in emerging market economies. Nevertheless, if one focuses on the last two recessions over the period 1980–2007, it is obvious that the Chilean economy experienced relatively milder episodes than the typical emerging market in our sample.

3.2 Dynamics of Recessions in Chile

We next examine how various macroeconomic and financial variables behave around recessions in Chile and how the dynamics of Chilean recessions compare with those in other emerging market economies. We focus on patterns in year-on-year growth in each variable for a six-year window—12 quarters before and 12 quarters after a peak (figure 7). We focus on year-on-year changes since quarter-to-quarter changes can be quite volatile. For comparison

Figure 6. Recessions and Financial Disruptions: Chile and Emerging Market Countries[a]

A. Duration

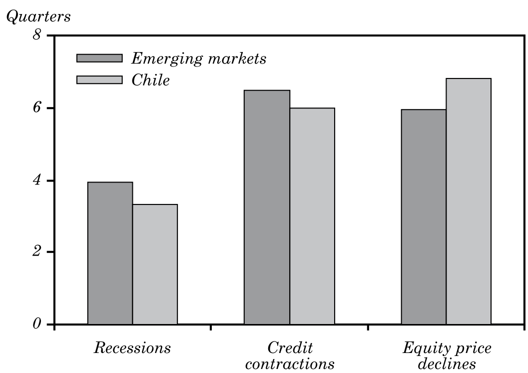
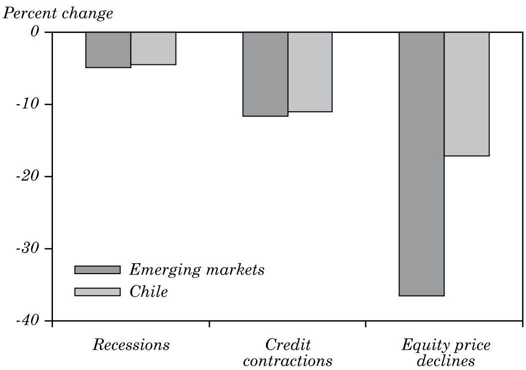
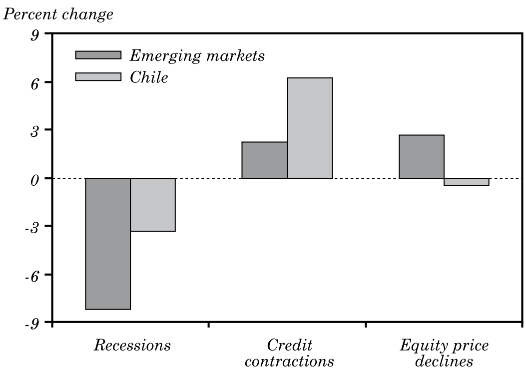


Figure 6. (continued)

B. Amplitude



C. Industrial production

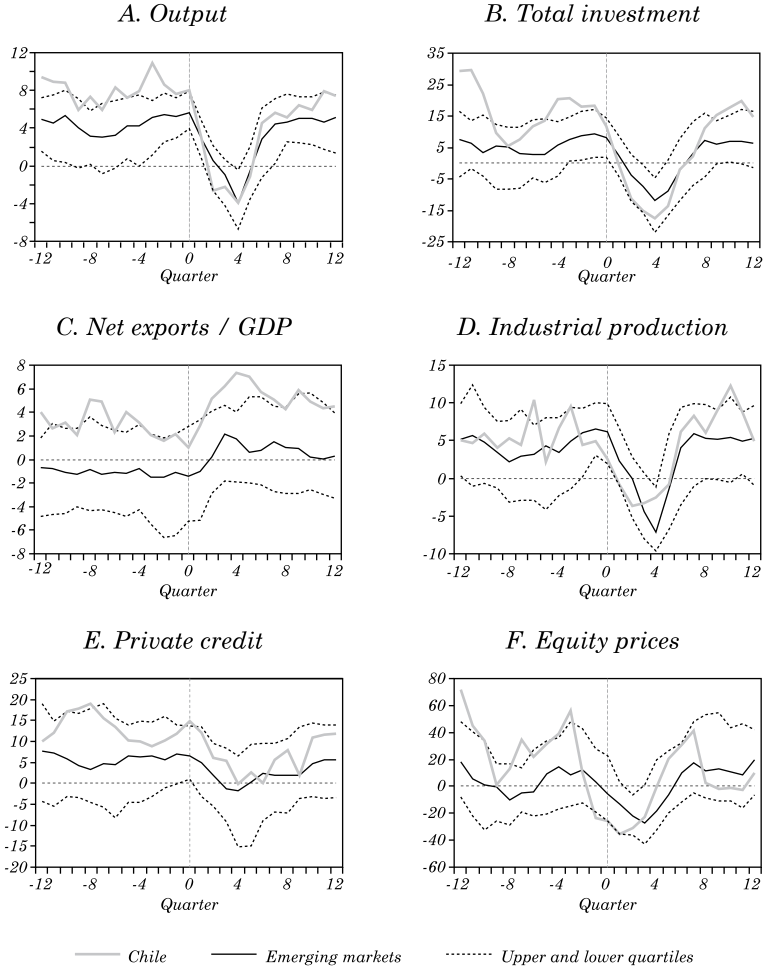


Source: Authors' calculations.
a. Duration is the mean of the number of quarters in a recession, credit contraction, or equity price decline. Amplitude is the median change in output, credit, and equity prices during recessions, credit contractions, and equity price declines, respectively. The bottom panel presents the median change in industrial production during recessions, credit contractions, and equity price declines.

purposes, we include the median growth rates of the three recessions in Chile and also those for all emerging markets, along with the top and bottom quartiles. The severe recessions are in the bottom quartile, consistent with our earlier definition of these episodes.

The evolution of output growth in a typical recession in Chile is no different than the typical recession in other emerging markets. Following the peak at date 0, output tends to register negative

Figure 7. Recession Dynamics in Emerging Market Countries and Chile[a]
Annual percent change



Source: Authors' calculations.

a. The gray line denotes the median of all Chilean observations. The solid line represents the median of all observations for emerging market countries, and the dotted lines correspond to the upper and lower quartiles. Zero is the quarter after which a recession begins (the peak in the level of output). The ratio of net exports to GDP is the level in percent.

annual growth after two quarters, falling to –4 percent four quarters after the peak. Relative to the typical emerging market recession, however, investment registers a much sharper decline in the first year of a recession in Chile. Moreover, the contraction in investment is deeper than that in output and lasts longer. In severe recessions, it can take up to three years for investment growth to recover. Industrial production in Chile also typically registers a sharp decline, although the contraction is milder than is typical in emerging markets.

Net exports improve sharply in the first year of a typical Chilean recession. The bounce in net exports in Chile is much larger than that observed in emerging market economies. The growth rate of exports slows but often stays positive in emerging markets. Import growth, however, often falls with the beginning of the recession and can decline to –10 percent in the first year of a recession.

Recessions in Chile appear to feature more significant declines in credit growth and equity prices than those in emerging market economies. In a typical emerging market recession, credit growth slows down sharply at the beginning and then contracts by about 2 percent in the first year. The growth rate of credit typically does not return to prerecession growth rates for a number of quarters. Recessions in Chile and other emerging markets are often preceded by slowdowns in the growth rates of equity prices. In the first year of a typical recession, equity prices decline on a year-to-year basis by roughly 30 percent. However, there is also evidence that equity prices are forward looking, as they often start registering positive growth ahead of the trough of the business cycle.

3.3 Financial Disruptions in Chile

Next, we provide summary statistics regarding the episodes of credit contractions and equity price declines in Chile, again comparing them with those in other emerging markets (tables 6 and 7). We identify three credit contraction episodes in Chile. The first and third of these episodes coincide with the early 1980s and the early 1990s recessions. The first one is also accompanied by a financial crisis. In terms of duration, a typical credit contraction episode in Chile lasts two times longer than a typical recession, at six quarters versus three quarters. In terms of amplitude, a typical credit decline in Chile is about 11 percent.

Table 6. Credit Contractions in Chile[a]
Percent change (unless otherwise indicated)

	Peak to trough			*Chile*		*Emerging markets*	
Indicator	*1982:2–1983:4*	*1985:1–1986:3*	*1989:4–1991:2*	*Mean*	*Median*	*Mean*	*Median*
A. Real credit							
Duration	6.00	6.00	6.00	6.00	6.00	6.48	5.00
Amplitude	−12.03	−11.00	−8.87	−10.63	−11.00	−20.13	−11.62
Slope	−2.00	−1.83	−1.48	−1.77	−1.83	−3.08	−1.86
B. Macroeconomic variables							
Output	0.39	3.65	8.91	4.32	3.65	1.76	1.93
Industrial production	6.21	10.77	5.11	7.36	6.21	2.54	2.18

Source: Authors' calculations.
a. Duration is the number of quarters between a peak and the next trough of a credit contraction. Amplitude is the percent change in credit from a peak to the next trough of a credit contraction. Slope is the ratio of amplitude to duration.

Table 7. Equity Price Declines in Chile[a]
Percent change (unless otherwise indicated)

	Peak to trough							
Indicator	*1980:3–1983:2[b]*	*1984:2–1985:2*	*1992:2–1993:2*	*1994:1–1994:3*	*1995:3–1998:4[b]*	*2000:1–2000:4*	*2001:3–2002:3*	*2005:3–2006:1*
Equity price								
Duration	11.00	4.00	4.00	2.00	13.00	3.00	4.00	2.00
Amplitude	–71.21	–17.20	–11.99	–6.63	–57.72	–15.54	–10.28	–3.23
Slope	–6.47	–4.30	–3.00	–3.32	–4.44	–5.18	–2.57	–1.62
Macroeconomic variables								
Output	–9.60	0.84	8.09	2.78	14.01	2.80	2.30	1.73
Industrial production	–7.36	–2.95	–1.35	0.35	6.56	–1.74	–0.50	1.60

Summary statistics for:	*Chile*		*Emerging markets*	
Indicator	*Mean*	*Median*	*Mean*	*Median*
Equity price				
Duration	5.38	4.00	5.93	5.00
Amplitude	–24.23	–13.77	–38.03	–36.63
Slope	–3.86	–3.81	–7.33	–6.29
Macroeconomic variables				
Output	2.87	2.54	4.05	3.47
Industrial production	–0.67	–0.92	3.56	2.63

Source: Authors' calculations.
a. Duration is the number of quarters between a peak and a trough of an equity price decline. Amplitude is the percent change in equity price from a peak to the next trough of an equity price decline. Slope is the ratio of amplitude to duration. The threshold amplitude for an equity price bust is –54.46.
b. The equity price busts in which the peak to trough decline in equity price is in the top 25 percent of all equity price declines.

The growth of economic activity, measured by output or industrial production, slows down, especially early on in a credit contraction episode, but the level of activity is typically higher at the end of these episodes than at the beginning. The increase in output over the course of a credit contraction is not surprising since these episodes do not always fully overlap with recessions and last twice as long as recessions. Although Chile did not experience a credit crunch episode during the period we examine, the typical credit decline episode in Chile was quite similar to the emerging market average in terms of duration, amplitude, and slope (see figure 6). However, the Chilean economy tends to perform better than the typical emerging market during credit contractions, as evidenced by much higher growth rates of output and industrial production.

In terms of equity price declines, Chile experienced eight episodes over the period 1980–2007, slightly more than other emerging market economies (six). Some of the emerging market economies, however, have shorter equity price series than Chile. The declines last between two and 13 quarters in Chile. The episodes of equity price declines are typically shorter than credit contractions, but still slightly longer than recessions. A typical decline episode in Chile leads to a fall of around 14 percent in equity prices, which is less than half the amplitude of a decline in such episodes in emerging markets.

Chile witnessed two equity busts over the sample period under consideration. The first one occurred during the recession of the early 1980s and resulted in a decline in equity prices of around 70 percent. The second one was in the mid-1990s and was associated with the Asian crisis. Equity price busts not only have greater amplitudes (by definition), but also last longer than credit contractions and equity price declines. While output in Chile rarely registered negative growth over the course of a typical equity price decline, industrial production tends to fall in most episodes. The episodes of equity price declines in Chile are more muted relative to those in other emerging markets, but they are associated with somewhat weaker growth, as well.

4. Conclusions

We provide a brief overview of the macroeconomic implications of recessions and financial disruptions in emerging market economies. To undertake this exercise, we utilize a rich data set of business and financial cycles based on reasonably long quarterly time series of multiple measures of real and financial activity. Our data set covers a large number of advanced and emerging market countries, which allows us to compare the features of these episodes in the two groups. Although our objective is to present an overview, we also address three specific questions.

First, what are the main features of recessions and financial disruptions in emerging markets? A typical emerging market country experiences about four recessions. The fraction of time spent in recession is typically 50 percent longer for Latin American emerging economies than for Asian emerging markets. In the case of advanced countries, the same statistic is about 13 percent, on average, which is much less than for emerging markets. Output declines by about 5 percent in a recession in emerging market economies, with substantial differences across regions. For example, the typical recession in Latin American emerging markets is two times more costly than in their Asian counterparts.

Recessions in emerging markets tend to be deeper than those in advanced countries: the amplitude of a typical emerging country recession is about three times larger than that of an advanced country. Our findings suggest that the typical recession in emerging economies is equivalent to a severe recession in advanced countries in terms of its amplitude and cumulative loss. The dynamics of adjustment around recessions in emerging markets also differ substantially from those in advanced countries. These findings confirm the results of a number of earlier studies about the more volatile nature of business cycles in emerging markets.

Financial market disruptions in emerging markets are also more severe than those in advanced countries. Although credit crunches in advanced countries last longer than those in emerging countries, crunches in advanced countries are much less intense. The periods of equity busts in advanced countries last as long as those in emerging markets, but they lead to smaller declines in equity valuations. The slopes of credit contractions and equity price declines in emerging markets are much larger than those in advanced countries, which highlights the highly volatile nature of credit and equity markets in these economies.

Second, how synchronized are these events across emerging markets? Our results suggest that recessions in emerging markets are highly synchronized events. Financial disruptions can be synchronous, as well. In particular, equity prices exhibit the highest degree of synchronization, reflecting the extensive integration of stock markets around the world. Credit contractions are somewhat less synchronized across countries, but still there are eight years in which more than 40 percent of countries experience credit contractions. Recessions tend to coincide most closely with contractions in domestic credit in emerging market economies and somewhat less with declines in equity prices. These findings are similar to the earlier results reported for advanced economies.

Third, how does the coincidence between recessions and financial disruptions affect macroeconomic outcomes? When recessions are accompanied by disruptions in financial markets, they tend to be longer and deeper. In particular, recessions associated with credit crunches appear to be more costly in terms of amplitude than recessions with equity price busts, while recessions associated with financial crises are about as costly.

In light of these general observations, we also ask whether the Chilean recessions and financial disruptions are different than those of other emerging markets. Chile witnessed three recessions in our sample period, whereas a typical emerging economy experienced four. After taking into account the small number of observations we have for Chile, we reach three tentative conclusions. First, the features of a typical Chilean recession are quite similar to those of emerging markets. Second, the dynamics of output around recessions in Chile are also similar to other emerging markets. However, if we exclude the very severe recession of the early 1980s and simply focus on the last two recessions prior to 2008, the Chilean economy appears to experience relatively milder episodes than the typical emerging market in our sample. Third, while the episodes of credit declines in Chile are quite similar to those in emerging markets in terms of their duration, amplitude, and slope, the Chilean economy tends to perform better than its peers during such episodes. In contrast to the credit contractions, the episodes of equity price declines in Chile are more muted relative to those in other emerging markets, but they are associated with somewhat weaker growth.

Consistent with its historical record presented here, Chile performed better than most other emerging market economies during the 2008–09 global financial crisis. Recent studies point to a number of factors that can explain Chile's performance over the past two years.[21] First, the macroeconomic and financial policies

21. De Gregorio (2009), IMF (2008), Ocampo (2009), García (2009), Jara, Moreno, and Tovar (2009), and Blanchard, Faruqee, and Das (2010) examine various aspects of the Chile's macroeconomic performance during the global financial crisis.

employed by Chile were sound and effective. For example, its fiscal policy was well-positioned to stimulate the economy, and its financial system was well-capitalized under rigorous supervision. Second, the commodity boom prior to the crisis resulted in large dividends for Chile. Third, exchange rate policies were instrumental in stabilizing foreign capital movements.

Our preliminary investigation has just scratched the surface of the complex linkages between recessions and financial disruptions in emerging market economies. There are a number of issues to be explored in future research. One additional approach to shed more light on these linkages would be to use individual firm data for a large sample of countries. Another fruitful area is to examine the nature of underlying shocks leading to differences in the features of recessions and financial disruptions in emerging markets and advanced countries.

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The Credit Channel and Monetary Transmission in Brazil and Chile: A Structured VAR Approach

Luis A.V. Catão
International Monetary Fund

Adrian Pagan
University of Technology, Sydney, and Queensland University of Technology

The widespread adoption of inflation-targeting regimes by emerging market economies has generated considerable interest in the channels through which monetary policy shocks affect output, inflation, and other relevant aggregates in such economies. Yet there is a paucity of empirical research for emerging markets relative to the large literature on advanced countries, partly reflecting shorter time series and other problems not typically faced in studies of the latter.[1] A few recent studies fit standard dynamic stochastic general equilibrium (DSGE) models to emerging market data (for example, Furlani, Portugal, and Laurini, 2008; da Silveira, 2008; Del Negro

At the time of writing, Luis A.V. Catão was affiliated with the Inter-American Development Bank.

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1. Although the literature on the relative performance of inflation-targeting regimes in emerging markets is now sizeable (see, for example, Loayza and Soto, 2002; Fraga, Goldfajn, and Minella, 2004; Mishkin and Schmidt-Hebbel, 2007), model-based studies on the monetary transmission in these economies remain scarce. A notable exception is the case of Chile, as discussed below.

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and Schorfheide, 2008), but they largely ignore some key structural features of emerging markets in the chosen specification. Moreover, the Bayesian methods used for estimation in these studies often impose strong priors, so that the empirical investigation is less about discovery than about quantifying the parameters of some prescribed model. This is not to deny that DSGE models are useful for thinking about interrelationships in the macroeconomy. Nevertheless, they are often best used as a source of structural information that provides a skeleton with which investigators can organize the data, rather than imposing the model on the data, at least until one is sure that it is a good representation of the data. Often the only way DSGE models are judged is by comparing the results to a vector autoregression (VAR), but this is unlikely to be a very powerful test. Simple checks, such as whether the model's assumptions about expectations and shocks are consistent with the data, are far more likely to reveal deficiencies in the specification.

Our objective in this paper is to develop a model that uses a particular DSGE model (namely, the New Keynesian model) as a skeleton and then to expand it so as to resemble a structural VAR (SVAR). Unlike existing SVARs that either force the system to be recursive (or ordered) or impose restrictions based on the signs or long-run properties of impulse responses, we propose that the VAR be structured by reference to some skeletal model that has a theoretical base. After eliminating the expectations in the model, we thereby produce a nonrecursive SVAR, which forms the basis of our VAR. By choosing the skeletal model appropriately, we can make an allowance for the role of external debt accumulation, exogenous fluctuations in the terms of trade, and endogenous determinants of the external trade balance through variation in domestic absorption. As we show in previous work (Catão, Laxton, and Pagan, 2008), the inclusion of an external debt accumulation equation in the structured VAR model not only is of interest in its own right—as it permits the tracking of the effects of monetary shocks through key external aggregates—but also imposes some stock-flow dynamics on the model that allow it to have an invertible VAR representation.

All linearized DSGE models imply that the data can be represented as a structured VAR. The shocks in the structure are identified in the DSGE approach by a combination of exclusion restrictions and the presence of some common parameters in the structural equations of the system. These serve to reduce the number of parameters to what can be estimated from the data. The structured VAR we adopt retains some of the exclusion restrictions of DSGE models but attempts to be less restrictive in relation to the specification of the underlying structural equations. It also aims to eclectically introduce some of the features of emerging market macroeconomies. In particular, we augment the canonical model to include a bank-dependent domestic private sector. This allows us to capture additional effects of monetary policy shocks through the bank intermediation channel emphasized by Bernanke and Blinder (1988), which is particularly relevant in emerging markets (Edwards and Végh, 1997; Catão and Chang, 2010). The effect of shocks to banks' lending capacity—arising from, say, exogenous changes in reserve requirements or banking intermediation technology—on output, inflation, and other aggregates can also be traced out in the model. Our structural VAR model is also designed to retain one of the important features emphasized in the DSGE perspective, namely, the integration of stocks and flows. This is rarely addressed in standard SVARs.

We empirically implement the modeling strategy on data for Brazil and Chile over 1999:1–2009:1. This sample period was chosen because the countries formally adopted an inflation target in 1999 (Brazil) and 2000 (Chile). Chile actually started targeting inflation in the early 1990s, but it operated a system of exchange rate bands through 1998, so targeting inflation was not the overriding goal of monetary policy. Moreover, an advantage of restricting the estimation period to 1999–2009 is that we are able to use the same sample for both countries, which facilitates comparison. Achieving a balance between retaining a large number of parameters, so as to capture the quite general dynamics that might be in the data, and achieving a relatively parsimonious specification, so as to aid interpretation, is often more an art than a science, particularly when the sample sizes available for estimation are very short.

Given the sample size, some restriction on the VAR is needed. The model we apply to both countries represents an expansion of the methodology used in Catão, Laxton, and Pagan (2008), in that we replace the recursive SVAR used there with a nonrecursive SVAR. Substantial differences emerge between the conclusions reached with a traditional recursive VAR and those from this paper's approach. Despite the relatively short time span available for estimation, our structured VAR estimates do not generate price puzzles, exchange rate puzzles, or other anomalies that abound in the literature, which would be found for both countries under a standard recursive SVAR.

The main results are as follows. First, the transmission mechanism works faster in Brazil and Chile than in the United States and other advanced countries, with the bulk of the effects on output and inflation taking place within a year. The magnitude of monetary policy effects on inflation and output growth are much the same as in advanced economies, but the mechanism is different for inflation, with exchange rate rather than output gap effects dominating. This is often found in small open economies such as Australia.

Second, the bank credit channel plays a nontrivial role in monetary transmission. Our results are consistent with the existence of two channels through which monetary policy affects credit and then output. One is via changes in the lending-deposit spread following shocks to the policy interest rate, amplifying the standard intertemporal effect of monetary policy changes on absorption. The other is an intratemporal effect: monetary tightening tends to appreciate the exchange rate in the short run, and this has expansionary effects on bank credit. The latter occurs when the domestic business sector tends to have a sizeable stock of foreign-currency-denominated debt or when the nontradables sector of the economy is more bank-dependent than its tradables counterpart, implying that the overall demand for bank credit will tend to increase as relative prices shift toward nontradable goods producers. This combination of the balance sheet effects of currency mismatches and the greater bank dependence of domestic firms implies that monetary policy will have nontrivial effects on bank lending and hence on absorption. Our estimates indicate that while the intertemporal channel eventually wins out, so that monetary tightening (loosening) depresses (boosts) bank credit, the intratemporal channel appears to play an offsetting role.

Third, the quantitative impact of credit shocks tends to be larger for Chile than Brazil. While neither is large in response to a 1 percent change in credit growth, the question is whether this is the right scenario given the typical size of credit shocks in emerging markets. Over the period 1999:1–2009:1, credit grew strongly in both countries, with standard deviations in credit shocks of around 9 percent in Brazil and 5 percent in Chile. So, although the impact of a 1 percent change in credit on inflation and output is relatively small, such large variations in actual credit growth might suggest that these developments have been important for macroeconomic outcomes. For Brazil, the impact of a positive 9 percent shock to credit growth on inflation is roughly equivalent to a decrease of

80 basis points in the interest rate, all else constant. In the case of Chile, the inflationary impact of a positive 5 percent shock to credit growth is equivalent to a decrease of around 100 basis points in interest rates.

The remainder of the paper is divided into five sections. Section 1 reviews the existing evidence on the monetary transmission mechanism in Brazil and Chile and provides a motivation for the model and results. Section 2 lays out the methodology, first in a general way and then in the context of the structural model that is used as the skeleton for our SVAR. Section 3 provides a discussion of the data, including the construction of output and absorption gaps. Section 4 presents the estimation results for the structural VAR equations, as well as the resulting impulse responses for money and credit shocks. The paper concludes with a brief summary and discussion of the main findings.

1. Existing Evidence

The introduction of the inflation-targeting framework in Brazil in 1999 generated significant interest in understanding the monetary transmission mechanism. As a result, a growing literature seeks to identify and measure the channels through which the central bank's policy interest rate (SELIC) affects output and inflation. Bogdanski, Tombini, and Werlang (2000) describe some of the channels and discuss the central bank's model, and their framework forms the basis for the empirical studies reviewed below.

Minella (2003) estimates a recursive four-variable VAR using the overnight interest rate, inflation, output, and M1 over the period 1975–2000, breaking the estimation into three subsamples: the "moderate" inflation period (1975–85); the high inflation period (1985–94); and the low inflation regime (after 1994). He finds that inflation inertia declines in the post-1994 period and that there is only weak evidence that monetary policy affects inflation in this post-stabilization period, even though his estimates point to significant effects of monetary policy shocks on output. Minella notes that this may well be because of an identification problem arising from the fact that the 1994–2000 period was dominated by interest rate responses to financial crises and the defense of the exchange rate peg, rather than by the overriding objective of anchoring inflation expectations. A possible reason for this anomalous result is that the exchange rate was not included in the VAR.

Other studies acknowledge the role of the exchange rate as a determinant of Brazilian inflation. Bevilaqua, Mesquita, and Minella (2007) find that the large appreciation of the real since 2005 has contributed significantly to the fall in inflation. Favero and Giavazzi (2004) conclude that exchange rate movements affect inflation expectations and, through this channel, the central bank interest rate setting. This suggests not only that the exchange rate may affect current inflation by changing the cost of imported goods, but also that there may be an important expectational channel at work.

Some attention has also been devoted to the interest rate reaction function. Using a Hodrick-Prescott (HP) filter to produce the output gap measure, Minella (2003) finds that the parameter on the output gap in the monetary policy reaction function has the wrong sign and is not statistically significant from zero. He argues that this could arise because of simultaneity bias caused by supply shocks that depress the output gap and raise inflation. The same study also finds that exchange rate volatility has been an important source of inflation variability in Brazil, based on a smaller VAR estimated on monthly data but with a sample that includes the pre-inflation-targeting period (1994–2002).

Da Silveira (2008) and Furlani, Portugal, and Laurini (2008) reexamine some of these issues from the perspective of a New Keynesian open economy DSGE model derived from Galí and Monacelli (2005), who use Bayesian techniques to estimate their parameters. Given their open economy set-ups, both studies have the exchange rate playing a key role in the transmission of monetary shocks via uncovered interest parity, though neither of them contemplates a similar role for the country risk premium, as we do below. Furthermore, because all goods in the Galí-Monacelli set-up are tradables, changes in the real exchange rate are proportional to changes in the terms of trade. Da Silveira (2008), in particular, finds that monetary policy lowers inflation via a strong nominal exchange rate appreciation, but the effects are not particularly strong and they are reinforced through the effect of monetary policy on the output gap. Furlani, Portugal, and Laurini (2008) examine whether the monetary policy reaction function should respond to exchange rates and output, as well as to inflation. They find that the Brazilian central bank does not respond much to exchange rate movements in setting domestic interest rates, but rather mostly reflects inflation developments and, to some extent, the output gap. Both studies also find, as we do, that shock accommodation is relatively swift, though their models do not allow for a bank credit channel, which our estimates identify as important.

As with Brazil, existing work on monetary transmission in Chile has moved from an earlier literature using VARs and semi-structural VARs to more recent work using DSGE modeling and Bayesian estimation. Early work in the VAR tradition includes Morandé and Schmidt-Hebbel (1997), Valdés (1998), Calvo and Mendoza (1999), and Cabrera and Lagos (2002). While some of these studies impose structural restrictions, they tend to rely strongly on atheoretic identifying assumptions and build a weak link between the estimated VAR and a theoretically based structural model. Not surprisingly, a number of puzzles emerged in this literature, including price, exchange rate, and liquidity puzzles (see Chumacero, 2003, for further discussion).

Much of the recent work is based on the small open economy model with Keynesian features set out in Galí and Monacelli (2005). This features monopolistic competition with Calvo pricing, differentiated output varieties, and complete asset markets. Céspedes and Soto (2005) present a variant of this model in which there is uncertainty about the monetary policy rule implemented by the central bank, implying that agents simultaneously optimize and solve a signal extraction problem about the nature of the monetary policy shock. When the authors compute impulse responses under standard calibrations of the model for the case of a disinflation shock (a shock to the inflation target), they find that the higher this uncertainty (that is, the lower the degree of the central bank's credibility), the slower is the fall in inflation to a given monetary tightening, along with a higher real exchange rate appreciation and sacrifice ratio. They complement this calibration exercise with generalized method of moments (GMM) estimates of the monetary policy rule over the pre-1999 and post-1999 periods. They find that in the full-fledged inflation-targeting regime, monetary policy has become more forward-looking (that is, more responsive to expected future inflation than current inflation) and the coefficient on the deviations of inflation from target in the monetary policy rule has risen (rather than fallen).

Caputo, Liendo, and Medina (2007) extend the basic open economy New Keynesian model to incorporate nominal wage rigidity, habit persistence, and a risk premium on external borrowing (rather than complete international asset markets). They then estimate this model with Bayesian techniques. They find that wage rigidity is typically more important than price rigidity for the Chilean economy, which complicates the trade-off between stabilizing inflation and output. Specifically, wage indexation generates a more persistent response of inflation to shocks and makes inflation fluctuations (and monetary policy responses to it) more costly in terms of output and employment. Estimates of the monetary policy response embodied in their model indicates that the policy response to inflation during the full-fledged inflation-targeting period is stronger than that to output and the exchange rate. Furthermore, they also find that this period has witnessed greater interest rate smoothness, with the responses to inflation (relative to output) becoming less aggressive. In fact, their estimates of the central bank reaction function perhaps indicate too mild a response to inflation developments, as the estimated parameters fail to meet the standard stability condition for a Taylor rule in a closed economy.

Del Negro and Schorfheide (2008) implement a similar strategy to ours in that they estimate a DSGE model (a version of the Galí-Monacelli model) to derive predictions of what the VAR coefficients (Π) would be (Π^*). A prior distribution for Π is then constructed by centering on Π^* and having a covariance matrix that is proportional (through the inverse of a hyperparameter, λ) to the form of the covariance matrix of $\hat{\Pi}_{OLS}$. The value of λ determines the extent to which the VAR coefficients are preferred to those from the DSGE model. When $\lambda = 0$, one would adopt the unrestricted VAR values for Π. As λ becomes large, one would prefer the values implied by the estimated DSGE model (of course, one also needs to determine the covariance matrix of the VAR errors as well). The parameter λ basically enables the analyst to explore how sensitive the conclusions will be to the choice of using the DSGE model versus the VAR. One might choose λ by reference to predictive success and then use the highest posterior probability as a criterion. There are some difficulties in moving back to structural shocks, simply because these are defined by the DSGE model, so it really needs to be correctly specified. The difficulties are less serious for monetary policy shocks, however, as the structural equation defining this is atheoretic.

A first question addressed by Del Negro and Schorfheide (2008) is the extent to which the central bank responds to the terms of trade and exchange rate fluctuations relative to inflation. Similarly to Caputo, Liendo, and Medina (2007), they find that Chile's central bank responds mostly to inflation rather than output. They also find evidence of very low pass-through from the terms of trade and nominal exchange rate shocks to consumer price index (CPI) inflation, which implies that the shocks that affect inflation are mostly domestic, rather than external. A second part of their investigation is to compare the impulse responses of the DSGE model and the combined DSGE-VAR model (that is, with an estimated λ). These are not very different, except for the exchange rate responses, and show little persistence. Just as we find in this paper, Del Negro and Schorfheide (2008) report strong effects of interest rate shocks on the output gap and inflation, although the impact on inflation is not as strong as our estimates suggest. As with the literature on Brazil, and in contrast with the model we develop below, none of these studies contemplates a separate role for the credit channel in monetary transmission. Nor do they consider (with the partial exception of Caputo, Liendo, and Medina, 2007) an integration of external debt stock, current account flows and exchange rate dynamics, as we do below.

2. Methodology

Let $\mathbf{z}_t$ be an $n \times 1$ vector of variables in the macroeconomic system. A typical structural equation in a macroeconomic model (normalized on the first variable, z_{1t}) has the following form:

$$z_{1t} = \mathbf{z}_t^{-'}\boldsymbol{\alpha}_1 + \mathbf{z}_{t-1}'\boldsymbol{\delta}_1 + E_t(\mathbf{z}_{t+1})'\gamma_1 + \varepsilon_{1t},$$

where ε_{1t} is a structural shock and $\mathbf{z}_t^-$ is $\mathbf{z}_t$ less z_{1t}. One approach to modeling these systems is to use structural VARs. The classic version of these are data oriented in that their role is to fit the data as closely as possible but still provide a structural interpretation in terms of the impulse responses. The latter is usually the focus of the analysis to the point that it is extremely rare to see the fitted SVAR equations ever presented and their consistency with the underlying theoretical model discussed. This means that they might well fail to be consistent with theoretical ideas. One instance in which this has been the case is found in the literature employing SVAR models with long-run restrictions on the effects of money growth: Pagan and Robertson (1998) find that the structural equation meant to be identified as a supply curve was influenced positively by nominal money growth.

In standard SVARs, γ_1=0 and various restrictions are placed on $\boldsymbol{\alpha}_1$ (mainly exclusion restrictions) in order to identify the shocks, ε_{1t}. In particular, the system is assumed to be recursive (or ordered) and is sometimes referred to as a just-identified VAR. An alternative way of generating the structural equations of an SVAR comes from theory-oriented models such as DSGE models. These impose restrictions (mainly exclusion) on $\boldsymbol{\alpha}_1$, $\boldsymbol{\delta}_1$ and $\boldsymbol{\gamma}_1$ in order to identify the shocks. Our approach is an intermediate one to these two polar cases, in that we use a theory-oriented model to provide a skeletal structure that is then augmented (if necessary) to yield a better match to the data. In some ways, our approach resembles Del Negro and Schorfheide's, except that their focus is on the VAR that is the reduced form of the structural equations, while ours focuses directly on modifying the structural equations.

Perhaps the simplest way to move from a theory-oriented SVAR to a data-oriented one is to substitute out $E_t(\mathbf{z}_{t+1})$ in the structural equations of the former. An approach that does not use any particular theory-oriented model, and is more robust to model specification error, is to make the expectation a function of some model variables, $\boldsymbol{\xi}_t$. Then if one regresses $\mathbf{z}_{t+1}$ against $\boldsymbol{\xi}_t$ to get coefficient estimates $\hat{\mathbf{A}}_1$, $E_t(\mathbf{z}_{t+1})$ could be measured as the combination $\mathbf{w}_t = \hat{\mathbf{A}}_1 \boldsymbol{\xi}_t$.[2] This approach was used in the FRB/US model (see Brayton and others, 1997), although the variables $\boldsymbol{\xi}_t$ were only a few of those in the FRB/US system. Since $\boldsymbol{\xi}_t$ generally involves both contemporaneous and lagged values of the model variables, the resulting SVAR will no longer be recursive. For example if one had a consumption Euler equation of the form

$$n_t = E_t(n_{t+1}) + \delta(i_{t-1} - \pi_{t-1}) + \varepsilon_t^n,$$

where n_t is consumption expenditure, i_t is a nominal interest rate, π_t is an inflation rate and ε_t^n is a preference shock, then substituting $\boldsymbol{\xi}_t'\phi_1 + \boldsymbol{\xi}_{t-1}'\phi_2$ for $E_t n_{t+1}$ will produce the following SVAR equation:

$$n_t = \boldsymbol{\xi}_t'\phi_1 + \boldsymbol{\xi}_{t-1}'\phi_2 + \delta(i_{t-1} - \pi_{t-1}).$$

Hence the original variables in the structural equation have been augmented by $\boldsymbol{\xi}_t$ and $\boldsymbol{\xi}_{t-1}$. What is critical, though, is that ϕ_1 and ϕ_2 can be estimated without reference to any structural model, so that the presence of these extra variables does not create any substantial estimation problems. Even if there was a coefficient attached to $E(n_{t+1})$, the estimation issues are not major, since only a single variable , $\boldsymbol{\xi}_t'\phi_1 + \boldsymbol{\xi}_{t-1}'\phi_2$, needs to be instrumented.

2. If direct measures of expectations were available, they could be used.

Our strategy is thus to construct an SVAR by first setting out a small theory-consistent model and then replacing the expectations appearing in it by what would be implied by an unrestricted VAR. Thereafter, we ask whether the resulting structural equations need to be augmented with further information (largely lagged values of the system variables). An important part of our strategy is the skeletal model that forms the core of our SVAR, for which we use a relatively standard New Keynesian model set out in the next subsection.

2.1 The Skeletal Structure for our Structural VAR

Our starting point for structuring the VAR is a canonical small macroeconomic model that has been used quite extensively in the macroeconomics literature and has often been deployed for analysis at the International Monetary Fund (IMF) and various central banks (see Berg, Karam, and Laxton, 2006). It is implicitly derived from optimizing (Euler) equations for consumption and investment (which we aggregate to domestic absorption), a Phillips curve equation for inflation, an exchange rate equation driven by uncovered interest parity (UIP), and a Taylor-type rule relating the policy-controlled interest rate to expected inflation and the output gap. Our variant distinguishes between absorption (n_t) and output (y_t). Later we use a convention that a coefficient α_{xy} shows a contemporaneous effect between x_t and y_t, β_{xy} shows the effect between x_t and y_{t-1}, and γ_{xy} is between x_t and y_{t-2}. Some license is taken when expectations are involved. Thus α_{ne} is the coefficient in the absorption equation that connects n_t and the expected value $E_t(n_{t+1})$. Thus, the model can be written as follows:[3]

$$\tilde{n}_t = \alpha_{nn^e} E_t(\tilde{n}_{t+1}) + (1-\alpha_{nn^e})\tilde{n}_{t-1} + \beta_{nr}\hat{r}_{t-1} + \varepsilon_t^n; \tag{1}$$

$$\tilde{y}_t - \tilde{n}_t = \alpha_{yz}\tilde{z}_t + \alpha_{yy^*}\tilde{y}_t^* + \delta_{yn}\tilde{n}_t + \varepsilon_t^y; \tag{2}$$

$$\hat{\pi}_t = \alpha_{\pi\pi^e} E_t(\hat{\pi}_{t+1}) + (1-\alpha_{\pi\pi^e})\hat{\pi}_{t-1} + \alpha_{\pi y}\tilde{y}_t - \alpha_{\pi z}\Delta\tilde{z}_t + \varepsilon_t^\pi; \tag{3}$$

$$\hat{\imath}_t = \beta_{ii}\hat{\imath}_{t-1} + \alpha_{i\pi^e} E_t\hat{\pi}_{t+1} + \alpha_{iy}\tilde{y}_t + \varepsilon_t^i; \tag{4}$$

3. A tilde (~) indicates a log deviation from equilibrium values; a hat (^) indicates a deviation in levels.

$$\tilde{z}_t - E_t\tilde{z}_{t+1} - (\hat{r}_t - \hat{r}_t^*) = \zeta_t + \varepsilon_t^z; \tag{5}$$

$$\Delta\hat{d}_t = \bar{d}\left[(1-\bar{\psi})\,\hat{\imath}_t - (1+\bar{\imath})\hat{\pi}_t\right] + \omega_n\tilde{n}_t - \tilde{y}_t + (\omega_m - \omega_x)\tilde{z}_t - \omega_x\hat{tt}_t; \tag{6}$$

$$\bar{\psi} = \hat{\imath}_t = \bar{\pi} + \Delta\ln\bar{Y}_t \tag{7}$$

$$\hat{r}_t = \hat{\imath}_t - E_t(\pi_{t+1} - \bar{\pi}_{t+1}). \tag{8}$$

The first equation provides a specification for the log of domestic absorption ($\tilde{n}_t$), absorption being GDP minus net exports. It is measured as a log deviation from some "equilibrium" value and so should be regarded as a gap variable. Models that emphasize gaps are a convenient way of organizing policy and forecast discussions, allowing one to concentrate separately on where one sees the system heading and the path of adjustment to that point. Most modern macroeconomic models can be written as gap models, so the approach is fairly flexible. The equilibrium value may be constant or time varying.[4] In this case, the absorption gap depends on the real rate of interest, r_t. The definition of the real rate will involve an expected inflation rate. In steady state, this would be the target rate of inflation $\bar{\pi}_t$, so we work with the real interest rate adjusted for the inflation target, $\hat{r}_t$, given in equation (8). Most empirical work with the New Keynesian model incorporates the target as a constant, but this cannot be the case for Brazil or Chile over the whole period of inflation targeting. When the target is varying, it may be reacting to the past inflation rate. Indeed a simple regression of the target on lagged observed inflation in Brazil does suggest such a relation, although

4. The need for the latter often reflects the fact that there are permanent stochastic components that need to be removed to induce stationarity in the measured gap. We discuss these transformations in detail below, but even if there were no permanent components in the data, it is often the case for emerging market economies that the equilibrium values to which the system will be adjusting are shifting over time in response to structural changes in the economy. Consequently, care should be taken when constructing these gaps, and any assessments of the resulting measures should rely heavily on institutional knowledge of the economy in question. This knowledge can be quite informative, not only of the presence of structural changes (such as those in the transition from high to low inflation regimes and across monetary policy frameworks), but also of how reasonable one's estimation results appear to be. A striking example in the empirical macroeconomic literature of the problems arising from ignoring country-specific features in broad cross-country regressions pertains to the identification of the long-run effects of fiscal deficits on inflation: although solidly backed by theory, these effects are not easily discernable without properly taking into account specific country-group features in the estimation strategy. See Catão and Terrones (2005).

it is rather weak. We have therefore chosen to treat the target as exogenous. No other variable in this model determines the level of absorption, which is consistent with the standard Euler equation for consumption in DSGE models.[5] Implied in such a specification is that the other variables making up absorption, principally investment, are also functions of a real interest rate. While it might be worth augmenting this equation with some expressions for the rate of return on investment and other measures of the actual relative price or cost of capital (including tax wedges for instance), such measures are not readily available for emerging markets. The proposed specification also implicitly captures accelerator effects through the lagged terms on absorption, which are often found to have significant explanatory power in investment equations.

The second equation is meant to determine output and links the real GDP gap ($\tilde{y}_t$), the domestic absorption gap ($\tilde{n}_t$), and import and export gaps. For Brazil the import and export shares are largely the same, so $\tilde{y}_t - \tilde{n}_t$ can be regarded as the log deviation of the current account from zero. Imports are determined by total expenditure and the real exchange rate, while exports are related to the real exchange rate and foreign expenditure. We thus simply eliminate imports and exports to produce a relation linking the output and domestic absorption gaps, the log of the real exchange rate z_t (measured as a deviation from steady state), and the foreign output gap $\tilde{y}_t^*$.

The specification assumes that there is no lag between trade flows and their determinants, but this needs to be investigated further since it is not derived from any theoretical framework. In fact, delays between orders and deliveries may cause lags.

Although this equation is fundamentally an identity, it ceases to be so when we replace exports and imports by a functional form. Hence, we add a shock to allow for this. In many emerging market countries, the opening up of the economy produces an import surge that is much larger than expected from the price and output elasticities for import demand. Although much of this movement can be accounted for through a time-varying equilibrium value for the

5. As discussed in the next section, we augment this canonical specification to include the role of domestic interest spreads (through an interest wedge that arises in models with deposit) and credit-in-advance constraints (see, for example, Edwards and Végh, 1997). Since the domestic interest spread is itself a function of the policy interest rate and a measure of the supply side of bank credit, this baseline specification for absorption will remain unchanged except for the addition of an extra term on the excess credit measure.

import share, one will probably want some of the observed changes to be captured by a shock that is persistent.

The third equation provides a specification for the inflation gap, $\hat{\pi}_t$, where $\hat{\pi}_t$ is the deviation of inflation from the target rate. It includes the output gap and the exchange rate gap.[6] As suggested by previous studies, the exchange rate plays a very significant role in influencing the price of tradeables and CPI inflation.

The fourth equation is a monetary policy reaction function, where $\hat{\imath}_t$ is defined as the nominal interest rate less the target inflation rate. The parameter β_{ii} seeks to capture the degree of interest rate smoothing in central bank policy, which is usually highly significant in policy reaction functions (and Brazil and Chile are no exceptions in this regard). In light of evidence from existing studies reviewed earlier, we do not include the exchange rate in the monetary policy rule. In our background empirical work, we tested whether the exchange rate should be present, and the results showed only a very weak dependence. We discuss this below for Brazil.

The exchange rate equation (equation 5) is risk-adjusted UIP, where $\hat{r}_t^*$ is the external real interest rate (proxied by the interest rate on U.S. three-month Treasury bills). The exchange rate is defined such that a rise represents an appreciation. There are two shocks in this equation. One, ζ_t, is a risk premium that can be considered as relating to model variables, while the other, ε_t^z, is a function of nonmodel variables and is treated as white noise and as uncorrelated with ζ_t. In many real business cycle models of small open economies, this risk premium shock is made a function of the level of net foreign debt relative to GDP (again measured relative to a steady-state value) (see, for example, Schmitt-Grohé and Uribe, 2003). Other factors may play a role, however, such as the level of domestic interest rates. Much of domestically issued debt in these countries is held by foreigners, and these external debt servicing obligations tend to increase country risk. Inclusion of debt obligations as a gauge of country risk and a wedge in UIP equations is not only appealing from a theoretical perspective, but also consistent with recent external developments in many emerging markets, where a decline in net external debt has been accompanied by a decline in

6. We have constrained the coefficients in this equation so that they add to one. In many models, they add to the discount factor. This is often around 0.99 in a quarterly model, so we follow a common practice that enforces a restriction that the coefficients sum to unity, which aids identification.

standard measures of country risk such as the J. P. Morgan Emerging Markets Bond Index.

The debt equation (equation 6) is a linearized version of the identity describing how the level of external debt to GDP changes over time, the derivation of which is fleshed out in Catão, Laxton, and Pagan (2008).[7] In this equation, the terms of trade ($\hat{tt}_t$) are taken as exogenously given—which is a reasonable assumption for a small open economy. The variables ω_m, ω_x, and ω_n are the import, export, and absorption shares in GDP, respectively, $\overline{d}$ is the steady-state ratio of net foreign debt to potential GDP, and ψ_t is the nominal potential GDP growth rate ($\Delta \ln \overline{Y}_t$). Since the evolution of the terms of trade and the trade balance shape the path of net external debt through this identity, and the level of debt would affect the exchange rate through the risk premium term, those variables will also be potentially important determinants of the exchange rate, output, and inflation.

2.2 Augmenting the Skeletal Structure

As mentioned in the previous section, our first step in extending the skeletal structure is to replace the expectations $E_t\tilde{n}_{t+1}$, $E_t\tilde{\pi}_{t+1}$, and $E_t\tilde{z}_{t+1}$ by functions of the model variables. In general, it will be the case that every variable affects the conditional expectations, although simulations of theory-oriented models such as that in Berg, Karam, and Laxton (2006) (using calibrated values for the parameters) suggest that many of the variables are of little importance. Now, the skeletal model will have a VAR(2) solution for the variables if the model shocks followed a VAR(1).[8] A VAR(2) would also be consistent with a range of other models. Thus a reasonable strategy is to begin by assuming that a VAR(2) should capture expectations quite well, that is, a VAR(2) in the skeletal model variables is fitted and used to produce $E_t\tilde{n}_{t+1}$, $E_t\tilde{\pi}_{t+1}$, and $E_t\tilde{z}_{t+1}$. Because there are

7. In its application to the present paper, we have chosen to ignore the impact of current exchange rate variations on current debt revaluations. This arises from the fact that we did not have evidence on the frequency of revaluations of actual debt to exchange rate movements, but it seems unlikely that it would react strongly to contemporaneous movements in exchange rates.

8. The solution is a VARX model with two lags in the endogenous model variables and no lags in the exogenous external variables ($\tilde{y}_t^*$, $\hat{r}_t^*$, and $\hat{tt}_t$). If the exogenous variables are represented as a VAR(1), then the VARX model can alternatively be written as a VAR(2) in all endogenous and exogenous variables, but with the special structure that the exogenous variables depend only on their own past history.

sixteen parameters in this regression, and our data sets are only forty observations long, we deleted some of the variables from the regressions if they did not seem important to the explanation of the variables expectations are being formed about. Generally, we retained a variable in the expectations-generating equation if its t ratio exceeded (or was close to) two.

The canonical model also needs to be expanded to capture previous research outlined earlier. We have already augmented the standard New Keynesian model to reflect open economy considerations more precisely. This involved separating out absorption and output effects, as well as introducing an external liability equation. A second extension was to incorporate an equation for private bank credit growth. In the Brazilian and Chilean financial systems, many firms (particularly smaller and medium-sized businesses) are still largely dependent on domestic banks for funding, and they have limited access to international capital markets. This channel might thus be expected to play a role, and it needs to be examined.

Ideally, we wish to capture a credit channel effect involving the amount of credit being granted by banks that is in excess of some "normal" level. Microfounded models of the credit channel featuring deposit- and credit-in-advance constraints, as well as costly banking (Edwards and Végh, 1997; Goodfriend and McCallum, 2007), imply that a wedge appears in the Euler equation governing absorption. Similar emphasis on the amplification mechanism associated with bank interest rate spreads is found in the earlier literature on the credit view (Bernanke and Blinder, 1988; Kashyap and Stein, 1994), where it is suggested that lending-deposit spreads ought to feature in an absorption equation like equation (1). As shown in Edwards and Végh (1997) for a typical emerging market context, such spreads are a direct positive function of the policy interest rate itself plus a term related to the credit-to-expenditure ratio.[9] It would seem logical to use such a ratio as credit to either GNE or GDP, but this is a difficult series to work with for both countries because of a sharp rise over the sample period. For example, in the case of Brazil, after being fairly stable around 0.24 from 1999 to 2004, it rose sharply to 0.44

9. The specific way in which Edwards and Végh (1997) model bank technology yields a relationship between the lending and deposit spreads (measured relative to the base interest rate) and the credit-to-deposit ratio. This directly translates into a functional relationship between bank spreads and the credit-to-expenditure ratio, since deposit-in-advance constraints imply that deposits are proportional to expenditure.

at the end of the period. Hence, it behaves more like an integrated series over our data period.[10]

Because of the problems with this data set, we use credit growth relative to a constant level as a proxy. As we observe in the next section, many gap measures are, in fact, constructed from the growth rate of a series. Thus, the gap between the log of the credit-to-GDP ratio and its normal level would be a function of the growth of credit less the potential growth rate of GDP. Given that the latter is reasonably constant, this suggests that our measure captures the ideas about excess credit reasonably well, but it is statistically tractable since it is a stationary process.[11]

At any point in time, domestic bank credit is endogenously determined within a system, so we need to decide how to account for this within an SVAR. To allow for contemporary effects of credit expansion on expenditure, we place the excess credit variable before any other variable of the system, that is, we assume that it is determined only by the past values of any model variables. To be consistent with some theoretical ideas, we restrict the explanatory variables entering the excess credit equation to absorption, the real interest rate (separated into its nominal and inflation components), and the real exchange rate. The latter can enter the equation for two reasons. First, there may be sizeable balance sheet effects of the type documented in Calvo, Izquierdo, and Mejía (2004).[12] Second, the nontradables sector may be more bank dependent than the tradables sector (see Catão and Chang, 2010). Both structural features imply that a real exchange rate appreciation will increase real credit demand in the nontradables sector, leading to higher aggregate credit. Although neither Brazil nor Chile are as dollarized as many other emerging markets, significant balance sheet effects may also be present, and they could further strengthen the positive impact of a

10. The estimated AR(1) coefficient is 1.02.

11. Allowing for the presence of an autonomous component in the excess credit variable that is not directly related to the interest rate seems particularly appropriate in the case of Brazil, where a large development bank (BNDES) accounts for up to one-fourth of domestic credit. BNDES's lending policies and rates arguably respond to other incentives, and its lending rates are typically below market rates.

12. While the dollarization of private sector liabilities was not nearly as extensive in Brazil as in many other emerging markets, it is far from negligible. Foreign-currency-denominated debt rose from very low levels in the early 1990s to 40 percent of total corporate debt in 2002 (Bonomo, Martins, and Pinto, 2003, table A2). Using a large panel of firm-level data, Bonomo, Martins, and Pinto (2003) also find that the balance sheet effects of currency movements have a significant impact on credit demand and investment.

real exchange rate on domestic credit. Section 4 provides supportive econometric evidence that real exchange rate appreciations tend to foster domestic credit growth in Brazil but not Chile.

We now need to make some specific comments about how the canonical model is to be augmented following the elimination of expectations. An obvious extension was to add higher-order lags in the structural equations. The need for higher-order lags was suggested by the fact that there was serial correlation left in the individual equations of the skeletal SVAR. A second lag in the dependent variable was sometimes found to be needed. Because the coefficients of the two lags often appear with opposite signs, a term such as $az_{t-1} + bz_{t-2}$ (with $a > 0$, $b < 0$, and $|b| < a$) can be written as $(a+b)z_{t-1} - b\Delta z_{t-1}$, that is, there is both a level and a growth rate effect.

We estimated all the equations with instrumental variables. This was done partly to avoid the fact that systems estimation requires that all the equations in the system be correctly specified to yield the expected efficiency gains. Otherwise, partial systems methods involving the use of instrumental variables should be preferable, and this is the route we take here. The following rules governed the selection of instruments. First, any exogenous or lagged variable appearing in an equation is taken as an instrument for itself. Second, $E_{t-1}\tilde{n}_t$, $E_{t-1}\tilde{\pi}_t$, and $E_{t-1}\tilde{z}_t$ from the VAR(2) were used as instruments for $\tilde{n}_t$, $\tilde{\pi}_t$, and $\tilde{z}_t$. Finally, residuals from structural equations further up the system were taken to be suitable instruments. Thus, we used the residual from the credit equation as an instrument in the absorption equation. This can be justified if the assumption (used in many DSGE models) that the shocks in the structural equations are mutually uncorrelated with one another is valid. If the number of instruments equaled the number of variables in each equation, and if residuals were among the former, then we would be enforcing this restriction. This is not strictly true, however, if we have an excess of instruments, but using the residuals as instruments does tend to enforce it. In some cases, the residuals can be good instruments—for example, the correlation of ε_t^n with $\tilde{n}_t$ is 0.41 (Brazil) and 0.88 (Chile). In other instances, we might expect that the conditional expectation would be a more powerful instrument. After estimation, we checked whether the shocks were mutually uncorrelated, and the correlations were not significantly different from zero. It is desirable to have uncorrelated shocks for well defined policy experiments.

As noted previously, our convention is that a coefficient α_{xy} shows a contemporaneous effect between x_t and y_t, β_{xy} shows the effect between x_t and y_{t-1}, and γ_{xy} is between x_t and y_{t-2}. Thus, the credit growth equation for Brazil could be written in the form

$$pc_t = \beta_{cc} pc_{t-1} + \beta_{cy} \tilde{y}_{t-1} + \beta_{ci} \hat{\imath}_{t-1} + \beta_{cz} \tilde{z}_{t-1} + \gamma_{cz} \tilde{z}_{t-2} + \varepsilon_t^c,$$

while the absorption equation might be written as

$$\tilde{n}_t = \alpha_{ne}(E_t \tilde{n}_{t+1}) + (1-\alpha_{ne})\tilde{n}_{t-1} + \beta_{nr}(\hat{\imath}_{t-1} - E_{t-1}\hat{\pi}_t) + \alpha_{nc} pc_t + \beta_{nc} pc_{t-1} + \varepsilon_t^n.$$

For the equations generating expectations, we add a superscript e to the coefficients. Hence, we have

$$E_t \hat{\pi}_{t+1} = \alpha_{\pi\pi}^e \hat{\pi}_t + \alpha_{\pi z}^e \tilde{z}_t + \alpha_{\pi y}^e \tilde{y}_t + \alpha_{\pi n}^e \tilde{n}_t + \beta_{\pi z}^e \tilde{z}_{t-1}.$$

3. Data

Our estimation data come from readily available official statistics for both countries. After describing these data sources and discussing some punctual issues regarding the choice of indicators for their theoretical counterparts, this section lays out and discusses some of the underlying methodological issues underpinning our estimates of output and absorption gap measures for each country.

3.1 Brazil

We restricted our sample to the inflation-targeting period as a response to evidence that large structural changes occurred around the point of its introduction. In particular, Tombini and Lago Alves (2006) find that inflation dynamics and exchange rate pass-through in Brazil recorded significant structural changes before and after 1999, while Minella (2003) reports far-reaching changes in the price indexation system and inflation dynamics after 1995.

Seasonally adjusted national income account data were taken from the IMF's *International Financial Statistics* (IFS) and the Brazilian Institute of Applied Economic Research (IPEA). Domestic bank credit to the private sector was taken from the same sources and seasonally adjusted using the X11 routine in AREMOS. The real exchange rate series is from the IMF and is computed as a weighted average among nearly all trading partners using CPI deflators and 2000 weights. The indicator of real world income was computed as the trade-weighted average of real GDP of the country's main trading partners, which account for over 80 percent of Brazil's trade.

The inflation variable is seasonally adjusted CPI including all items—with both administered and free market prices. While it is customary to separate the two on account of the belief that administered prices have a stronger backward-looking adjustment component (largely due to the nature of the multi-year contracts between the government and the new incumbents in the utility industries privatized in the 1990s), we see this distinction as somewhat artificial. For a number of reasons, it can be potentially misleading for the purpose of setting the monetary policy stance and is perhaps irrelevant if the task at hand is indeed to model aggregate inflation. First, administered prices still respond to demand pressures, albeit with a longer lag, because of backward-looking indexation clauses in the underlying concession contracts. Second, although utility prices are typically key inputs to free market prices, the interaction between the two is certainly complex, and simply including both series in a VAR is unlikely to address such complexity. Third, the extent to which wage earners make such a distinction between the types of inflation is unclear. Indeed, if they only care about overall inflation, second-round effects will stem from this, and that reduces the advantage of decoupling the two inflation rates. For these reasons, the estimation results reported below refer to the full CPI.

To parameterize equation (6), we need ω_m, ω_x, and $\bar{d}$. These were replaced by the average ratios of imports, exports, and net debt to GDP over 1999–2009. Because ω_m and ω_x were virtually the same over this period, we fix them both at 0.11. We used the average growth rate of real GDP over the period and target inflation (4.5 percent in recent years) to compute $\bar{\psi}$. This makes it 1.9 percent per quarter.

3.2 Chile

As with Brazil, we restrict our sample to the post-1999 period and use quarterly data throughout. Seasonally adjusted national income data were taken from the IMF's *International Financial Statistics* and the Central Bank of Chile. The real exchange rate series is from the IMF and is computed as a weighted average among nearly all trading partners using CPI deflators and 2000 weights. As in the case of Brazil, the indicator of real world income was computed as the trade-weighted average of real GDP of the country's main trading partners, which account for over 90 percent of Chile's foreign trade.

To parameterize equation (6), we need ω_m, ω_x, and $\bar{d}$. The first two were replaced by taking the simple average of ω_m and ω_x over 1999–2009. The debt ratio was the historical average over this period. Likewise, we used the average growth rate of real GDP (around 4 percent) and target inflation (3 percent) to compute $\bar{\psi}$. This makes it 1.95 percent per quarter.

3.3 Producing Gap Measures for Both Countries

Measures of output and absorption gaps are present in the skeletal model we use, so we need to estimate them. In much of the existing literature, the permanent component is extracted with the Hodrick-Prescott (HP) filter. As Harvey and Jaeger (1993) point out, however, the HP filter can be regarded as extracting a permanent component P_t from a series z_t by applying the Kalman smoother to the state space model:

$$z_t = P_t + T_t;$$

$$\Delta^2 P_t = v_t;$$

$$T_t = u_t;$$

$$\lambda = \frac{\mathrm{var}(u_t)}{\mathrm{var}(v_t)}.$$

The model clearly implies that

$$\begin{aligned}\Delta^2 z_t &= \Delta^2 P_t + \Delta^2 T_t \\ &= v_t + \Delta^2 u_t \\ &= e_t + \alpha_1 e_{t-1} + \alpha_2 e_{t-2},\end{aligned}$$

where e_t is an uncorrelated process. Setting $\lambda = 1{,}600$, we find that $\alpha_1 = -1.77$, $\alpha_2 = 0.8$. Fitting this model to Brazilian GDP data over 1999:1–2009:1, we get $\alpha_1 = -0.95$, $\alpha_2 = -0.05$. Of course this process has a common unit root to the moving average and autoregressive (AR) parts which cancels, implying that the log of Brazilian GDP is an I(1) process, which contrasts with the I(2) model implied by the HP filter.

This suggests that we want to use a measure of the permanent component of a series that is extracted under the assumption that data is I(1). One filter that does this is the Beveridge-Nelson (BN) filter. The logic of this is that the permanent value of z_t is

$$\begin{aligned}
P_t &= E_t(z_\infty) \\
&= E_t\left(z_t + \sum_{j=1}^{\infty} \Delta z_{t+j}\right) \\
&= z_t + E_t \sum_{j=1}^{\infty} \Delta z_{t+j},
\end{aligned}$$

such that the transitory component is $z_t - P_t = -E_t \sum_{j=1}^{\infty} \Delta z_{t+j}$, and this is the gap. We thus need to prescribe a model for Δz_t to be able to compute the transitory component. When Δz_t is an AR(p), $E_t \sum_{j=1}^{\infty} \Delta z_{t+j}$ will be a linear function of $\Delta z_t, \Delta z_{t-1}, \ldots, \Delta z_{t-p+1}$. In that case, the BN measure of the output gap is constructed as the negative of an average of growth rates. This means that one will see a negative relation between the output gap and growth, so that regressing inflation against output growth should produce a negative coefficient on the latter.

One criticism of the BN filter is that the resulting output gap estimate is not as smooth as the HP-filtered estimate. This may well be true when a low-order AR process is used to approximate Δy_t, but a higher-order AR often produces much smoother results (see, for example, Morley, 2007). The intuition is that the gap is constructed by averaging growth rates, which generally results in some persistence in the output gap measure. However, the greater smoothness seen with the HP filter comes from two sources. One is the assumption that the permanent component evolves very smoothly, that is, it is I(2), and the other is that it is a two-sided filter that uses weighted averages of growth rates in both the past and the future. To demonstrate this, we applied an HP filter to the Brazilian log of GDP series and then regressed this against three lagged and forward values of GDP growth. That produced a regression of the form

$$\begin{aligned}
\tilde{y}_t^{HP} = {} & 0.45\Delta y_t + 0.28\Delta y_{t-1} + 0.17\Delta y_{t-2} + 0.20\Delta y_{t-3} \\
& -0.39\Delta y_{t+1} - 0.28\Delta y_{t+2} - 0.30\Delta y_{t+3}.
\end{aligned}$$

While 75 percent of the variation in $\tilde{y}_t^{HP}$ is explained by these variables, only 33 percent is due to the lagged and current values of Δy_t. The BN filter is therefore unlikely to approximate the HP filter too closely while it remains a one-sided filter. The relation between the HP-filtered gap and growth rates seen above shows that there are clear econometric issues with using the former as a regressor, since future values of the growth rates are involved. Laxton, Shoom, and Tetlow (1992) perform a simulation experiment in which the potential level of output actually followed an I(1) process. They find that using the output gap from an HP filter produces an estimate for the parameter on the output gap in a Phillips curve that is well below the true value used in producing the simulated data.

In each case, the BN-filtered output and absorption gaps were determined by fitting an AR(4) to growth rates over the sample period. We ran into difficulties measuring the foreign output gap, however, in that the appropriate series (the trade-weighted GDP of Brazil's and Chile's trading partners) have extremely persistent growth rates: fitting an AR(1) to Brazilian data for 1999:1–2009:1 yielded a point estimate of the AR(1) coefficient of 0.99. Hence, the BN filter is not appropriate in this case, whereas the HP filter is much closer to what is needed. Since we have no model of trading partners' GDP (this is treated as exogenous), there seems to be no reason not to use the HP filter on that data to produce a foreign output gap.

4. Model Estimates

This section presents the estimated structural VAR models for Brazil and Chile, along with the impulse responses to a 100 basis point rise in the annualized interest rate and a 1 percentage point rise in the growth rate of credit. These increases are relative to the steady-state levels, and all variables in the model equations are intended to be measured that way. Thus, what is being explained is the nature of the adjustment back to equilibrium. There may be forces here that are not present in equilibrium (for example, nominal interest rates may affect disequilibrium expenditure), but in equilibrium we expect that expenditure will be governed by the real interest rate.

As we observed in the introduction, papers based on SVAR models rarely present the structure, but rather only report the impulse responses. One reason for this is that it is quite possible to have reasonable impulse responses resulting from what might appear to be odd-looking structural equations. But there are three compelling reasons to present the structural equations of our model. First, it reveals how the skeletal model needs to be modified to fit the data. This provides some information for those who wish to work with a theoretical model that is close to our skeletal one, and quite a few papers use variants of our skeletal model for policy analysis in emerging economies.

Second, it is sometimes useful to refer back to the structural equations when seeking an explanation for either the pattern or the magnitude of the impulse responses. Indeed, one can conduct sensitivity analysis by varying the estimated structural parameters to see what the effect would be of adopting alternative parameter values. Given our small sample sizes, we cannot precisely determine the values of these parameters, so it is useful to be able to assess how sensitive our conclusions are to the point estimates of the structural equations used in constructing the impulse responses. This is a central theme in Del Negro and Schorfheide (2008).

Third, a principle of full disclosure seems desirable in empirical work. This would seem to demand the provision of information on the structural equations, even though this is rarely done.

The model uses annualized inflation and interest rates. This means that the UIP equation has to be changed accordingly. Gaps are in percentage values. The debt ratio is measured as net debt to annualized GDP.

4.1 Brazil

The structural VAR that was fitted is given below, with t ratios in parentheses:

$$pc_t = -\underset{(-2.37)}{0.35}\, pc_{t-1} + \underset{(2.18)}{2.67}\, \tilde{y}_{t-1} - \underset{(-2.19)}{1.26}\, \hat{\imath}_{t-1} + \underset{(3.44)}{0.603}\, \tilde{z}_{t-1} - \underset{(-1.71)}{0.326}\, \tilde{z}_{t-2} + \varepsilon_t^c;$$

$$\tilde{n}_t - \tilde{n}_{t-1} = \underset{(12.86)}{0.61}\left[E_t(\tilde{n}_{t+1}) - \tilde{n}_{t-1}\right] - \underset{(-2.66)}{0.025}\, \hat{r}_{t-1} + \underset{(1.22)}{0.004}\, pc_t + \underset{(2.29)}{0.006}\, pc_{t-1} + \varepsilon_t^n;$$

$$\tilde{y}_t = \underset{(1.92)}{0.61}\, \tilde{n}_t - \underset{(-1.92)}{0.02}\, \tilde{z}_{t-1} + \underset{(2.92)}{0.42}\, \tilde{y}_{t-1} + \varepsilon_t^y;$$

$$\hat{\pi}_t - \hat{\pi}_{t-1} = \underset{(4.86)}{0.58}\left[E_t(\hat{\pi}_{t+1}) - \hat{\pi}_{t-1}\right] + \underset{(0.84)}{0.79}\, \tilde{n}_t - \underset{(-3.01)}{0.17}\, \tilde{z}_{t-1} + \underset{(2.49)}{0.15}\, \tilde{z}_{t-2} + \varepsilon_t^\pi;$$

$$\hat{\imath}_t = \underset{(10.48)}{1.08}\, \hat{\imath}_{t-1} + \underset{(3.20)}{0.26}\, E_t \hat{\pi}_{t+1} - \underset{(-3.93)}{0.32}\, \hat{\imath}_{t-2} - \underset{(-1.54)}{0.02}\, \tilde{z}_{t-1} + \varepsilon_t^i;$$

$$\zeta_t = \underset{(1.10)}{0.27}(\tilde{z}_{t-1} - E_{t-1}\tilde{z}_t) - \underset{(2.80)}{0.43}\hat{\imath}_{t-1} + \underset{(2.90)}{0.56}\hat{r}^*_{t-1} + \underset{(2.10)}{0.28}\hat{d}_{t-1}$$
$$+ \underset{(1.93)}{0.17}\tilde{z}_{t-1} + \underset{(0.47)}{0.08}E_{t-1}\hat{\pi}_t + \varepsilon^z_t;$$

$$\zeta_t = \tilde{z}_t - E_t\tilde{z}_{t+1} - \left[\frac{(\hat{r}_t - \hat{r}^*_t)}{4}\right].$$

The equations generating expectations are as follows:

$$E_t\hat{\pi}_{t+1} = \underset{(2.89)}{0.38}\hat{\pi}_t - \underset{(-4.58)}{0.28}\tilde{z}_t + \underset{(3.72)}{0.22}\tilde{z}_{t-1} + \underset{(1.74)}{1.29}\tilde{n}_t;$$

$$E_t\tilde{n}_{t+1} = -\underset{(-2.46)}{0.07}\hat{\imath}_t + \underset{(2.25)}{0.016}\tilde{z}_t - \underset{(-2.67)}{0.02}\tilde{z}_{t-1} + \underset{(6.90)}{1.02}\tilde{n}_t - \underset{(-5.83)}{0.70}\tilde{n}_{t-1} + \underset{(1.65)}{0.01}pc_t;$$

$$E_t\tilde{z}_{t+1} = \underset{(1.79)}{0.26}\tilde{z}_t - \underset{(-0.95)}{0.91}\tilde{y}_t - \underset{(-2.07)}{4.12}\tilde{n}_t + \underset{(3.76)}{6.35}\tilde{y}^*_t - \underset{(-4.21)}{0.80}\hat{d}_t.$$

In constructing these equations, we tried to err on the side of caution given the small number of available observations. Consequently, we generally used the basic rule that a variable was left in the structural equations if it had a t ratio greater than (or close enough to) unity. This is the equivalent of applying the Akaike information criterion (AIC) to decide whether a regressor should be retained. In some instances, we introduced a variable into the model even though it was not significant. If the variable was supposed to be present in the skeletal model, then the lack of significance represents evidence in the data against that part of the model. In other cases, we included the variables in anticipation of queries from readers.

We start our analysis with the credit growth equation, which is negatively affected by interest rates (in particular, by nominal rather than real rates, although these rates are measured relative to their equilibrium, which includes target inflation) and positively by the output gap. The high magnitude of the coefficient on the output gap is a response to the very high growth in credit relative to GDP. This highlights the importance of improving the excess credit variable in the face of major changes in credit availability over the sample period. The positive exchange rate effect that might have been expected from our earlier discussion is also observed.

Credit growth then augments the absorption equation provided by the skeletal model. It seems to play a significant role in affecting absorption.[13] Moreover, forward-looking expectations seem to dominate the backward component (0.61 versus 0.39). This might be regarded as unusual for many advanced economies, but it is consistent with the conclusion of Caputo, Liendo, and Medina (2007) for Chile. However, setting the coefficient to 0.50 would not be inconsistent with the data at standard levels of statistical significance.

Since the skeletal model has an identity for GDP connecting absorption, imports, and exports, we need import and export price and income elasticities to complete it. Given that those are unavailable, we fitted a regression to capture these missing functions. The import and export shares are much the same in Brazil, so the dependent variable is basically the deviation of the current account from its steady-state value. The terms are much like what we would expect, although the exchange rate effects are not particularly strong. No lags in absorption were significant in this equation.

The inflation equation is close to the skeletal one, although the absorption gap (a better-performing variable than the output gap in this case) is not significant. The prediction by the skeletal model that it is the change in the exchange rate that affects inflation is easily accepted, but we have chosen to leave the exchange rate in levels rather than differences.

The interest rate rule has neither an absorption gap nor an output gap, which is in line with Furlani, Portugal, and Laurini (2008). Expected inflation produced a better fit than actual inflation. The exchange rate has a small impact on interest rate decisions, and we therefore left it in the relation. The most striking difference with the skeletal model is the presence of a second lag in interest rates. As noted earlier, this equation can be rewritten in terms of a first-order lag of the policy interest rate with a coefficient of 0.76 and a lagged change in the policy rate with a coefficient of 0.32, that is, $0.76\hat{\imath}_{t-1} + 0.32\Delta\hat{\imath}_{t-1}$.

The exchange rate equation is more complex than habitually found in the literature, particularly in the stylized DSGE models used to fit these countries, as reviewed earlier. To clarify, we generalized the skeletal model by replacing $E_t\tilde{z}_{t+1}$ with $[\phi\tilde{z}_{t-1}+(1-\phi)E_t\tilde{z}_{t+1}]$. A number of empirical implementations of theoretical models perform this step to reflect the well-known failure of UIP in exchange rates in the short-run (see Berg, Karam, and Laxton, 2006). It produces the

13. The estimated equation involved $\Delta\tilde{n}_t$ as the dependent variable and $E_t(\tilde{n}_{t+1}-\tilde{n}_{t-1})$ as a regressor. We used $E_{t-1}\tilde{n}_t$and $\tilde{n}_{t-1}$ as separate instruments for the latter variable. This was also true of the inflation equation.

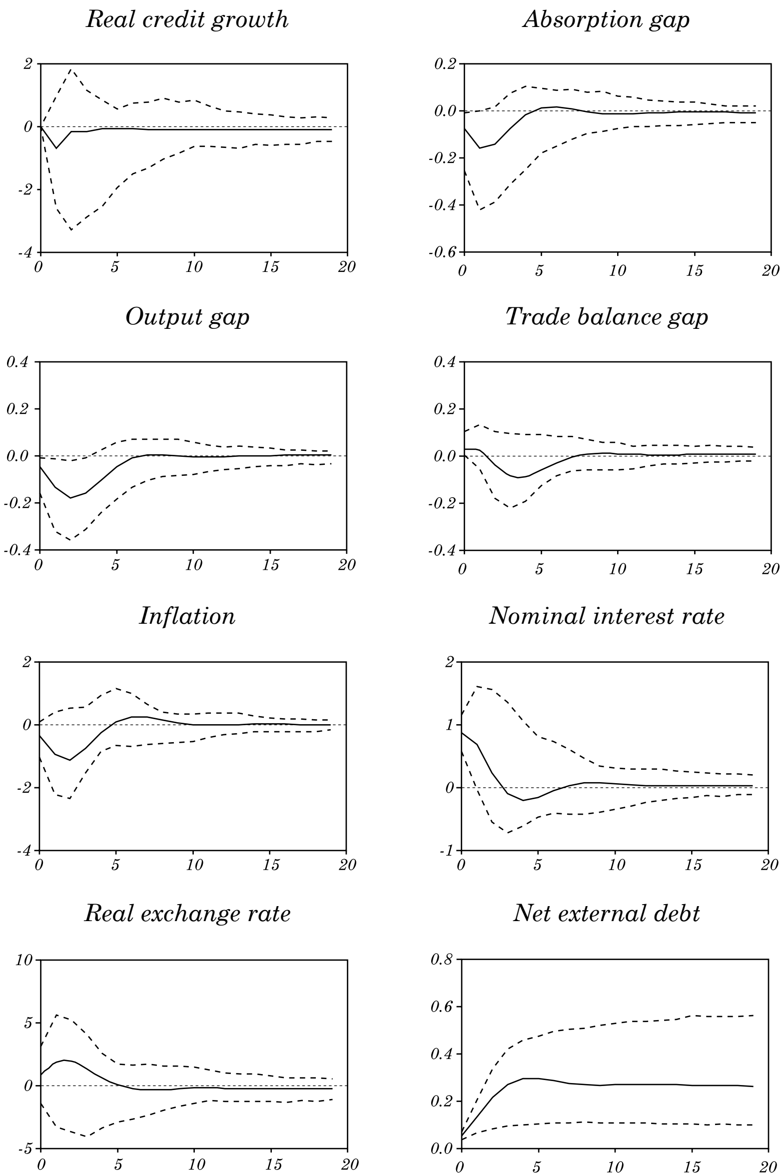
first term on the right-hand side of our estimated equation, except for a component $\phi(E_t\tilde{z}_{t+1} - E_{t-1}\tilde{z}_t)$. However, this latter term had a zero coefficient when we added it to the regression. The lagged nominal interest rate might seem to be an odd regressor. To show that it is not proxying for a real interest rate, we added in the expected inflation rate, which clearly is not accepted by the data. Once again, however, we note that $\hat{\imath}_t$ is measured as a deviation from an equilibrium rate. Since this includes the expected inflation rate, $\hat{\imath}_t$ cannot be thought of as a purely nominal rate.

Figure 1 gives the impulse responses for the 100 basis point rise in interest rates; figure 2 contains those for a 1 percent increase in credit growth. The figures also present the confidence intervals, which were chosen by simulating the model with the point estimates of the parameters and then choosing the range from 2.5 percent to 97.5 percent for the simulated parameter estimates. In these simulations, the estimated parameters might imply an unstable VAR, as the debt equation is always close to a unit root. When it was unstable, we discarded the simulated values.[14]

First, the interest rate rise. The strong exchange rate appreciation, rather than the output gap effect, is probably what produces the inflation response. There is no price puzzle or exchange rate puzzle in the results. The bulk of the effects take place within five quarters. This entails a much shorter lag than in traditional closed economy models, based on what existing estimates show for the United States and the euro area (see Angeloni and others, 2003). The immediate contractionary impact of the rate rise on the absorption gap is stronger than on the real GDP gap, so the trade balance improves. At the same time, the higher onshore-offshore interest rate differential appreciates the real exchange rate (UIP-type effects) and boosts external debt (for example, through the carry trade). Consistent with the theories discussed above on the credit channel in emerging markets, the initial real exchange rate appreciation tends to boost bank credit growth (through both a higher relative price of nontradeables and a positive balance sheet effect), which somewhat offsets the negative effect of monetary tightening on absorption through the intertemporal channel. Thus, the positive effects of the appreciation on credit growth

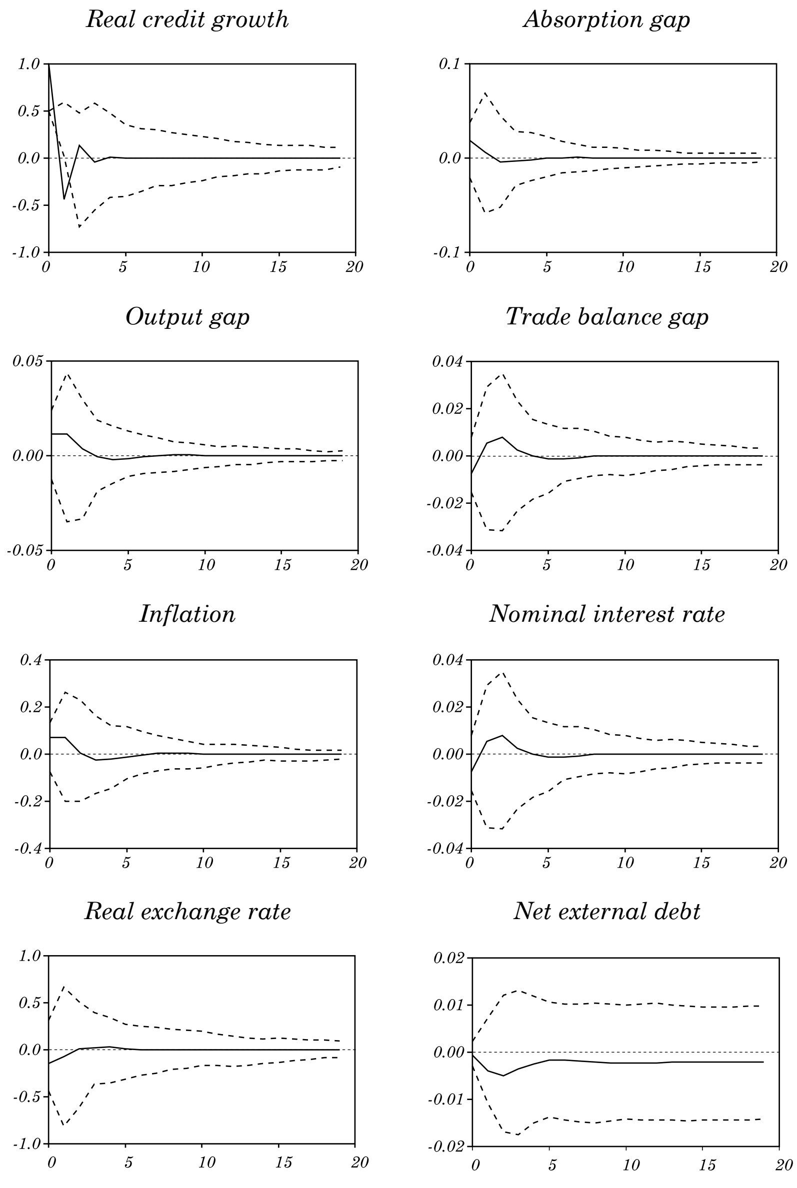
14. The oscillations in the credit shock confidence intervals come from the fact that the autoregressive parameter in the credit growth equation is negative. Because the point estimate is small, the effect dies out quickly in the estimated impulse responses. Some simulations, however, yield a large negative value, in which case the oscillations persist for quite some time.

Figure 1. Brazil: Impulse Responses to a One Percent Rise in the Annualized Interest Rate



Source: Authors' calculations.

Figure 2. Brazil: Impulse Responses to a One Percent Rise in Credit Growth



Source: Authors' calculations.

and absorption kick in. The trade balance deteriorates between the second and fifth quarters after the shock, while the pace of disinflation and credit contraction both slow down. Overall, though, the negative intertemporal channel still dominates, ultimately leading to a fall in inflation, real credit growth, and absorption on average over the entire post-shock period.

In the experiment involving credit growth, we see a rise in absorption and a rise in inflation. As expected, the absorption gap (which is equivalent to absorption growth in the immediate aftermath of the shock) increases by around .02 percent. It rapidly disappears, however, as interest rates rise and an exchange rate depreciation chokes off credit growth and absorption. The effects are even more short-lived than those associated with interest rate shocks, particularly regarding credit growth, in that they virtually vanish after four quarters. The same rise and fall is true for inflation, although it lasts a quarter or two longer. Given that there have been very large movements in real credit growth—with one standard deviation being the equivalent of 9 percent (annualized) growth—the impulse responses understate the impact of credit over the period, since the norm is not 1 percent growth but variations that are about nine times as high. This indicates that the macroeconomic effects of a standard deviation in credit growth appear to be of a higher magnitude and shorter duration than in developed countries.[15] The strength of the credit channel is robust to dropping the other feature of our model, which distinguishes it from more standard New Keynesian set-ups estimated in previous work—namely, the debt accumulation equation.[16] This indicates that the credit channel of monetary transmission is important in itself, quite separately from the open economy features of the skeletal model.

4.2 Chile

The structural VAR for Chile is fitted over 1999:1–2008:4, and its equations are given below. As for Brazil, the absolute *t* ratios are in parentheses. The import, export, and debt ratios were set to their

15. See the discussion by Eichenbaum (1994) on the difficulties of identifying credit channel effects in empirical work on the United States, for which longer and better data series and more disaggregated empirical evidence are available.

16. As one might expect, the main effect of shutting off the debt accumulation equation is on the real exchange rate response. Estimated impulse responses with the debt accumulation equation shut off are not reported to conserve space, but they are readily available on request.

averages over the period, and the nominal growth in potential GDP was set to 1.95 percent per quarter, based on a potential annual growth rate of 4.0 percent and target inflation of 3 percent per year. The results are not sensitive to this choice.

$$pc_t = \underset{(2.93)}{0.5}\, pc_{t-1} - \underset{(-0.83)}{0.57}\, \hat{r}_{t-1} + \underset{(0.66)}{0.15}\, \tilde{z}_{t-1} - \underset{(-0.77)}{0.17}\, \tilde{z}_{t-2} + \varepsilon_t^c;$$

$$\tilde{n}_t - \tilde{n}_{t-1} = \underset{(5.53)}{0.65}\left[E_t(\tilde{n}_{t+1}) - \tilde{n}_{t-1}\right] - \underset{(-1.40)}{0.15}\, \hat{r}_{t-2} + \underset{(1.33)}{0.04}\, pc_{t-1} - \underset{(-2.25)}{0.06}\, pc_{t-2} + \varepsilon_t^n;$$

$$\tilde{y}_t = \underset{(2.43)}{0.30}\, \tilde{n}_{t-1} - \underset{(-1.58)}{0.05}\, \tilde{z}_{t-1} + \underset{(1.65)}{0.05}\, \tilde{z}_{t-2} + \underset{(3.02)}{0.43}\, \tilde{y}_{t-1} + \varepsilon_t^y;$$

$$\begin{aligned}\hat{\pi}_t - \hat{\pi}_{t-1} = {} & \underset{(10.35)}{0.49}\left[E_t(\hat{\pi}_{t+1}) - \hat{\pi}_{t-1}\right] + \underset{(2.86)}{0.21}\, \tilde{y}_t - \underset{(-3.17)}{0.05}\, \tilde{z}_t \\ & + \underset{(3.06)}{0.04}\, \tilde{z}_{t-1} + \underset{(3.57)}{0.03}\, pc_t + \varepsilon_t^{\pi};\end{aligned}$$

$$\hat{\imath}_t = \underset{(8.73)}{1.23}\, \hat{\imath}_{t-1} - \underset{(-3.46)}{0.45}\, \hat{\imath}_{t-2} + \underset{(0.98)}{0.16}\, \tilde{y}_t + \underset{(2.87)}{0.14}\, E_t(\hat{\pi}_{t+1}) + \varepsilon_t^i;$$

$$\zeta_t = \underset{(7.38)}{0.60}\, \tilde{z}_{t-1} - \underset{(-3.17)}{0.22}\, \tilde{z}_{t-2} + \underset{(4.38)}{0.29}\, \hat{d}_t + \varepsilon_t^z;$$

$$\zeta_t = \tilde{z}_t - E_t \tilde{z}_{t+1} - \left[\frac{(\hat{r}_t - \hat{r}_t^*)}{4}\right].$$

The equations generating expectations are as follows:

$$E_t \hat{\pi}_{t+1} = \underset{(10.19)}{1.41}\, \hat{\pi}_t - \underset{(-4.34)}{0.63}\, \hat{\pi}_{t-1} + \underset{(1.16)}{0.117}\, \tilde{n}_t + \underset{(1.59)}{0.025}\, pc_{t-1} + \underset{(2.65)}{0.325}\, \tilde{y}_t^*;$$

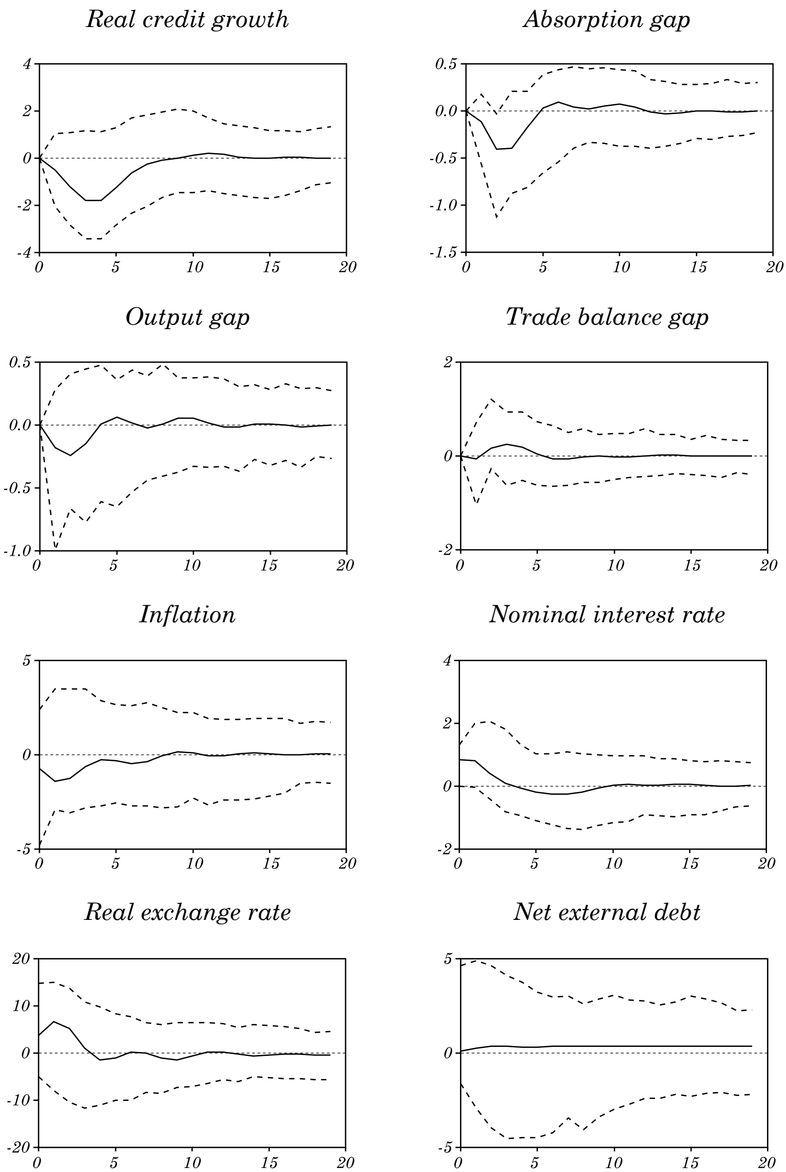
$$E_t \tilde{n}_{t+1} = -\underset{(-1.16)}{0.13}\, \hat{\imath}_{t-1} + \underset{(1.72)}{0.4}\, \tilde{y}_t - \underset{(-1.39)}{0.26}\, \tilde{y}_{t-1} - \underset{(-3.81)}{0.513}\, \tilde{n}_{t-1} + \underset{(1.89)}{0.314}\, \tilde{y}_t^*;$$

$$E_t \tilde{z}_{t+1} = \underset{(2.38)}{1.15}\, \hat{\imath}_t + \underset{(3.49)}{0.64}\, \tilde{z}_t - \underset{(-2.21)}{0.32}\, \tilde{z}_{t-1} - \underset{(-2.55)}{0.28}\, pc_{t-1} - \underset{(-3.43)}{0.63}\, \hat{d}_t + \underset{(1.13)}{0.96}\, \tilde{y}_t^*.$$

There are some notable similarities and differences with the Brazilian case. First, the exchange rate effect on credit growth is much weaker than in Brazil and more imprecisely estimated. The weaker effect may reflect the greater hedging of private sector balance sheets in Chile, which makes them less sensitive to currency valuation effects. Second, as in Brazil, credit affects absorption, probably through the growth of credit rather than the level, which is consistent with the fact that the dependent variable is the growth in absorption. Third, in terms of the output equation, the exchange rate effects are more than twice as strong for Chile as for Brazil, and they enter as rates of change (since the estimated coefficients on $\tilde{z}_{t-1}$ and $\tilde{z}_{t-2}$ are the same). This points to a higher elasticity of the trade balance to the real exchange rate in Chile. At the same time, the impact of domestic absorption on the real GDP gap is not as strong, consistent with Chile being a much more open economy. Credit has a direct effect on inflation, and the coefficient on the output gap is very statistically significant. As in Brazil, the exchange rate clearly plays a nontrivial role in inflation, despite the general wisdom that exchange rate pass-through is lower in Chile. Indeed, the point estimate of –0.05 on the real exchange rate change ($\Delta\tilde{z}_t$) in the inflation equation suggests that a 10 percent nominal appreciation lowers CPI inflation by 50 basis points, all else constant. This is a nonnegligible effect. When we combine this estimate with the evidence that the exchange rate is highly responsive to shocks to the domestic interest rate (as illustrated in the impulse responses below), it follows that interest rate shocks do have a sizeable effect on inflation, not just through the output gap effect but also via the exchange pass-through into domestic CPI.

The interest rate equation resembles the results for Brazil in that it has two lags of the interest rate and a significant positive response to expected inflation. The output gap has a stronger effect on interest rate setting than was the case for Brazil, though neither is precisely estimated. The coefficient on expected inflation is less than $1-\beta_{ii}-\gamma_{ii}$, so the Taylor principle fails. This does not lead to explosive inflation, however, because there is a separate exchange-rate-induced effect on inflation in an open economy and because expectations are generated independently of the structural model. Finally, as in Brazil, deviations from UIP are significantly related to changes in the debt-to-GDP ratio, $\hat{d}_t$, implying that fluctuations in net external debt have a significant impact on exchange rate dynamics, consistent with our earlier theoretical discussion.

Figure 3. Chile: Impulse Responses to a One Percent Rise in the Annualized Interest Rate



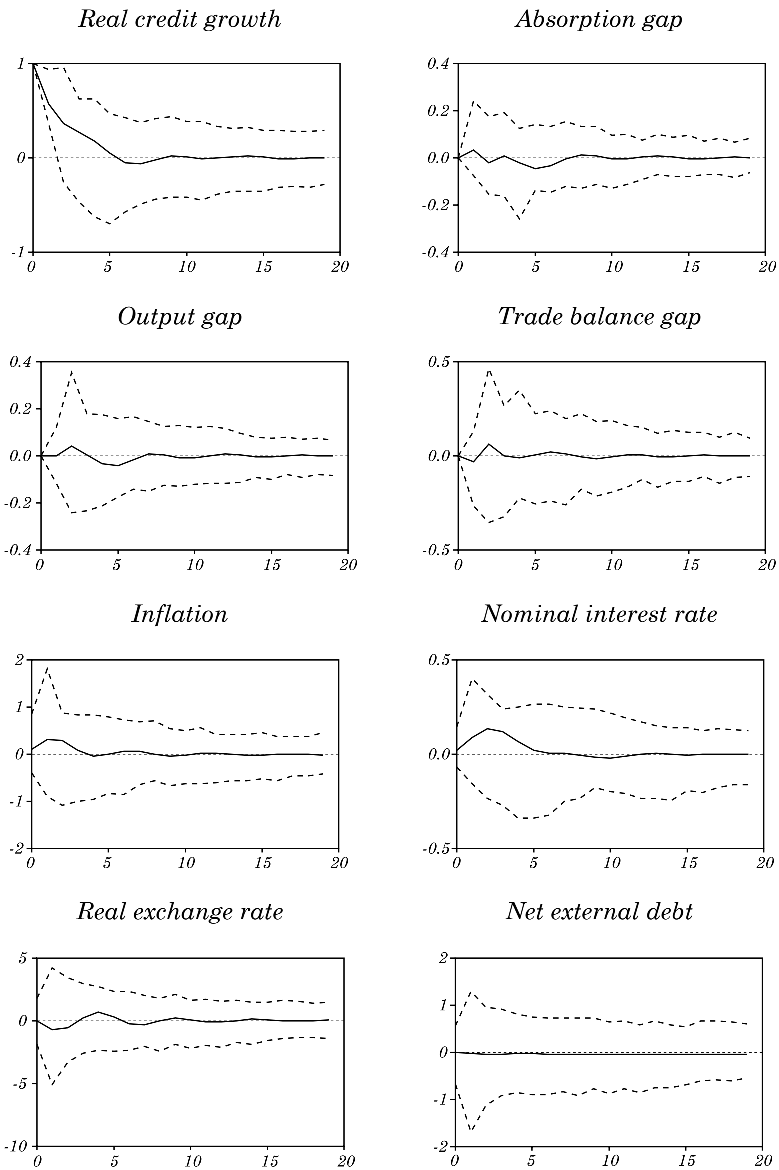
Source: Authors' calculations.

If a recursive SVAR(2) was fitted to a standard ordering of variables $\{\tilde{y}_t, \hat{\pi}_t, \hat{\imath}_t, \tilde{z}_t\}$, one would find that a rise in interest rates causes a rise in inflation and an initial depreciation in the exchange rate. This finding holds when the system is expanded to the full set of variables $\{pc_t, \tilde{n}_t, \tilde{y}_t, \hat{\pi}_t, \hat{\imath}_t, \tilde{z}_t, \tilde{d}_t\}$. The structural VAR impulses given in figure 3, however, are very different and consistent with what one would get with standard New Keynesian models. One reason for the differences would seem to lie in the very strong exchange rate appreciation in Chile relative to other emerging market countries, despite the relatively low pass-through. At the heart of it is the very strong exchange rate response in Chile to the onshore-offshore interest rate differential: figure 3 indicates that the real exchange rate response to monetary tightening is more than twice as high as in Brazil, with the real exchange rate appreciating by over 6.7 percent at its peak in response to a 100 basis point rise in the domestic policy rate, all else constant. This compares with a 2.0 percent response in Brazil, whereas the effect through the external debt term is similar in the two countries (0.28 in Chile versus 0.29 in Brazil). So, while our single equation estimates shown above indicate that the exchange rate pass-through to CPI is nearly three times lower in Chile than in Brazil, the effect of monetary policy on inflation through the exchange rate channel is quite strong in Chile because the exchange rate is so responsive to onshore-offshore interest rate differentials.

Figure 4 shows the results of a shock of a 1 percent increase in credit growth in Chile. Again, the results are similar to Brazil, although the exchange rate effects (a depreciation) are substantially stronger. Because the standard deviation of the estimated credit growth equation shock is around half of that for Brazil, performing one-standard-deviation shocks would make the results for the two countries comparable, though still stronger in Chile.[17] This seems consistent with the evidence of a much greater banking sector penetration in Chile than in Brazil, as gauged by standard indicators of financial depth such as the ratio of bank credit to GDP (72 percent in Chile versus 40 percent in Brazil in 2008).

17. As with Brazil, the estimated strength of the credit channel in Chile is robust to dropping the debt accumulation equation from the model, so it stands on its own relative to the open economy features of this model economy. The respective estimates are available on request.

Figure 4. Chile: Impulse Responses to a One Percent Rise in Credit Growth



Source: Authors' calculations.

5. Conclusion

This paper has laid out a structural model of monetary transmission that incorporates key features of emerging markets in a manner parsimonious enough to be estimated with existing data and yet grounded on a DSGE theoretical skeleton. In particular, we have allowed for the role of a bank-dependent domestic sector and the impact of bank credit on aggregate demand and external aggregates that have not featured in previous studies. An SVAR representation of the model was derived and used to examine the Brazilian and Chilean experiences with full-fledged inflation-targeting regimes since 1999. The two countries display important differences in economic structure and in the track record of economic policymaking. Most notably, Brazil is far more closed to trade, is less reliant on primary commodities, and has a more recent record of monetary and inflation stability than Chile. These differences make a comparative assessment of monetary transmission in the two countries particularly interesting. This diversity also provides a strict test of the general validity of the skeletal model and our estimation approach.

Our SVAR estimates yield very reasonable results for both countries. Indeed, we find no price puzzles, exchange rate puzzles, or any counterintuitive results in the impulse responses, which are common in VAR studies. This suggests that the proposal of a DSGE skeletal model as the basis of a structural VAR representation might provide a useful approach for examining monetary transmission in other emerging markets that are operating inflation-targeting regimes.

A common finding is that the transmission mechanism operates with shorter lags than in advanced countries (notably the United States): the bulk of the effects on output and inflation take place within five quarters. This is arguably consistent with structural factors (such as the shorter maturity of domestic credit) and the still-considerable (albeit reduced) weight of the exchange rate and imported inflation in domestic currency pricing, as is often mentioned in the literature.

The exchange rate effects on disinflation are nontrivial. This is all the more interesting in Brazil, which is still relatively closed to foreign trade, with ratios of exports and imports to GDP below 15 percent. Both countries display a sizable effect on the exchange rate of changes in the domestic interest rate policy, and net external debt accumulation has a significant bearing on deviations from UIP. This is consistent with structural models based on interest parity with an endogenous country risk premium. These have featured in the literature of other countries, but have not been as prominent in previous work on Brazil and Chile. The strong exchange rate response to such risk-adjusted interest rate differentials helps explain recent episodes of large real currency swings, as both net external debt and onshore-offshore interest rate differentials have varied widely in recent years.

Regarding the role of bank credit in monetary transmission, our estimates indicate a nontrivial role for bank credit in monetary propagation. In both countries, there is evidence that changes in the policy rate affect credit growth and that the latter affects absorption. Moreover, at least in the case of Brazil, such a credit channel plays an intratemporal role in moderating the impact of monetary policy shocks on absorption via exchange rate effects: while higher interest rates reduce absorption through the standard intertemporal effect, they also boost bank credit demand via the short-run exchange rate appreciation that monetary tightening typically entails. The attendant balance sheet and wealth effects arising from such currency appreciations (particularly for nontradables producers, which tend to be more dependent on bank credit) thus mitigates the otherwise standard contractionary effect that monetary tightening has on absorption. Even though the contractionary effect wins out in the aggregate, it appears to be somewhat mitigated by the intratemporal exchange rate effect. We also find an independent role for credit shocks, which may reflect changes in reserve requirements and other regulations, as well as shocks to intermediation efficiency. Our estimates suggest that there are nontrivial effects on output and inflation in both countries, although these are reasonably short-lived, particularly in the case of Brazil.

An obvious practical implication is that policies that affect bank credit have direct effect on output and inflation in both countries, at least in the short run. This may incidentally help explain the relative shallowness of the recent financial crisis in both countries, despite the sheer size of the external adverse shock to these countries' terms of trade, trading partners' income, and country risk. The far-reaching countercyclical credit policies implemented in both countries mitigated the fall in absorption and prevented a bank crisis, which—given the significance of the estimated impact on absorption—would have greatly added to the contractionary impact of the external shock.

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Revisiting Overborrowing and its Policy Implications

Gianluca Benigno
London School of Economics

Huigang Chen
JD Power

Christopher Otrok
University of Virginia

Alessandro Rebucci
Inter-American Development Bank

Eric R. Young
University of Virginia

Economies with imperfect financial market access may experience crises that cause significant economic dislocation. These crises are characterized by the sudden stop of domestic or international credit flows and they are associated with large declines in consumption, output, relative prices, and asset prices.[1]

An important question for emerging-market economies is whether, in normal times when access to financial markets is unconstrained and

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1. The recent global crisis arising from the U.S. subprime mortgage market is the most vivid example of a financial sudden stop, but the long sequence of emerging market crashes since the mid-1990s is an equally important illustration of how disruptive financial "sudden stops" can be.

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plentiful, excessive borrowing affects the likelihood and the severity of these crises. This question is important because the policy implications of alternative answers are very different. If there is excessive or inefficient borrowing in good times (that is, "overborrowing"), policy should be geared primarily toward addressing the ex ante inefficiency that causes it; for example, by imposing a tax on capital flows or other forms of capital controls and prudential regulations to reduce the incentives to borrow excessively.[2] In this case, policy should focus less on mitigating the consequences of a crisis when one occurs, and more on strengthening the ex ante incentives to borrow efficiently in good times. In contrast, if there is no overborrowing in good times, policy should focus primarily on designing efficient ex post intervention mechanisms in bad times (such as nationally or multilaterally financed bailouts), to minimize the costs of the inevitable crises associated with imperfect access to financial markets.[3] We emphasize here that, as Benigno and others (2009) discuss, there is an important link between ex ante and ex post policies: indeed, full knowledge of ex post policies might modify agents' behavior in normal times and hence the required ex ante intervention.

A rapidly growing literature has examined this issue. In early contributions, Fernández-Arias and Lombardo (1998) and Uribe (2007) examined the possibility of overborrowing in economies subject to exogenous (either individual or aggregate) debt limits. More recently, Lorenzoni (2008) and Korinek (2010) have explored the possibility of overborrowing qualitatively in models in which the debt limit is endogenous. Uribe (2007) and Bianchi (2009) examined the issue quantitatively with contrasting results. While Uribe (2007) finds no overborrowing, Bianchi (2009) finds that overborrowing is quantitatively relevant and has significant welfare implications. In endowment economies, Korinek (2010) and Bianchi (2009) suggest that only macro-prudential policies have scope to prevent and mitigate crises. In contrast, based on a model with production similar to the one used in this paper, Benigno and others (forthcoming) find underborrowing in their baseline model and conclude that both ex ante and ex post policy interventions are needed to achieve constrained efficiency.[4]

2. See, for instance, the recent introduction of a tax on international portfolio flows by Brazil, or Chile's earlier experience with capital controls on foreign inflows.

3. See Caballero (2010) for a detailed discussion of alternative modalities of ex post interventions.

4. Benigno and others (2009) find that it is optimal (in Ramsey's sense) to intervene ex post, once a sudden stop actually occurs.

This paper analyzes quantitatively the extent to which there is overborrowing in a business cycle model for emerging market economies. We investigate overborrowing in a small, open-economy model with production and imperfect access to international capital markets, as in Benigno and others (forthcoming). Our occasionally binding credit constraint is embedded in a standard two-sector (tradable and non-tradable goods) small open economy in which financial markets are not only incomplete but also imperfect, as in Mendoza (2002). For simplicity's sake, in this model production occurs only in the non-tradable sector of the economy. The asset menu is restricted to a single-period, risk-free bond paying off the exogenously given foreign interest rate. In addition to asset market incompleteness, we assume that access to foreign financing is constrained to a fraction of households' total income. Thus, foreign borrowing is denominated in units of the tradable good but is leveraged on income generated at different relative prices (that is, the relative price of a non-tradable good). The specification of the borrowing constraint thus captures "liability dollarization," a key feature of emerging market capital structure (for example, Krugman, 1999; Aghion, Bacchetta, and Banerjee, 2004).[5] As is well known, however, pecuniary externalities like the one at work in our model can arise in much more general circumstances: namely, whenever a relative price enters the specification of a financial friction in a multiple good economy (see Arnott, Greenwald, and Stiglitz, 1994 for a detailed discussion and a survey of the theoretical literature).

Two defining features of this environment are common in most of the related literature. First, the international borrowing constraint binds only occasionally: the crisis, defined as the event in which the constraint binds, is an endogenous event that depends on agents' decisions, the policy regime, and the state of the economy. Second, in this environment the scope for policy intervention arises from the existence of a pecuniary externality stemming from individual agents failing to internalize the aggregate impact of their borrowing decisions on the relative price of non-tradable goods. This in turn affects the value of collateral.[6]

5. The latest wave of crises in emerging Europe and corporate sector problems in Mexico and Brazil in the fourth quarter of 2008 represent striking evidence of the importance of this kind of feature.

6. Benigno and others (2009), among others, show that the competitive equilibrium allocation of this economy is not constrained-efficient in the sense of Kehoe and Levine (1993). Benigno and others (2009) also discuss how efficiency can be restored with a distortionary tax on non-tradable consumption in a deterministic two-period version of the model used here. Implementation issues are not discussed further in this paper.

To investigate overborrowing quantitatively we compare the competitive equilibrium (CE) with the constrained efficient allocation chosen by a welfare-maximizing social planner (SP), and solve using global solution methods. That is, we solve for decision rules for all endogenous variables across both states of the world, when the constraint binds and when it does not. This approach assumes that behavior distant from crisis periods is based on full knowledge of what the equilibrium will be when the economy enters the crisis state. This solution method, while computationally costly, is critical for understanding the interaction between different states of the world.[7]

We find that overborrowing is a quantitative matter: it depends on both the model specification and the values for model parameters. Specifically, in our production model, CE and SP allocations diverge when the constraint binds and when it does not, with under- or overborrowing in normal times (that is, when the constraint does not bind) depending on the parametrization of the economy. In the baseline calibration, we find underborrowing in normal times. In an alternative calibration, with more impatient agents and more volatile shocks, we find overborrowing in normal times. In both cases, however, in times of crisis (that is, when the constraint binds), there is inefficient underborrowing. That is, in crisis, agents in CE always consume less tradable goods than in the SP allocation.

In general, the main difference between CE and SP allocations is that the social planner takes into account the effects of his or her consumption choices on aggregate prices, and thus on the value of collateral (the literature refers to this as a "pecuniary externality"). The implications of this pecuniary externality depend on the structure of the economy. In general, even in normal times, the possibility that the constraint might bind in the future increases the current marginal utility of tradable consumption (that is, increases the private marginal value of saving). But the *social* marginal value of saving (from the perspective of the social planner) is higher than the *private* value (from the perspective of individual agents), because of the pecuniary externality effect. All else being equal, this mechanism involves higher saving in the SP allocation compared to the CE allocation, and generates overborrowing in the endowment economies studied by Bianchi (2009) and Korinek (2010).

7. The technical challenge in solving such a model is that the constraint binds only occasionally and changes location in the state space of the model, depending on the realization of both the exogenous and the endogenous state variables.

But in a production economy an opposite force arises. The relatively higher marginal utility of tradable consumption from the social planner's perspective generates a higher *social* marginal benefit of supplying one more unit of labor compared to the *private* one in normal times. Relatively higher production and consumption of non-tradable goods can then lead to relatively higher borrowing and tradable consumption in the SP compared to the CE, and thus generates the possibility of underborrowing.

The relative strength of these two effects depends on the parametrization of the economy: for example, the second channel dominates the first in our baseline calibration, but we find that the first channel dominates the second when agents are more impatient and shocks are more volatile, thus inducing overborrowing rather than underborrowing. Overborrowing always arises in the endowment economies we study, because the second effect is not present. Also, in the endowment case, the planner cannot manipulate the value of collateral when the constraint binds, as he or she cannot alter the production possibilities of the economy: thus CE and SP allocations must always coincide once the crisis occurs in an endowment economy.[8]

From a qualitative point of view, our findings suggest that only for ex post interventions is there a clear cut rationale to address the economic dislocation associated with the sudden stop. These findings also suggest that the design of economy-wide, ex ante intervention policies is not robust: indeed, different structures of the economy or different calibrations of the same economy may require different interventions, depending on the presence of either under- or overborrowing.

We then measure quantitatively the gap between CE and SP allocations. To do so, we determine the percentage of consumption that agents are willing to forgo to move from one allocation to the other, in every state and for every date. We find that in production economies, the overall welfare gains from implementing the SP allocation are one order of magnitude larger than in endowment economies. In addition, welfare gains are always larger near crisis times than in normal ones, in both production and endowment economies.

In terms of policy implications, our findings are consistent with the position that nationally or multilaterally financed bailouts are

8. The equivalence between SP and CE allocations arises in states of the world in which the crisis occurs (that is, the constraint is binding) for both allocations.

important to help mitigate the effects of crises. In contrast, our analysis suggests that the case for economy-wide, macro-prudential policy intervention tools, such as taxes on capital flows and capital controls (as opposed to interventions specifically targeting the financial system), is very weak.

There are important caveats to these policy conclusions. Moral hazard, time-consistency considerations, and the economic cost of distortions are not present in the class of models analyzed in this paper. As a result, the case for ex post (ex ante) policy intervention may be over (under) stated by our analysis. Considering moral hazard would weaken the case for ex post interventions. In addition, Chari and Kehoe (2009) show that the lack of credibility of efficient ex post intervention policies call for an ex ante prudential intervention geared toward containing the excesses induced by the time-inconsistency of the optimal ex post intervention. This would further strengthen the case for ex ante interventions.

Nonetheless, while it is well known that bailouts can induce moral hazard, it is less well understood that prudential regulations and capital controls can hamper long-run growth. Nikolov (2009), for instance, studies the private choice of leverage in a model with heterogeneous firm productivity, based on a stochastic version of Kiyotaki and Moore (1997). He finds that mandating tighter, economy-wide leverage ratios than those chosen by private agents in a competitive equilibrium does reduce aggregate volatility, but at the cost of lowering average growth, with welfare-reducing consequences. As a result, in his model, the aggregate leverage ratio of the competitive equilibrium is constrained-efficient. This further weakens the case for ex ante interventions.[9]

The rest of the paper is organized as follows. Section 1 discusses the pecuniary externality that may give rise to under- or overborrowing. Section 2 describes the model we use. Section 3 discusses its parametrization and solution. Section 4 illustrates the model's working and basic properties, and reports our main quantitative results, comparing CE and SP equilibria using alternative model specifications and parameter values. Section 5 discusses the policy implications, while section 6 concludes.

9. This limitation does not apply to the policy analysis of Benigno and others (2009), in which the Ramsey planner explicitly trades off the benefits of intervening either ex ante or ex post against the efficiency costs of doing so with a distortionary tax on non-tradable consumption. In contrast, all contributions in the existing literature just compare competitive allocations with socially planned ones, discussing implementation issues without accounting for any implementation cost.

1. Overborrowing and Pecuniary Externalities

Before turning to the presentation of the model, we discuss the source of the externality that may give rise to over- or underborrowing and hence scope for policy intervention. Overborrowing has been discussed extensively in the literature so our discussion of the pecuniary externality that may give rise to it takes the form of a review of the relevant literature.

In an early contribution, Fernández-Arias and Lombardo (1998) investigate analytically whether an economy with an aggregate debt limit tends to overborrow relative to an economy in which the debt limit is imposed at the level of the individual agent. They find that agents fail to internalize the debt limit, and the economy overborrows. Uribe (2007) investigates overborrowing quantitatively and finds that the amount borrowed is independent of foreign lenders basing their decisions on individual as opposed to aggregate variables.

The models used in these early analyses are similar. The key difference between the two environments is that in Uribe (2007), when the constraint is binding, the domestic interest rate adjusts and induces agents to internalize the credit limit, while Fernández-Arias and Lombardo (1998) assume that the domestic interest rate is equal to the world interest rate and agents fail to internalize the debt ceiling in their deterministic model. Both papers, however, share two common ingredients. First, the debt ceiling is exogenously specified.[10] Second, this is a one-good economy, in which the pecuniary externality that is our focus cannot arise (see Benigno and others, 2009, section 2, for more details).

Later work has considered richer environments in which there are multiple goods and the borrowing limit is endogenous. In these environments, the interaction between the borrowing constraint and the dependence of the borrowing limit on a relative price generates a pecuniary externality that is not internalized in the competitive equilibrium allocation and might give rise to constrained-inefficient borrowing. The social planner, on the other hand, takes into account the way in which this relative price is determined in the competitive allocation when choosing an optimal plan and accordingly selects a constrained-efficient amount of borrowing (again, see Benigno and

10. Uribe (2007) considers one extension in which the constraint is endogenous in the sense explained in the previous section. In this case, he finds small amounts of overborrowing.

others, 2009, for more details). For instance, in a closed economy model, Lorenzoni (2008) shows that entrepreneurs do not take into account the effects of asset prices on the amount that they can borrow, so that in the competitive equilibrium, under certain specific assumptions, financial contracts lead to excessive borrowing. Korinek (2010) and Bianchi (2009) carried out similar analyses in a small open economy similar to our baseline model, but without production, in which the amount that individuals can borrow depends on the income generated in both sectors of the economy and their relative price. Both authors concluded that there was overborrowing, qualitatively (Korinek, 2010) and quantitatively, with potentially significant welfare consequences (Bianchi, 2009). The policy implication of these analyses was the recommendation of economy-wide prudential taxation on capital flows to bring the competitive allocation of the economy into line with that chosen by the social planner for efficiency.

In related work, in his stochastic version of the Kiyotaki and Moore (1997) model, Nikolov (2009) finds that, when the leverage ratio is a choice variable, these pecuniary externalities do not necessarily induce sizable divergence between the CE and the SP. This is because, interestingly, in Nikolov's (2009) model, there is not only production but also firm heterogeneity. Thus, in this environment, there is a trade-off between the lower volatility and the lower average growth associated with mandating a lower aggregate leverage ratio than that privately chosen in the CE of the economy. So mandating lower regulatory leverage ratios may impose significant efficiency costs that, in this setup, are welfare reducing.

2. The Model

The model that we propose is a simplified version of the one used by Benigno and others (forthcoming). This is a simple two-sector (tradable and non-tradable) small open production economy, in which financial markets are not only incomplete but also imperfect, as in Mendoza (2002), and in which production occurs only in the non-tradable sector.

2.1 Households

There is a continuum of households $j \in [0,1]$ that maximize the utility function

$$U^j \equiv E_0 \sum_{t=0}^{\infty} \left[\beta^t \frac{1}{1-\rho} \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta} \right)^{1-\rho} \right], \tag{1}$$

where C_j denotes the individual consumption basket and H_j the individual supply of labor. For simplicity, we omit the j subscript for the remainder of this section, but it is understood that all choices are made at the individual level. The elasticity of labor supply is δ, while ρ is the coefficient of relative risk aversion. In equation (1), the preference specification follows from Greenwood, Hercowitz, and Huffman (1988): in the context of a one-good economy this specification eliminates the wealth effect from the labor supply choice. Here, in a multi-good economy, the sectoral allocation of consumption will affect the labor supply decision through relative prices. The consumption basket, C_t, is a composite of tradable and non-tradable goods:

$$C_t \equiv \left[\omega^{\frac{1}{\kappa}} (C_t^T)^{\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}} (C_t^N)^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}}, \tag{2}$$

where the parameter κ is the elasticity of intratemporal substitution between consumption of tradable and non-tradable goods, while ω is the relative weight of the two goods in the consumption basket.

We normalize the price of tradable goods to 1. The relative price of the non-tradable good is represented by P^N. The aggregate price index is then given by

$$P_t = \left[\omega + (1-\omega)(P_t^N)^{1-\kappa} \right]^{\frac{1}{1-\kappa}},$$

with a one-to-one link between the aggregate price index, P, and the relative price, P^N. Households maximize utility subject to their budget constraint, which is expressed in units of tradable consumption. The constraint each household faces is

$$C_t^T + P_t^N C_t^N = \pi_t + W_t H_t - B_{t+1} + (1+i) B_t, \tag{3}$$

where W_t is the wage in units of tradable goods, B_{t+1} denotes the net foreign asset position at the end of period t with gross real return $1+i$. Households receive profits, π_t, from owning the representative firm. Their labor income is given by $W_t H_t$.

International financial markets are incomplete and access to them is also imperfect. The asset menu includes only a one-period bond denominated in units of tradable consumption. In addition, we assume that the amount that each individual can borrow internationally is limited by a fraction of his current total income:

$$B_{t+1} \geq -\frac{1-\phi}{\phi}(\pi_t + W_t H_t). \tag{4}$$

This constraint captures the effects of liability dollarization, since foreign borrowing is denominated in units of tradables, while the income that can be pledged as collateral is also generated in the nontradable sector. This constraint is also endogenous as it depends on the current realization of profits and wage income. We don't explicitly derive the credit constraint as the outcome of an optimal contract between lenders and borrowers. However, we can interpret this constraint as the outcome of a lender-borrower interaction, in which the lender will not permit borrowing beyond a certain limit.[11] This limit depends on the parameter ϕ, which measures the tightness of the borrowing constraint and depends on current gross income that could be used as a proxy of future income.[12]

Households maximize equation (1) subject to (3) and (4), by choosing C_t^T, C_t^N, B_{t+1}, and H_t. The first-order conditions of this problem are the following:

$$C^T : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} \omega^{\frac{1}{\kappa}} (C_t^T)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_t, \tag{5}$$

$$C^N : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} (1-\omega)^{\frac{1}{\kappa}} (C_t^N)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_t P_t^N, \tag{6}$$

$$B_{t+1} : \mu_t = \lambda_t + \beta(1+i)E_t(\mu_{t+1}), \tag{7}$$

11. As emphasized by Mendoza (2002), this form of liquidity constraint shares some features, namely the endogeneity of the risk premium, which would be the outcome of the interaction between a risk-averse borrower and a risk-neutral lender in a contracting framework, as in Eaton and Gersovitz (1981). It is also consistent with anecdotal evidence on lending criteria and guidelines used in mortgage and consumer financing.

12. As we discuss in Benigno and others (2009), a constraint expressed in terms of future income that could result from lender-borrower interaction in a limited commitment environment would introduce further computational difficulties that we need to avoid for tractability.

$$H_t : \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta} \right)^{-\rho} \left(H_{j,t}^{\delta-1} \right) = \mu_t W_t + \frac{1-\phi}{\phi} W_t \lambda_t . \tag{8}$$

When the credit constraint is binding ($\lambda_t > 0$), the Euler equation (7) incorporates an effect that can be interpreted as arising from a country-specific risk premium on external financing. In this framework, moreover, even if the constraint is not binding at time t, an intertemporal effect arises due to the possibility that the constraint might be binding in the future: this effect is embedded in the term $E_t\,(\mu_{t+1})$, which implies that current consumption of tradable goods would be lower than the unconstrained case, when the constraint is expected to bind in the future.

Based on the conditions above, we can combine equations (5) and (6) to obtain the intratemporal allocation of consumption, and equations (5) with (8) to obtain the labor supply schedule, respectively:

$$\frac{(1-\omega)^{\frac{1}{\kappa}} (C_t^N)^{-\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}} (C_t^T)^{-\frac{1}{\kappa}}} = P_t^N , \tag{9}$$

$$H_{j,t}^{\delta-1} = \left(\frac{\omega C}{C^T} \right)^{\frac{1}{\kappa}} W_t \left(1 + \frac{1-\phi}{\phi} \frac{\lambda_t}{\mu_t} \right). \tag{10}$$

Note here that

$$\left(\frac{\omega C}{C^T} \right)^{\frac{1}{\kappa}} = \left[1 + \left(\frac{1-\omega}{\omega} \right)^{\frac{1}{\kappa}} \left(\frac{C_t^N}{C_t^T} \right)^{\frac{\kappa-1}{\kappa}} \right]^{\frac{1}{\kappa-1}} \omega^{\frac{1}{\kappa-1}} = \left[1 + \left(\frac{1-\omega}{\omega} \right) (P_t^N)^{1-\kappa} \right]^{\frac{1}{\kappa-1}} \omega^{\frac{1}{\kappa-1}} .$$

So, if we were in a one-good economy, there would be no effect coming from the marginal utility of consumption for the labor supply choice, because of the GHH specification. For later use, it is also useful to note that an increase in P^N would lower $(\omega C/C^T)^{1/\kappa}$, and the labor supply curve becomes flatter as P^N increases.[13] When the constraint

13. In what follows we refer to the labor supply curve in a diagram in which labor is on the vertical axis and the wage rate on the horizontal one.

is binding ($\lambda_t > 0$), the marginal utility of supplying one more unit of labor is higher and this helps to relax the constraint. In this case, the labor supply becomes steeper and agents substitute leisure with labor to increase the value of their collateral for given wages and prices.

Importantly, labor supply is also affected by the possibility that the constraint may be binding in the future. If in period t the constraint is not binding but may bind in period $t+1$, we have

$$\left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho}\left(H_{j,t}^{\delta-1}\right) = \mu_t W_t$$

and

$$\mu_t = \beta(1+i)E_t\left[\lambda_{t+1} + \beta(1+i)E_t(\mu_{t+2})\right],$$

so that the marginal benefit of supplying one more unit of labor today rises in line with the probability of the constraint becoming binding in the future. This effect will induce agents to supply more labor for any given wage, and the labor supply curve will be steeper in this case than when there is no credit constraint. In equilibrium, this effect increases non-tradable production and consumption and affects tradable consumption, depending on the degree of substitutability between tradable and non-tradable goods. When goods are complements, any increase in non-tradable consumption is associated with an increase in tradable consumption that reduces the amount agents save in the competitive equilibrium. The opposite would occur if goods were substituted.

2.2 Firms

Firms are endowed with a stochastic stream of tradable goods, $\exp(\varepsilon_t)Y^T$, where ε_t is a stochastic process, and produce non-tradable goods, Y^N. We assume that ε follows an autoregressive process of the first order (AR(1)). For simplicity, we abstract from other sources of macroeconomic uncertainty, such as shocks to the technology for producing non-tradables and the world interest rate.

Firms produce non-tradable goods, Y_t^N, with a variable labor input and a Cobb-Douglas technology

$$Y_t^N = AH_t^{1-\alpha},$$

where A is a scaling factor. The firm's problem is static and current-period profits, π_t, are

$$\pi_t = \exp(\varepsilon_t)Y^T + P_t^N A H_t^{1-\alpha} - W_t H_t.$$

The first-order condition for labor demand is

$$W_t = (1-\alpha)P_t^N A H_t^{-\alpha}, \tag{11}$$

so that the value of the marginal product of labor is set equal to the real wage (W_t). For the case in which we have constant returns to scale ($\alpha = 0$), we obtain

$$W_t = P_t^N A,$$

so that the real wage in terms of the relative price of non-tradables is constant (as long as we don't have any shock to productivity of non-tradables), and equilibrium labor is determined by the supply side while the wage rate is determined by the demand side of the labor market.

2.3 Aggregation and Equilibrium

To gain insight into the model, we focus on the labor market equilibrium condition when firms have constant returns to scale technology, such that $\alpha = 0$. Combining equations (11) and (10) we obtain

$$H_{j,t}^{\delta-1} = \left(\frac{\omega C}{C^T}\right)^{\frac{1}{\kappa}} P_t^N A\left(1 + \frac{1-\phi}{\phi}\frac{\lambda_t}{\mu_t}\right).$$

When the international borrowing constraint is not binding ($\lambda_t = 0$), a shock that triggers a decrease in P_t^N will reduce the labor supply and production of non-tradable goods. Indeed, in this case, equilibrium in the labor market becomes

$$H_{j,t}^{\delta-1} = \left[1 + \left(\frac{1-\omega}{\omega}\right)(P_t^N)^{1-\kappa}\right]^{\frac{1}{\kappa-1}} P_t^N A.$$

To determine the goods market equilibrium, we combined the household budget constraint and company profits with the equilibrium condition in the non-tradable goods market to obtain the current account equation for our small open economy:

$$C_t^T = Y_t^T - B_{t+1} + (1+i)B_t. \tag{12}$$

The non-tradable goods market equilibrium condition means that

$$C_t^N = Y_t^N = AH_t.$$

Finally, using the definitions of firm profits and wages, the credit constraint means that the amount that the country as a whole can borrow is constrained by a fraction of the value of its GDP:

$$B_{t+1} \geq -\frac{1-\phi}{\phi}\left[\exp(\varepsilon_t)Y^T + P_t^N Y^N\right], \tag{13}$$

Thus, together equations (12) and (13) determine the course of foreign borrowing.

2.4 Social Planner Problem

Let us now consider the social planner's problem. The planner maximizes equation (1) subject to resource constraints, the international borrowing constraint from an aggregate perspective, and the pricing rule for the competitive equilibrium allocation. In particular, noting that the competitive rule (9) determines the relative price, we can rewrite equation (13) as

$$B_{t+1} \geq -\frac{1-\phi}{\phi}\left\{\exp(\varepsilon_t)Y^T + \left[\frac{(1-\omega)(C_t^T)}{\omega}\right]^{\frac{1}{\kappa}} (AH_t)^{\frac{\kappa-1}{\kappa}}\right\}.$$

The planner chooses the optimal path C_t^T, C_t^N, B_{t+1}, and H_t, and the first-order conditions for this problem are given by

$$\begin{aligned} C^T : &\left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} \omega^{\frac{1}{\kappa}} (C_t^T)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} \\ &= \mu_{1,t} - \lambda_t \frac{1-\phi}{\phi}\frac{1}{\kappa}\frac{(1-\omega)}{\omega}\left[\frac{(1-\omega)(C_t^T)}{\omega}\right]^{\frac{1}{\kappa}-1} (AH_t)^{\frac{\kappa-1}{\kappa}}, \end{aligned} \tag{14}$$

$$C^N: \left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{-\rho} (1-\omega)^{\frac{1}{\kappa}} (C_t^N)^{-\frac{1}{\kappa}} C^{\frac{1}{\kappa}} = \mu_{2,t}, \tag{15}$$

$$B_{t+1}: \mu_{1,t} = \lambda_t + \beta(1+i)E_t(\mu_{1,t+1}), \tag{16}$$

and

$$H_t: \left(C_t - \frac{H_t^{\delta}}{\delta}\right)^{-\rho} \left(H_t^{\delta-1}\right) = \mu_{2,t}A + \frac{1-\phi}{\phi}\lambda_t \left[\frac{(1-\omega)(C_t^T)}{\omega}\right]^{\frac{1}{\kappa}} \frac{\kappa-1}{\kappa} A(AH_t)^{-\frac{1}{\kappa}}. \tag{17}$$

There are two main differences between the competitive equilibrium first-order conditions and those associated with the planner's problem, arising from occasionally binding financial friction. First, equation (14) shows that, in choosing tradable consumption, the planner takes into account how a change in tradable consumption affects the value of collateral (see also Korinek, 2010 and Bianchi, 2009). This is usually called the price externality in the related literature and occurs when the constraint is binding (that is, $\lambda_t > 0$). As noted above, however, even if the constraint is not binding today, the possibility that it might bind in the future can affect the marginal value of tradable consumption today (that is, the marginal value of saving). Indeed, as Bianchi (2009) notes, the Euler equation from the planner's perspective becomes

$$\mu_{1,t} = \beta(1+i)E_t\left[\lambda_{t+1} + \beta(1+i)E_t(\mu_{1,t+2})\right],$$

where $E_t(\mu_{1,t+2})$ is given by equation (14) and takes into account the future effect of the pecuniary externality. Crucially, this implies that through this effect and at the same allocation, the marginal social value of saving (the marginal value in the SP allocation) will be higher than the private value (in the CE allocation). Thus, the decentralized equilibrium might display overborrowing.

In the production economy under study, the presence of occasionally binding financial friction has an additional effect. In particular, we can rewrite the labor supply equation by using equation (15) and the equilibrium condition in the non-tradable good market as follows:

$$H_t^{\delta-1} = \left[\frac{(1-\omega)C_t}{AH_t}\right]^{\frac{1}{\kappa}} A\left\{1+\frac{1-\phi}{\phi}\frac{\lambda_t}{\mu_{2,t}}\left[\frac{(1-\omega)(C_t^T)}{\omega}\right]^{\frac{1}{\kappa}}\frac{\kappa-1}{\kappa}(AH_t)^{-\frac{1}{\kappa}}\right\}.$$

This expression shows that, when the constraint is binding, the marginal utility of supplying one extra unit of labor is affected by the degree of substitutability between tradables and non-tradables. If goods are substitutes then, when the borrowing constraint is binding, it is worth supplying one more unit of labor, as that helps relax the constraint. If goods are complements, however, it is worth decreasing the amount of labor supplied. In both cases the planner tends to relax the international borrowing constraint by increasing the value in units of tradable or non-tradable production. In the case of complements, this is achieved by an increase in prices that dominates the negative effect of lower non-tradable production and consumption. In the case of substitutes, this is achieved by increasing non-tradable production and consumption, which overcomes the effect of lower prices.

More importantly, changes in labor supply also occur when the constraint is expected to bind in the future. Indeed, in this case, taking the ratio of equations (15) to (14) we have

$$\frac{(1-\omega)^{\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}}}\frac{(C_t^N)^{-\frac{1}{\kappa}}}{(C_t^T)^{-\frac{1}{\kappa}}}\mu_{1,t} = \mu_{2,t}. \tag{18}$$

This expression shows that a higher current marginal utility of tradable consumption in the SP (arising because the constraint might bind in the future) also suggests a higher marginal utility for non-tradable consumption, which in turn boosts the marginal utility of supplying one unit of labor today. As a result, in the SP allocation, labor supply and non-tradable production are relatively higher in the CE than in the SP, even when the constraint is not binding. When goods are complements, this increase in non-tradable consumption will be associated with a higher increase in tradable consumption (reducing the amount agents save) in the SP allocation compared to the CE allocation. When goods are substitutes, however, the amount the planner saves will increase, as agents substitute tradable consumption with non-tradable consumption.

Thus, this mechanism could generate underborrowing in the CE compared to the SP allocation. Underborrowing could occur both when goods are complements or substitutes. This depends on the strength of the labor supply effect and the relative adjustment to tradable consumption in the CE versus the SP allocation. For example, even when goods are substituted and tradable consumption falls (following the labor supply mechanism just mentioned), the decline in tradable consumption could end up larger in the CE than in the SP, suggesting that agents would underborrow.

3. Parameter Values and Solution Method

In this section we discuss the parameter values chosen and briefly describe the global solution method that we use in the numerical computations.

3.1 Parameter Values

The model is calibrated using a quarterly frequency and the parameter values we use are reported in table 1.[14] As in Benigno and others (forthcoming), these values are set according to work by Mendoza (2010) and Kehoe and Ruhl (2008) to the extent possible, but also to facilitate the convergence of the numerical solution procedure.

We set the world interest rate to $i = 0.0159$, which yields an annual real rate of interest of 6.5 percent; a value between 5 percent (Kehoe and Ruhl, 2008) and 8.6 percent (Mendoza, 2010). The elasticity of intratemporal substitution between tradables and non-tradables follows Ostry and Reinhart (1992) who estimate a value of $\kappa = 0.760$ for developing countries.[15] The value of δ is 2, reflecting a Frisch elasticity of labor of 2. For simplicity, the elasticity of intertemporal substitution is unitary ($\rho = 1$).

14. When we calibrate the model at annual frequency, for robustness, the results are qualitatively the same. Some quantitative differences emerge due to the fact that the annual calibration allows for more foreign borrowing as a share of GDP in the stochastic steady state of the model for the same parameter values.

15. There is considerable debate about the value of this parameter. The estimate we use is consistent with Kehoe and Ruhl (2008) who set this parameter to 0.5.

Table 1. Model Parameters

Parameter	*Value*
Structural parameter	
Elasticity of substitution between tradable and non-tradable goods	$\kappa = 0.760$
Intertemporal substitution and risk aversion	$\rho = 1$
Labor supply elasticity	$\delta = 2$
Credit constraint parameter	$\phi = 0.7$
Labor share in production	$\alpha = 0$
Relative weight of tradable and non-tradable goods	$\omega = 0.48568$
Discount factor	$\beta = 0.98$
Exogenous variable	
World real interest rate	$i = 0.0159$
Steady state relative price of non-tradables	$P^N = 1$
Productivity process	
Persistence	$\rho_\varepsilon = 0.86$
Volatility	$\sigma_\varepsilon = 0.015$

For simplicity also, the labor share of production in the non-tradable sector is assumed to be unitary ($\alpha = 0$). We then normalize steady-state tradable output to one (that is, $Y^T = 1$) and set ω and A to obtain a steady-state ratio of tradable to non-tradable output of 0.75 (slightly higher than Mendoza, 2002) and a unitary relative price of non-tradables in steady state (that is, $P^N = 1$).

We set $\beta = 0.98$ (implying an annual value of 0.92237) to obtain a ratio for foreign borrowing to annualized GDP of about 25 percent in the deterministic steady state.[16] The value of the credit constraint parameter (ϕ) determines the probability of a sudden stop. We set this parameter to 0.7, which makes the constraint binding in the deterministic steady state and yields a realistic probability of a sudden stop, as typically defined in the empirical literature. In the competitive equilibrium, the unconditional probability of a sudden stop is about 2 percent per quarter (or 8.2 percent annually). For

16. For this calculation we added an elastic discount factor to the model to pin down foreign debt in steady state.

this calculation, a sudden stop is defined as an event in which the constraint is strictly binding.

Finally, in our analysis, we focus on the behavior of the economy subject to only one stochastic shock to the endowed tradable output, which we model as an AR(1) process. Specifically, the shock process for tradable GDP is

$$\varepsilon_t = \rho_\varepsilon \varepsilon_{t-1} + v_t, \tag{19}$$

where v_t is an independent and identically distributed innovation, such that $v_t \sim N(0, \sigma_\varepsilon^2)$. The parameters of this process are set to $\rho_\varepsilon = 0.86$ and $\sigma_\varepsilon = 0.015$, which are the first autocorrelation and the standard deviation of total GDP reported by Mendoza (2010).

With these parameters, as Benigno and others (forthcoming) show, the model produces the sharp reversal in capital flows, the plunging output and consumption, and substantial real exchange rate depreciation (proxied by the fall in the relative price of non-tradable goods), typical of a sudden stop. In this sense, our model is quantitatively capturing the sudden stop phenomena we observe in the data.

3.2 Solution Method

To solve the competitive equilibrium, we use the algorithm proposed by Benigno and others (forthcoming). Here we summarize their solution procedure and explain how we apply this solution to the social planner's problem. A key step involves transforming the system of Kuhn-Tucker conditions into a standard system of nonlinear equations, as per Garcia and Zangwill (1981). The transformed system can then be solved using standard nonlinear equation solution methods.

We can then represent model equilibrium as a recursive dynamic programming problem, summarized by the following Bellman equation:

$$V(b, B, \varepsilon) = \max_{B'} \left\{ u\left[C - z(H)\right] + \beta E\left[V(b', B', \varepsilon') \mid \varepsilon\right] \right\}, \tag{20}$$

where

$$u\left[C - z(H)\right] = \frac{1}{1-\rho}\left(C_{j,t} - \frac{H_{j,t}^{\delta}}{\delta}\right)^{1-\rho}.$$

The value function, $V(b,B,\varepsilon)$, depends on three state variables: individual borrowing, b, aggregate borrowing, B, and the stochastic shock to the tradable endowment, ε. In equilibrium, individual and aggregate borrowing must coincide, but from the perspective of the representative agent in our model, the borrowing constraint is imposed at the individual level, taking relative prices as given. Our solution explicitly accounts for this feature of the model specification by treating aggregate and individual debt separately in the value function.

A solution for the decentralized equilibrium defined above will be given by (i) a value function $V(B,\varepsilon)$ and (ii) a set of laws of motion (hereafter, also called decision rules or policy functions) for aggregate borrowing ($B = G_B^n(B,\varepsilon)$), aggregate employment ($H = G_H^n(B,\varepsilon)$), and the relative price of the non-tradable good basket ($P^N = G_{P^N}^n(B,\varepsilon)$) that satisfy the Bellman equation (20). Note that while the value function depends on both individual and aggregate borrowing, the decision rules for all other endogenous variables only depend on aggregate borrowing.

To solve for the social planning equilibrium we set up a dynamic programming problem. The programming problem is written as an optimization of the value function, subject only to resource constraints and the borrowing constraint. Thus, the planner chooses all quantities directly. Specifically, the problem can be written as

$$v(B,\varepsilon) = \max_{c^T,c^N,H,B'} \left\{ u\left[C - z(H)\right] + \beta E_{\varepsilon'}\left[v(B',\varepsilon') \mid \varepsilon\right] \right\},$$

subject to

$$C^T = (1+r)B + \varepsilon - B',$$

$$C^N = AH,$$

$$B' \geq -\frac{1-\varphi}{\varphi}(\varepsilon + P^N AH),$$

$$P^N = \frac{(1-\omega)^{\frac{1}{\kappa}}(C^N)^{-\frac{1}{\kappa}}}{\omega^{\frac{1}{\kappa}}(C^T)^{-\frac{1}{\kappa}}}.$$

We compute a solution to this problem numerically. The shock is discretized into a Markov chain with 11 states, as in Floden (2008). Methods to solve the programming problem are standard (for example, Johnson and others, 1993). In particular, we use cubic splines to approximate the value function and we then solve the maximization problem using a feasible sequential quadratic programming routine.

4. Quantifying Overborrowing

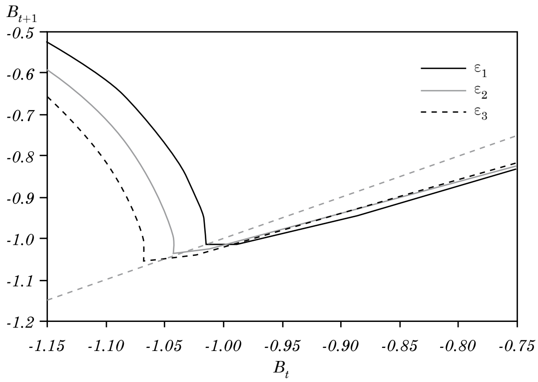
In this section we discuss the basic properties of the competitive equilibrium allocation, comparing it to the social planner version, to quantify overborrowing. We conduct this comparison using alternative model specifications and assumptions for key parameter values.

4.1 Competitive Equilibrium

The properties of the competitive equilibrium are more fully explained in Benigno and others (2009). Here we review them briefly. The policy function for B_t is plotted in figure 1. In this figure, each solid line depicts the policy function for B_t conditional on a particular state of the tradable shock. This line is drawn assuming the same shock occurs in each period. For illustrative purposes, we report the decision rule for the worst state (state 1), and progressively better ones, together with the 45-degree (dashed line) trajectory. If the first state occurs perpetually, then the policy function will meet the 45-degree line at exactly the point where the constraint binds. The economy remains from this point on and at this point, and the multiplier is still zero. If the economy is currently at the intersection between the decision rule for one of the better states and the 45-degree line and receives a worse shock, the constraint can bind strictly on impact, as the economy jumps to the corresponding new decision rule. For example, if we are at the point where state 3 intersects the 45-degree line and we receive a worse shock, we move up directly to a point where the constraint binds strictly (with positive multiplier). So the point on the decision rule where the constraint starts to bind strictly depends on the particular exogenous state at which we evaluate the rule and the value of endogenous state variable B_t.

Figure 2 reports the policy functions for other variables of the model as a function of the endogenous state, B_t. Policy functions are drawn assuming the continuation of the worst shock. All variables

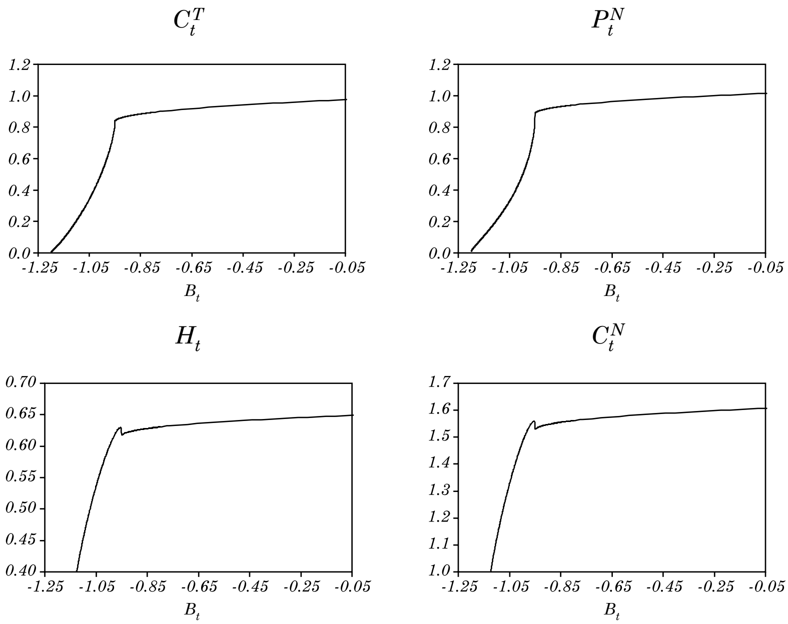
Figure 1. Decision Rule for Foreign Borrowing in the Competitive Equilibrium



Source: Authors' calculations.

(C_t^T, P_t^N, C_t^N, and H_t) follow a similar pattern. Before the constraint binds (that is, before the kink in these rules), the economy behaves in a seemingly linear manner as this shock continues to materialize. Far from the constraint, the ongoing realization of the shock reduces both tradable and non-tradable consumption and increases debt (not reported in figure 2), as agents smooth the impact of the shock by borrowing more from abroad. Once the constraint is reached, however, decision rules are driven by the need to respond to it. Agents can no longer borrow their desired amount: consumption of tradable goods decreases, lowering the relative price of non-tradable goods. A falling relative price of non-tradable goods has two effects. The first is to reduce borrowing capacity by lowering the collateral value of non-tradable income and hence generating an amplification mechanism similar to Irving Fisher's debt deflation, discussed by Mendoza (2010). This effect amplifies the fall in tradable consumption. The second effect occurs on the production side of the economy. As the price of non-tradable goods falls, the wage in units of tradables declines, thus reducing labor supply despite the fact that, as the constraint binds, the marginal utility of supplying one more unit of labor is higher. This second channel, combined with the amplified response of tradable consumption and the relative price of non-tradables, produces a fall in employment and non-tradable production and consumption.

Figure 2. Decision Rules in the Competitive Equilibrium



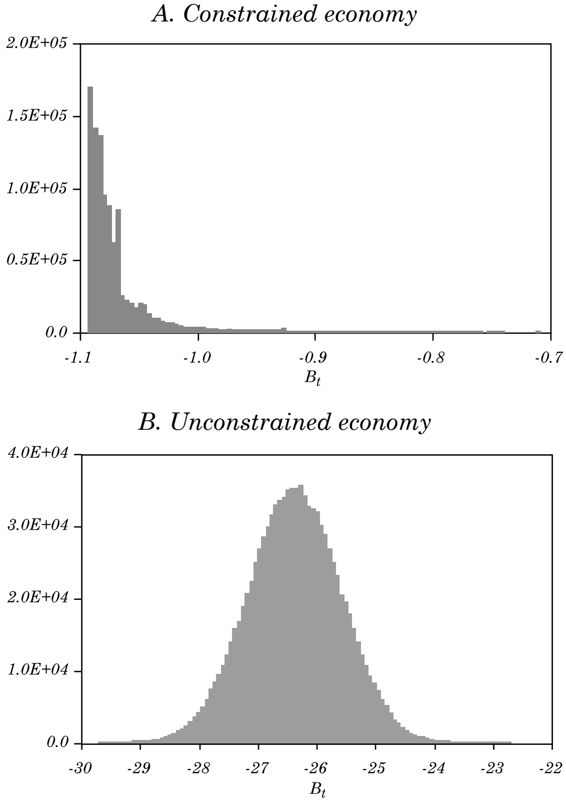
Source: Authors' calculations.

The foreign debt distribution in the stochastic steady state of the model illustrates a more intuitive working of the borrowing constraint. In figure 3, we compare the ergodic distribution of foreign debt for two economies, one with and one without the occasionally binding borrowing constraint.[17] As we can see, the foreign debt distribution of the economy with the constraint is shifted to the far right of the unconstrained economy and is truncated. That is, agents would like to borrow much more than they can in the constrained economy, and are aware of the state-contingent borrowing limit and the possibility of running into a sudden stop because of it. Private agents' precautionary saving motive, then, means that the average amount borrowed is lower than in the unconstrained economy. In the stochastic steady state

17. To compute the ergodic distribution of the unconstrained economy we need a stationary model. To achieve stationarity we use an elastic discount factor in both the constrained and the unconstrained economy. However, the elastic discount factor is not present in the model with the constraint that we use to produce all other results.

of the economy, which averages all possible equilibrium outcomes, there is therefore an endogenous debt limit beyond which agents do not want to go. The ergodic distribution of borrowing will be truncated at that point. Note however that this is not necessarily the point at which the borrowing constraint binds strictly at any particular time or state of the economy.

Figure 3. Ergodic Distribution for Foreign Borrowing



Source: Authors' calculations.

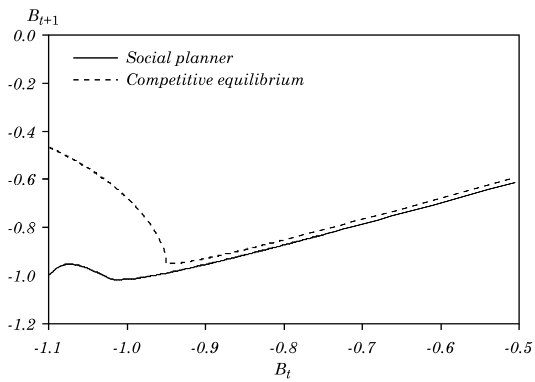
4.2 Comparing with the Social Planner Equilibrium

We now compare the allocations in the competitive equilibrium with those chosen by the social planner, under alternative model specifications and parameter assumptions.

4.2.1 Production economies

Figure 4 plots the decision rule for B_t for the worst possible state of the exogenous state, ε_t, in our baseline model with endogenous labor supply. It shows that there is slight underborrowing when the constraint is not binding and much more underborrowing when the constraint is binding.[18] This shows that, in the benchmark economy, there is theoretical scope for both ex ante and ex post policy interventions, geared toward inducing more borrowing than private agents choose to take on, both before and after a sudden stop.

Figure 4. Decision Rule for Foreign Borrowing



Source: Authors' calculations.

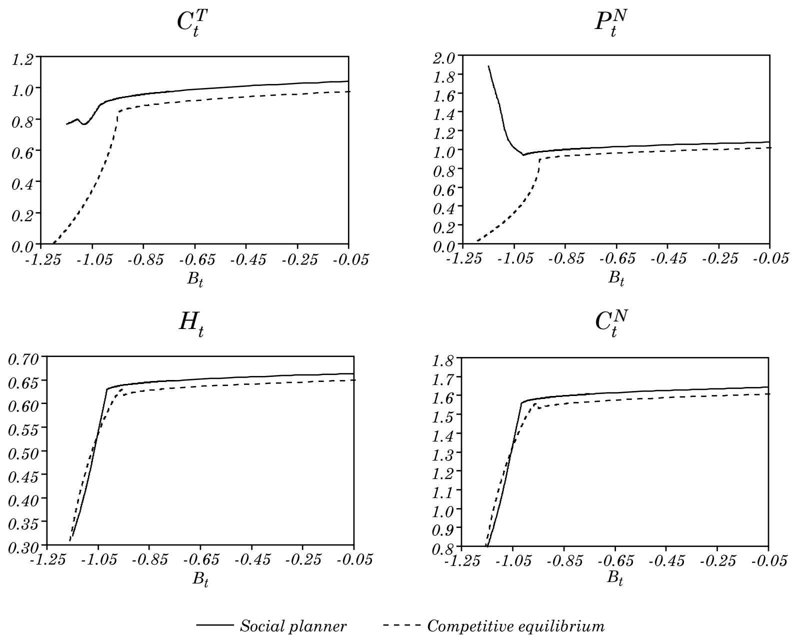
Figure 5 compares the behavior of the other endogenous variables for the worst value of the exogenous state ε_t, as in figure 2. Consistent with the underborrowing presented in figure 4, there is a wedge between the policy functions of the CE allocation and the SP, which is larger when the constraint binds. As we noticed earlier, when the constraint does not bind, two opposite forces are at work in our production economy. On the one hand, the social planner would like to reduce current consumption of tradables, thereby taking into account the amplification effects caused by any price externality that might arise in the future, when the constraint binds. On the other, the increase in the marginal utility of tradables causes an increase

18. That is, for each value of the endogenous state B_t, B_{t+1} is smaller in the CE than in the SP throughout the support of the decision rule.

in the marginal utility of non-tradables and in labor supply, with higher non-tradable production and consumption. Under our baseline calibration, this second effect dominates the first one, causing tradable consumption to be higher and saving lower than in the CE allocation. The equilibrium relative price of non-tradables is also higher in the SP than in the CE. A policy intervention geared at moving the CE closer to the SP would therefore have to induce more borrowing in normal times and a more appreciated relative price for non-tradable goods.

When the constraint binds, the differences between the CE and the SP become even more marked. There are two key differences: first, the relative price of non-tradables increases in the SP, collapsing in the CE as the economy goes deeper into debt (see figure 5). Second, in the SP allocation, we see lower labor and non-tradables consumption than in the CE. These differences reflect how agents and the planner react to the constraint in the two equilibria. The planner limits the deflationary impact of meeting

Figure 5. Decision Rules for Relative Prices, Consumption, and Labor



Source: Authors' calculations.

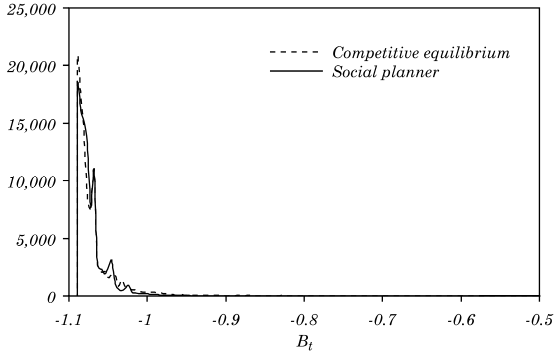
the borrowing constraint by increasing the value of collateral through prices (that is, by increasing P^N) rather than quantities (that is, it reduces Y^N). As we discussed in section 2, when goods are complements, supplying one less unit of labor generates a relative marginal benefit in the SP and not the CE. The value of collateral is higher in the SP than in the CE because, when goods are complements, the relative price of non-tradables increases and offsets the negative impact of lower non-tradables production and consumption. The overall implications of the planner's allocation is to allow for higher borrowing capacity and, as a consequence, higher tradable consumption, even when the constraint binds. In contrast, in the CE, when the constraint is binding, all else being equal, agents supply more labor to relax the constraint by increasing their non-tradable labor income. However, they don't internalize the effect that higher labor supply has, all else being equal, on the equilibrium relative price. Indeed a lower relative price will tighten the constraint even more and reduce tradable consumption. As a result, tradable consumption falls more and faster than in the SP.

Figure 6 compares the ergodic distributions of borrowing in the CE and the SP allocations. The two post a similar ergodic distribution of debt, despite differences in the decision rules conditional on the worst possible state.[19] Nonetheless, the mean debt-to-GDP ratio of this distribution is slightly lower in the CE than in the SP, as one would expect based on the discussion above. As table 2 reports, the average debt-to-annual-GDP ratio is –10.20 percent in the CE and –10.22 percent in the SP. This difference is very small, but statistically very significant (standard errors not reported).

The probability of having the constraint bind strictly is higher in the SP than in the CE (table 2). It amounts to 2.3 percent per quarters simulated in the SP (9.2 percent per year) and only 2.06 percent in the CE (8.2 percent per year). This difference can be interpreted in terms of precautionary saving behavior, and the decision rules we discussed above illustrate how the latter comes about in our benchmark production economy. The sudden stop is less costly in the SP than in the CE equilibrium, in terms of total consumption in units of tradable goods, with a welfare gain from

19. This is because the decision rules for better states are much closer to each other when the constraint does not bind and the economy spends little time in the worst state.

Figure 6. Ergodic Distribution for Foreign Borrowing



Source: Authors' calculations.

Table 2. Average Foreign Borrowing and the Probability of a Sudden Stop

Variable	*CE*	*SP*
Annual average debt in the ergodic distribution (% of annual GDP)		
Production, benchmark parameters	–10.20	–10.22
Production, alternative parameters	–7.31	–6.90
Endowment, benchmark parameters	–10.25	–10.14
Endowment, alternative parameters	–7.40	–7.10
Quarterly unconditional sudden stop probabilities (% per quarter)		
Production, benchmark parameters	2.06	2.30
Production, alternative parameters	1.53	2.20
Endowment, benchmark parameters	13.66	1.70
Endowment, alternative parameters	2.36	0.23

Source: Authors' calculations.

removing the constrained-inefficiency imposed, 0.03 percent of consumption at each state and date (table 3). Agents therefore try to borrow less and to face a sudden stop less frequently in the CE than the SP. Consistent with the small differences in average debt and the probability of sudden stop we reported, the overall welfare

Table 3. Welfare Gain of Moving from the CE to the SP[a]
Percent of tradable consumption

Variable	*Overall*	*At the sudden stop*
Production, benchmark parameters	0.01	0.03
Production, alternative parameters	0.30	0.90
Endowment, benchmark parameters	0.001	0.003
Endowment, alternative parameters	0.04	0.12

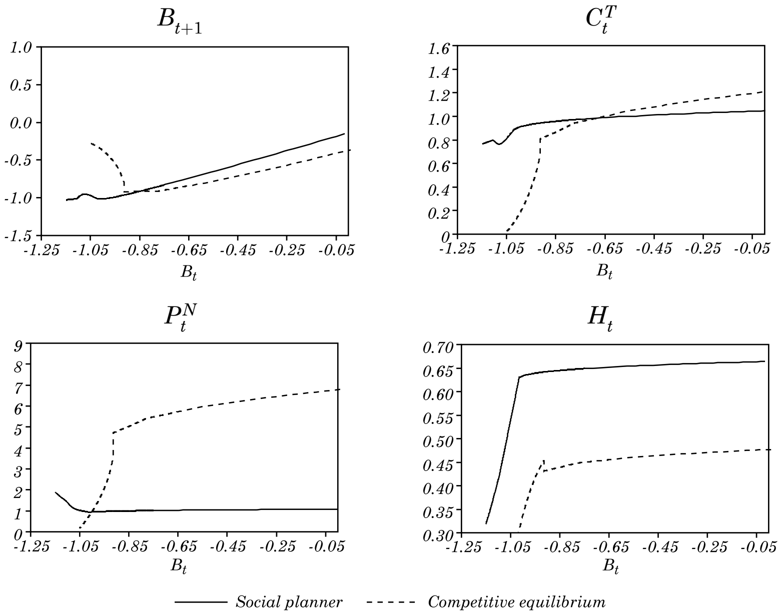
Source: Authors' calculations.
a. The welfare gains of moving from the competitive equilibrium (CE) to welfare-maximizing social planner (SP) are calculated as the percent of total consumption that agents are willing to forego, at every date and state, to move from one allocation to the other. That is the percentage reduction in consumption at all future dates and states in the SP that equates expected utility in the CE with expected utility in the SP. This cost is calculated at each point on the state space. The "overall" welfare cost is calculated by weighting the cost in each state by the unconditional probability of being in that state. We also construct the welfare gain when near a sudden stop. This calculation is complicated by the fact that the sudden stop does not always occur in the same state. Our solution is to simulate the model for 100,000 periods and keep track of the state(s) in which the economy is in before entering a sudden stop. We then average the gains over these states right before a sudden stop occurs.

gain of moving from the CE to the SP equilibrium is a mere 0.01 percent of consumption at each date and state.[20]

Consider now the same economy under an alternative calibration, in which agents are more impatient (that is, the discount factor is lower, at 0.91) and shocks are less persistent but four times more volatile than in the baseline (that is, $\rho_\varepsilon = 0.54$ and $\sigma_\varepsilon = 0.059$, as for instance in Bianchi, 2009). Figure 7 reports the same decision rules as figure 5, while figure 8 compares the ergodic distributions of B_t in the CE and the SP allocations. As we can see from figure 7, with more impatient agents and more volatile shocks, we now generate overborrowing in the CE equilibrium compared to the SP equilibrium, when the constraint does not bind. Being more impatient, agents' current consumption of tradable goods is higher. Since the marginal utility of current consumption is now smaller than in the previous case, the increase in current consumption (away from the constraint) dominates the negative effect of lower current consumption of tradables induced by the labor margin, so that tradable consumption

20. The intuition for this result is that welfare is state dependent in our economy. The largest differences in the behavior of these economies arise at the sudden stop, which in turn occurs only infrequently. Given that the economy spends most of its time outside the sudden stop state, the overall welfare difference between the two allocations is very small. Indeed, as shown by Mendoza (2002), the second moments of an economy with or without such constraints are quite similar.

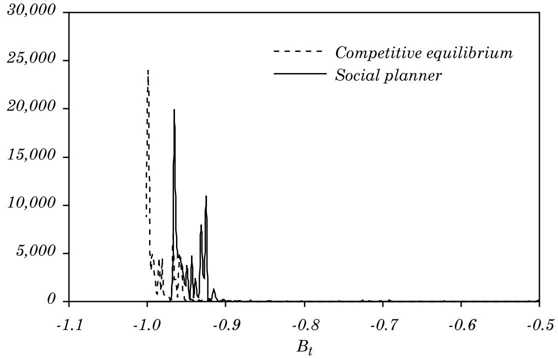
Figure 7. Decision Rules under the Alternative Calibration[a]



Source: Authors' calculations.

a. The alternative calibration considers more impatient agents and larger shocks.

Figure 8. Ergodic Distribution for Foreign Borrowing under Alternative Calibration[a]



Source: Authors' calculations.

a. The alternative calibration considers more impatient agents and larger shocks.

is higher in the CE than the SP allocation. In equilibrium, as goods are complements, we see higher consumption of tradables, higher consumption of non-tradables, and a higher relative price of non-tradables in the SP allocation. In contrast, when the constraint is binding, the decision rules of the CE behave similarly to the benchmark economy, relative to those of the SP.

This economy's behavior thus differs not only quantitatively but also qualitatively with respect to the benchmark economy. The important policy implication is that this alternative economy would require an ex ante policy intervention of opposite sign to that in the benchmark model to close the gap between the CE and the SP. However, when the constraint binds (after the kink in the decision rules), the difference compared to the benchmark calibration is only quantitative. This suggests that the sign of an ex post policy intervention would be the same in the two economies, although the intensity of that intervention might vary because of different parameter values.

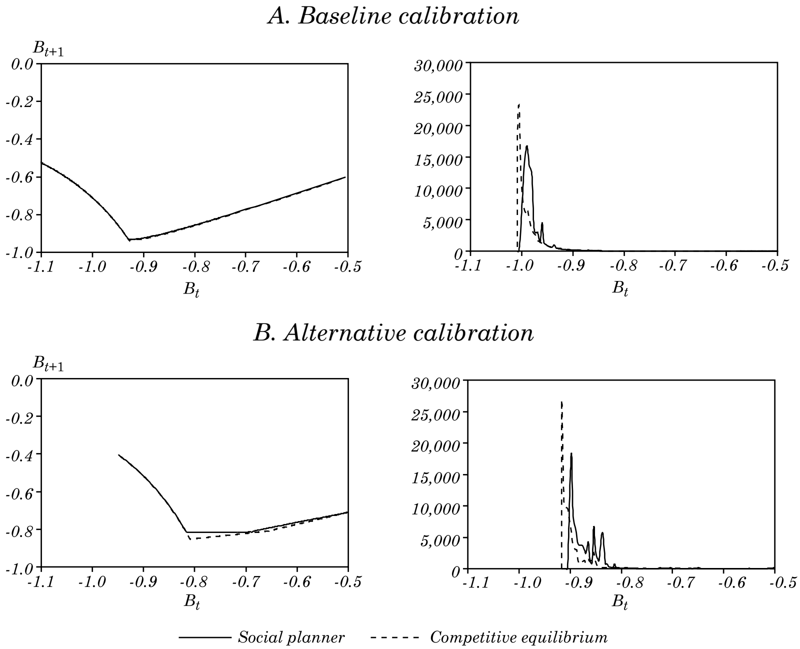
As table 2 reports, average debt in the stochastic steady state of the economy with the alternative calibration is smaller than in the benchmark model (despite the higher degree of impatience assumed), and larger in the CE than in the SP (at –7.31 and –6.9 percent of annual GDP, respectively) because there is overborrowing. Average debt is smaller in both the CE and the SP than in the benchmark economy, because the sudden stop is much more costly (about 30 times more costly in both allocations), with a welfare gain of moving from the CE to the SP at the sudden stop of 0.9 percent of consumption at every date and state (and an overall welfare gain of 0.3 percent). As a result, private agents self-insure more, as compared to the benchmark economy. This also leads to a significantly smaller probability of sudden stop in the CE in this case (1.53 percent per quarter). In contrast, the likelihood of the SP facing sudden stops is about the same as for the benchmark economy (2.2 percent of quarters).

4.2.2 Endowment economies

Consider now an endowment economy under the baseline and alternative calibrations for the same two sets of parameter values used for the production economy. The only change compared to the benchmark economy presented in section 3 is that labor supply in the non-tradables sector is now exogenous. Figure 9 compares the decision rule and the ergodic distribution for foreign borrowing in the CE and the SP for both calibrations. Figure 10 compares the decision rule for borrowing, tradable consumption, and the relative price of non-tradables. As we can see from panel A of figure 9, for the baseline parameter values and the worst realization of the shock, once we shut off the endogenous labor supply, there is essentially no difference in the decision rule for foreign borrowing between the CE and the SP allocations, either before or after the constraint binds. Nonetheless, we can see that in the ergodic distribution of foreign borrowing (which averages over all possible realizations of the shock and points on the support of the decision rules) there is slight overborrowing of about 0.10 percent of annual GDP (with average foreign borrowing reported in table 2 at –10.25 and –10.14 percent of annual GDP in the CE and the SP, respectively). This shows that, in this case, as discussed above, the distortion introduced by the credit constraint in the intertemporal margin leads households to undervalue the current marginal utility of tradable consumption for more favorable realizations of the exogenous state. The distortion, however, leads to a very small difference between the private and socially efficient level of foreign borrowing for the baseline parameter values.

Interestingly, the probabilities of sudden stops are 13.0 percent in the CE and 1.7 percent per quarter in the SP. In the CE, the probability of sudden stop is much higher in the endowment economy than in the production economy. This is because households cannot rely on the labor margin to supply more collateral when the constraint binds or is expected to bind in the future, despite facing the same incentive to borrow. As a result average borrowing is slightly higher as a share of total income and the probability of a sudden stop is much higher in the endowment than in the production economy. In contrast, in the social planner allocation for an endowment economy, in which there is no margin on which to act once the sudden stop is reached, there is less borrowing than in the production economy and a significantly lower probability of reaching the sudden stop, both with respect to the CE equilibrium of the endowment economy and the SP equilibrium of the production economy. Note here that the sudden stop is more costly for the SP of the endowment economy than the SP of the production economy, as tradable consumption falls by about 40 percent and 25 percent respectively (figure 5 and figure 10, panel A). However, the sudden stop cost is about the same in the CE and the SP equilibrium of the endowment economy, because the SP cannot improve on the CE when the constraint binds in the endowment economy. Consistent

Figure 9. Endowment Economies under Different Calibrations

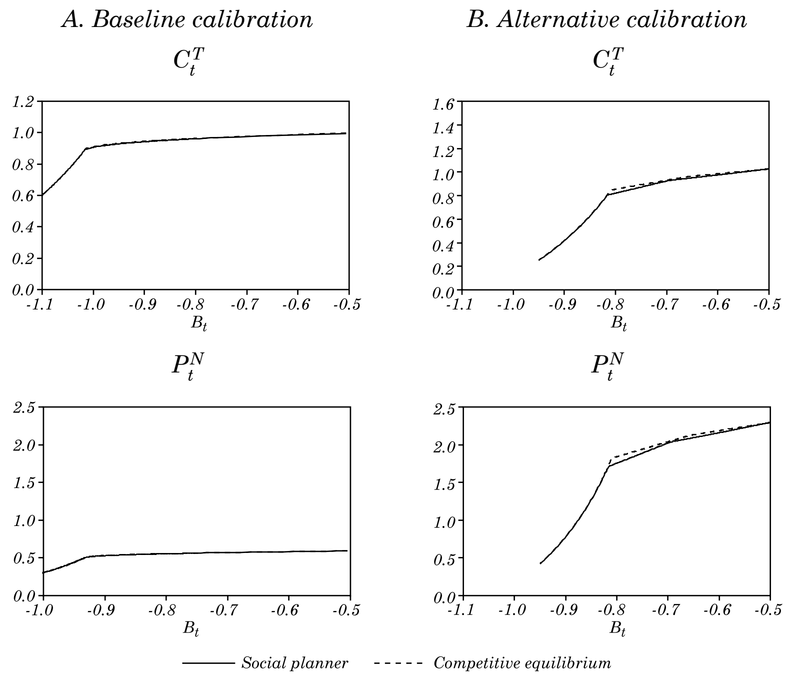


Source: Authors' calculations.

with this observation, the welfare gains of moving from the CE to the SP in this endowment economy, either overall or at the sudden stop, are one order of magnitude smaller than in the production economies above, at only 0.001 percent and 0.003 percent of consumption at each date and state, respectively (see table 3).

In an endowment economy with more impatient agents and larger shocks, there is more overborrowing than in the endowment economy with the baseline calibration, but precautionary saving is higher in both the CE and the SP equilibrium. Overborrowing, as measured by the difference in the average ergodic distribution of foreign borrowing, is about 0.30 percent of annual GDP, with average foreign borrowing of –7.40 and –7.10 in the CE and the SP, respectively (table 2). This is also evident from panel B of figure 9, which shows that the decision rule for B_t, conditional on the worst possible state, displays clearer evidence of overborrowing in the intermediate region of the state space.

Figure 10. Endowment Economies under Different Calibrations



Source: Authors' calculations.

Because of higher precautionary saving, the probabilities of sudden stops are also much smaller than in the endowment economy with base calibration (at 2.36 and 0.23 percent per quarter in the CE and the SP, compared to 13.66 and 1.70, respectively). The differences in the probability of a sudden stop across calibrations and the higher precautionary saving in this economy are associated with much more costly sudden stop dynamics in the alternative calibration than in the baseline. As we can see from figure 10, panel B, in fact, tradable consumption falls by about 75 percent with the alternative calibration compared to about 25 percent in the baseline one. A much higher cost of sudden stop leads to a large (overall and at the sudden stop) welfare gain of moving from the CE to the SP equilibrium in this economy, despite the fact that the planner cannot ameliorate the CE allocation at the sudden stop, at 0.04 and 0.12 percent of consumption at all dates and states, respectively (table 3). The planner's incentive to curtail borrowing is particularly strong in this case.

5. Policy Implications

The quantitative analysis in the previous section has important policy implications. The recent literature, reviewed in section 1, has focused on the theoretical and quantitative possibility of overborrowing, unambiguously recommending ex ante interventions to curtail it, such as a Tobin tax or other economy-wide prudential controls on international capital inflows.

While consistent with a theoretically second-best view of the world, in practice this clear-cut policy prescription warrants several qualifications. First, it is not possible to analyze the relative merits of both ex ante and ex post intervention strategies in models in which the planner can only intervene ex ante. In an endowment economy, by construction there is no scope for ex post policy interventions. As tradable consumption is pinned down by the constraint when this binds in an endowment economy, neither private agents nor the planner can manipulate the collateral value of non-tradable income to relax the borrowing constraint, and thus seek a better allocation.

Second, overborrowing is clearly a quantitative matter, and there is no solid basis to conclude that it is a key and general feature of emerging economies. As we saw in the previous section's quantitative analysis, simply by introducing small changes in key parameter values that are not easily anchored to the data in simple models, we find slight underborrowing instead of overborrowing in production economies. It follows that both sets of policy instruments should be implemented to "hedge" the model and parameter uncertainty that policy makers face.

By the well established standards of the dynamic stochastic general equilibrium (DSGE) methodology, such lack of robustness is sufficient to require a more cautious approach to economy-wide prudential controls on capital inflows, especially in light of the (at best mixed) historical experience with such policy tools.[21] DSGE standards indicate that the pros and cons of alternative policy

21. See Ostry and others (2010) for a thorough review of the existing literature, as well as new empirical evidence on the effectiveness of economy-wide capital controls.

regimes should be evaluated quantitatively in models that fit the data well, as is now the case for traditional monetary and fiscal stabilization policy issues. But rich models with occasionally binding financial frictions are not as amenable to quantitative analysis as the canonical New Keynesian model that has been investigated in the monetary policy literature.

We must, therefore, recognize that these models are in their infancy and do not yet provide clear-cut policy recommendations. The important implication is that economy-wide capital controls alone, as recommended in the literature (and as recently implemented by Brazil), may not achieve constrained efficiency in more richly specified and parameterized economies.

Third, such interventions are distortionary and may hamper economic efficiency if imposed inappropriately. As Nikolov (2009) has pointed out, for instance, in this kind of model environment there is a trade-off between the higher volatility associated with mandating looser prudential controls (that is, a higher leverage ratio in his model) and the lower average growth associated with imposing tighter prudential controls (that is, lower leverage ratios in his model). So mandating lower, economy-wide regulatory leverage ratios on prudential grounds may impose significant efficiency costs in terms of lower average growth.[22] This point is largely absent from the current debate, in part because it is difficult to evaluate such a trade-off quantitatively in the models available. Nonetheless, Nikolov's (2009) analysis clearly highlights the risk involved, consistent with the traditional debate in the literature on capital controls reviewed by Ostry and others (2010).[23]

Fourth, even when ex ante economy-wide interventions reflect the appropriate economy-wide policy regime from a second-best welfare perspective, they do not eliminate sudden stops and financial crises completely; they only mitigate their severity and may reduce their likelihood, as our analysis highlights. Thus, even with prudential policies in place, we still need to design policies that can respond to

22. Note however that this does not mean that specific sectors of the economy, such as the domestic financial system, would not benefit from such policy interventions.

23. As we noted already, this limitation does not apply to the policy analysis by Benigno and others (2009), in which the Ramsey planner explicitly trades off the benefits of intervening either ex ante or ex post with the efficiency costs of doing so using a distortionary tax on non-tradable consumption. In contrast, the existing literature only discusses implementation issues without accounting for implementation costs, when comparing competitive allocations with socially planned ones.

sudden stops in financial flows, as Caballero (2010) stresses. Our analysis of the two production economies, in which there is a wedge between the CE and the SP allocations both before and after the constraint binds, brings this out clearly.

Nonetheless, there are no moral hazard or time-consistency concerns in our setup. For instance, moral hazard considerations might surface in a microfounded specification of our constraint. Once moral hazard of ex post policies is considered, ex ante policies may become more desirable. Similarly, time-inconsistency problems are absent from these models. As Chari and Kehoe (2009) illustrate, the time-inconsistency of optimal ex post interventions may also call for ex ante interventions. The rationales for ex ante intervention policies would be different, however, addressing the need to avoid moral hazard and the time-inconsistency of ex post intervention policies, as opposed to correcting inefficient borrowing, as discussed in this paper.

6. Conclusions

The recent theoretical literature suggests that an economy-wide, macroprudential tax on leveraged borrowing might reduce the probability of a financial crisis and limit the ensuing adverse effects if one eventually occurs. These conclusions are based on the notion that agents do not save enough in tranquil times as a precaution against a possible crisis and hence overborrow. In our analysis in this paper we have shown that these policy conclusions are not robust. We examine production and endowment economies in which the pecuniary externality on which the literature has focused is present and creates the scope for policy intervention. While in endowment economies there is always overborrowing and there is no scope for policy intervention in crisis times, our baseline production economy displays underborrowing and a much larger welfare gain from ex post rather than ex ante policy intervention.

There are two important caveats to our analysis. First, the comparisons between the social planner and competitive equilibriums do not take into account the efficiency costs associated with any potentially distortionary policy tools needed to implement the social planner allocation. This suggests that the Ramsey allocation (which takes these costs into account) could differ from the social planner version. Second, the analysis in this paper and the relevant literature has neglected an important aspect of policy design: the fact that there is an important link between ex ante and ex post policies. Full knowledge of ex post policies may influence agents' behavior in normal times, and hence modify the ex ante policy design as well. In a companion paper (Benigno and others, 2009) we look at both these important aspects using a framework similar to the one in this paper.

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The Financial Accelerator under Learning and the Role of Monetary Policy

Rodrigo Caputo
Central Bank of Chile

Juan Pablo Medina
Central Bank of Chile

Claudio Soto
Central Bank of Chile

The financial crisis that unraveled after the Lehman Brothers collapse affected in different degrees almost all countries around the world, independently of the direct exposure of their financial institutions to toxic assets. Most countries saw a sharp drop in demand, together with sudden increases in financial spreads and a dramatic fall in stock markets. Developed countries and many emerging market economies responded with a considerable monetary easing accompanied by unconventional central bank policies and fiscal stimulus packages to moderate the downturn in the economy.

The sharp fall in assets prices was followed by a striking recovery, which has gone hand-in-hand with a reduction in financial market stress and an initial recovery in activity.[1] In fact, financial conditions in many countries quickly returned to their pre-Lehman levels at the end of 2009 (figure 1). While this may, in part, reflect the strong policy responses around the world, it is also consistent with the view that market participants overreacted to the initial shock and have been adjusting their expectations upward as the crisis turned out to be milder than initially thought.

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1. This striking recovery took place, mainly, in emerging economies.

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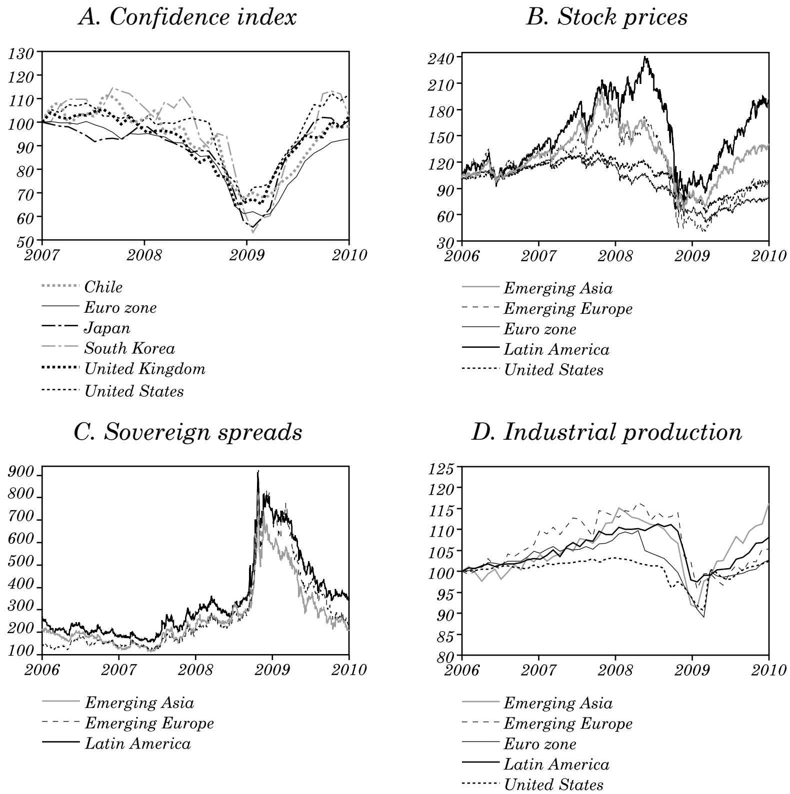
Figure 1. Some Recent Stylized Facts



Sources: Bloomberg and Central Bank of Chile.

In this paper, we show that imperfections in financial markets, coupled with small departures from the standard rational expectations assumption used in most macroeconomic models, may lead to a significant amplification of the effects of shocks. We develop a dynamic stochastic general equilibrium (DSGE) model with nominal frictions and a financial accelerator mechanism as in Bernanke, Gertler, and Gilchrist (1999), under the assumption that agents form their expectations based on adaptive learning (Evans and Honkaphoja, 2001). With a rather standard parametrization, our model is able to generate the dramatic fall in output and a relatively rapid recovery, similar to what we have observed in the recent crisis.

While both the financial accelerator mechanism and the learning assumption alone are able to amplify the effects of detrimental shocks on output, it is the combination of the two elements that turns out to be key for generating a sizable drop in output in response to negative shocks and producing a relatively fast recovery in asset prices. In this sense, the presence of a learning process, different from rational expectations, tends to exacerbate the impact of negative productivity shocks.

The model is a standard New Keynesian model with sticky prices and sticky wages. We introduce a financial accelerator mechanism as in Bernanke, Gertler, and Gilchrist (1999) and Gilchrist and Saito (2008), where firms are subject to idiosyncratic shocks and need to borrow to finance investment. Under the assumptions that the realization of idiosyncratic shocks is private information and that there is a costly state verification, the optimal contract between lender and borrower is a standard debt contract. The interest rate in this debt contract exhibits a premium above the risk-free interest rate, which is a positive function of the leverage of the borrower (the firm). Bernanke, Gertler, and Gilchrist (1999) show that the existence of this finance premium generates an accelerator effect that amplifies the impact of shocks on activity.[2] The adaptive learning approach that we use, in turn, follows from the idea that private agents and policymakers in the economy behave like applied economists and econometricians. In practice, econometricians base their forecasts on estimated models that are adapted and reestimated quite often. In our model, agents form their expectations of macroeconomic variables precisely by using the statistical forecasting models that applied economists use. The learning mechanism in our model is a constant-gain learning process, which does not guarantee convergence to a rational expectations (RE) equilibrium after a shock.[3]

This adaptive learning approach generates important propagation and amplification mechanisms that are not present under rational expectations equilibrium models. This is shown, for example, by Marcet and Nicolini (2003) in a standard monetary model with a quasi-rational learning process that is able to match the recurrent

2. Other contributions in this literature include Carlstrom and Fuerst (1997) and Kiyotaki and Moore (1997).

3. We do not analyze E-stability in our model, but the simulations discussed in sections 2 and 3 suggest that we do not obtain E-stability. For a deeper discussion on this topic, see Evans and Honkapohja (2001).

hyperinflations experienced by several countries in the 1980s. Milani (2005, 2007) also shows that when learning replaces rational expectations in a New Keynesian model, the estimated degrees of habits and indexation—which are usually important in RE models to explain inertia—are close to zero. This finding suggests that the propagation of shocks arises in the model economy mainly from expectations and learning. Similar conclusions are obtained by Slobodyan and Wouters (2009), who find that a DSGE model under adaptive learning can fit business cycle fluctuations much better than a model under rational expectations.

In our framework, the adaptive learning assumption, combined with the financial accelerator mechanism, leads to a large amplification of the effects of shocks on activity, demand, inflation, and asset prices. A detrimental shock that reduces output—modeled as a persistent fall in productivity—leads to a fall in the asset prices observed by agents and in the net worth of the firms, feeding back into expectations formation. If shocks are sequential, the expectations formation mechanism can endogenously generate a significant deviation of asset prices from their fundamental values, considerably amplifying the financial accelerator effect of detrimental shocks. These asset price fluctuations interact with the financial accelerator mechanism, reinforcing movements in real variables that, in turn, affect expectations and asset prices. Adam, Marcet, and Nicolini (2008) refer to this phenomenon under learning as momentum in asset prices. Eventually, the response of the monetary authority lowering the interest rate reverses the evolution of asset prices, reducing the risk premium and generating a recovery that feeds back into an improvement in asset prices. Thus, assets prices recover rapidly and activity approaches its equilibrium path under rational expectations relatively quickly.

We consider a model with nominal rigidities because it induces nontrivial policy trade-offs in the face of negative productivity shocks. This allows us to analyze the implication of alternative monetary policy regimes in the context of learning.[4]

In the baseline specification of the model, we assume that monetary policy is conducted by a simple Taylor rule. However, we are also interested in analyzing alternative specifications for the design of the monetary policy. In particular, we are interested in analyzing

4. The amplification of shocks due to the interaction of the financial accelerator mechanism and learning also holds in a simple real business cycle model that does not incorporate the nominal frictions. Results are available on request.

the case of a central bank that responds not only to fluctuations in output or inflation, but also to asset price movements. This question has been extensively debated in recent years.[5] One prominent view is that a monetary policy that directly targets asset prices appears to have undesirable side effects. Bernanke and Gertler (1999, 2001) show that even in a model with a financial accelerator mechanism, like the one considered in this paper, asset prices become relevant only if they signal potential inflationary or deflationary forces. In other words, it is desirable for the central bank to focus exclusively on underlying inflationary pressures.[6]

An alternative view favors a more active role of monetary policy in the detection and prevention of asset market misalignments. For instance, Cecchetti and others (2000) argue that asset price bubbles create distortions in investment and consumption, leading to excessive fluctuations in activity and inflation. Hence, a monetary policy rate that responds modestly to deviations of asset prices from fundamentals would enhance overall macroeconomic and financial stability. Moreover, they suggest that a systematic policy of "leaning against the bubble" might reduce the probability of bubbles arising in the first place. Borio and Lowe (2002) also support the view that a monetary response to credit and asset markets may be appropriate to preserve both financial and monetary stability.[7]

As Bernanke and Gertler (2001) note, how monetary policy should behave in the face of endogenous panic-driven financial distress is an open question. One limitation of models that claim that central banks should not react directly to asset price fluctuations when

5. See IMF (2009, chapter 3) for a recent overview on this issue.

6. Other recent studies reach similar conclusions based on alternative frameworks in which financial frictions amplify the propagation of economic disturbances. For example, Gilchrist and Leahy (2002) do not find a strong case for including asset prices in monetary policy rules, despite the fact that asset prices exhibit large fluctuations that affect the real economy. Iacoviello (2005) develops a theoretical model in which collateral constraints are tied to housing values; he finds that responding to asset prices yields negligible gains in terms of output and inflation stabilization. In an economy with credit market imperfections, Faia and Monacelli (2007) find that monetary policy should respond to increases in asset prices, but the marginal welfare gain of responding to the asset price flattens out when monetary policy responds more aggressively to inflation. Finally, a recent empirical analysis by Ahearne and others (2005) tends to support the view that in practice, central banks have not reacted to episodes of rising asset prices, beyond taking into account their implications for inflation and output growth.

7. Tetlow and von zur Muehlen (2002) argue that a nonlinear monetary feedback rule that responds to bubbles might improve welfare, but only when the bubbles become large enough and, especially, when their size leaves little doubt that fundamentals cannot be their sole driving factor.

they deviate from their fundamentals is that their nonfundamental movements are generated exogenously. More precisely, asset prices deviate from fundamentals because agents have incomplete information about the driving forces in the economy. As time goes by, agents learn about these forces and asset prices converge back to their fundamentals. Thus, in these models, there is no feedback from the nonfundamental component of asset prices into the expectation formation. Our model with adaptive learning and financial frictions is able to tackle this issue since it endogenously generates asset price bubbles through the interaction of movements in different variables and the learning mechanism. This raises the question of whether responding aggressively only to inflationary pressures is still efficient in this environment. Our preliminary results indicate that this is the case. Even in the presence of endogenous bubbles, responding aggressively to inflation reduces output and inflation volatility. If the central bank adjusts its policy instrument in response to asset price fluctuations, it may reduce output volatility and even inflation volatility in the short run. However, this monetary policy leads to a surge in inflation some periods after the shocks. On the other hand, a policy that aggressively responds to *changes* in asset prices may marginally reduce output volatility with respect to a policy that reacts aggressively to inflation, but at the cost of generating inflationary pressures.

The rest of the paper is organized as follows. Section 1 presents a linearized version of a closed economy model with a financial accelerator. Section 2 discusses the adaptive learning mechanism that governs agents' expectations. In section 3, we use a standard calibration to analyze the effects of a sequence of bad productivity shocks on the economy. Section 4 analyzes alternative monetary policy rules and their stabilizing properties. Finally, section 5 concludes.

1. The Model Economy

This section sketches a closed economy New Keynesian DSGE model that features sticky prices and wages and costly adjustments in the capital stock. The model also incorporates an external finance premium as in Bernanke, Gertler, and Gilchrist (1999), which amplifies the responses of the endogenous variables to different shocks. Fluctuations in the economy are triggered by trend productivity shocks that are persistent over time. We present a linearized version of the model that is obtained by taking first-order expansions of the decision rules and equilibrium conditions around the flexible-price steady state. In what follows, a lower case variable represents the log deviation of the respective variable from its trend. Details of the model derivation can be found in Bernanke, Gertler, and Gilchrist (1999) and Gilchrist and Saito (2008).

Households maximize their intertemporal expected utility subject to their budget constraint. The log-linearized version of the Euler equation for consumption, c_t , is given by

$$c_t = -\left(i_t - E_t \pi_{t+1}\right) + E_t c_{t+1} + E_t z_{t+1}, \tag{1}$$

where z_t corresponds to productivity growth at time t. The expectations operator, E_t, encompasses the standard rational expectations (RE) operator and also the expectations obtained under the adaptive learning mechanism that we discuss in detail below. The interest rate, i_t , corresponds to the market interest rate at which households are able to borrow, and π_t is the inflation rate at time t. For simplicity, we assume that i_t is the risk-free interest rate determined each period by the monetary policy authority.

Households are assumed to supply differentiated labor services, whose elasticity of substitution in the production technology is ε_L. Each household optimally sets its wage rate only infrequently and then supplies all labor demanded at its current wage rate. When not optimally adjusted, wages are updated according to past inflation. Let ϕ_L be the fraction of households that do not optimally adjust wages in a particular period, and χ_L the weight given to past inflation in their indexation scheme. The evolution of real wages, wr_t, is thus given by

$$\begin{aligned}\left[\kappa_L + (1+\beta)\right] wr_t = {} & \kappa_L mrs_t + wr_{t-1} + \beta E_t wr_{t+1} \\ & -(1+\beta\chi_L)\pi_t + \chi_L \pi_{t-1} + \beta E_t \pi_{t+1},\end{aligned} \tag{2}$$

where $mrs_t = \sigma_L l_t + c_t$ is the marginal rate of substitution between labor, l_t, and consumption; σ_L corresponds to the inverse labor supply elasticity; and β is the intertemporal discount factor. The parameter $\kappa_L = [(1-\beta\phi_L)(1-\phi_L)/\phi_L(1+\sigma_L\varepsilon_L)]$ defines the sensitivity of real wages to fluctuations in mrs_t.

We assume that a large set of retail firms rebrand intermediate varieties, which they sell to assemblers who pack them into final goods. Those goods are consumed by households and are accumulated as new capital. Retailers have monopoly power over a particular variety of the intermediate goods and optimally set their prices only infrequently, as in Calvo (1983). A fraction ϕ of the firms are not able to reoptimize in a particular period. When prices are not reoptimized, firms adjust them according to past inflation. From these assumptions, we derive the following extended New Keynesian Phillips curve, which links inflation, π_t, with marginal costs, mc_t:

$$\pi_t = \frac{(1-\beta\phi)(1-\phi)}{\phi(1+\beta\chi)} mc_t + \frac{\beta}{1+\beta\chi} E_t \pi_{t+1} + \frac{\chi}{1+\beta\chi} \pi_{t-1}, \tag{3}$$

where $mc_t = (wr_t + l_t) - y_t$ corresponds to the real marginal costs relevant to firms producing intermediate varieties; y_t is output; and χ is the weight given to past inflation in the indexation mechanism.

Firms producing intermediate varieties hire labor from households and rent capital from entrepreneurs to produce new intermediate varieties of goods. They use a Cobb-Douglas production technology that features a stationary productivity trend growth rate, g, which is subject to shocks, z. Cost minimization by these intermediate firms determines the optimal composition of factors of production:

$$k_{t-1} - z_t - l_t = wr_t - r_{k,t}, \tag{4}$$

where k_{t-1} is the capital stock at the beginning of period t, and $r_{k,t}$ is the net rental rate of capital. A large set of entrepreneurs accumulate capital and rent it to the producer of intermediate varieties. Assuming that there are quadratic adjustment costs to adding new units to the capital stock, we obtain the following expression relating investment, inv_t, to the real price of installed capital, qr_t, and the capital stock at the beginning of period t:

$$inv_t = -\frac{1}{\zeta_I} qr_t + (k_{t-1} - z_t), \tag{5}$$

where ζ_I is the inverse of the elasticity of the adjustment cost of capital. The equilibrium condition in the financial market determines the real price of capital, qr_t. By a no-arbitrage condition, this price is a function of the expected rental price of capital to intermediate producers, $E_t r_{k,t+1}$, and the relevant discount factor for capital producer firms, $E_t(i_{k,t} - \pi_{t+1})$, which, in turn, depends on the interest rate charged on loans, $i_{k,t}$:

$$qr_t = -E_t\,(i_{k,t} - \pi_{t+1}) + \frac{r_k}{R_k} E_t r_{k,t+1} + \frac{1-\delta}{R_k} E_t qr_{t+1}, \tag{6}$$

where δ is the depreciation rate of capital, and R_k corresponds to the gross return of capital in steady state (see the appendix). The interest rate charged on loans to entrepreneurs investing in new capital goods corresponds to the risk-free interest rate plus and external financial risk premium, which arises from an incomplete information approach to the financial intermediation process. Entrepreneurs finance part of their investment with internal resources and the rest by borrowing from financial intermediaries. These financial intermediaries charge a premium over the risk-free interest rate, which stems from a costly state-verification problem. Entrepreneurs are subject to idiosyncratic shocks and may default on their debt. Given that information is incomplete and that verifying the realization of the idiosyncratic shock is costly, the optimal contract takes the form of a standard debt contract, in which the interest rate available to entrepreneurs has a premium above the risk-free interest rate. As Bernanke, Gertler, and Gilchrist (1999) and Calstrom and Fuerst (1997) show, this premium is a function of the entrepreneur's leverage:

$$i_{k,t} = i_t + \chi_k(qr_t + k_{t-1} - n_t). \tag{7}$$

The second term on the right-hand side of equation (7) corresponds to the external risk premium, which, as mentioned above, is a function of the leverage of the firm, $qr_t + k_{t-1} - n_t$. The parameter χ_k defines the sensitivity of the external risk premium to the evolution of leverage in the economy. As in Bernanke, Gertler, and Gilchrist (1999), we limit the amount of equity entrepreneurs are able to accumulate over time. For this reason, we assume that entrepreneurs do not live infinitely long and die with a certain probability each period. Equity from entrepreneurs that die is split among all members of the society. The evolution of the aggregate net worth, n_t, is thus given by[8]

$$n_t = n_{t-1} - z_t + \frac{K}{N}\left(\frac{r_k}{R_k} r_{k,t} + \frac{1-\delta}{R_k} qr_t - qr_{t-1}\right) - \left(\frac{K}{N} - 1\right)(i_{k,t-1} - \pi_t). \tag{8}$$

8. We are assuming that the share of entrepreneur's labor in aggregate production is close to zero. See Gilchrist and Saito (2008).

The steady-state leverage, $(K/N) - 1$, is a measure of the degree of financial fragility in the economy. It determines the sensitivity of a firm's equity to changes in the interest rate charged on loans and thus to asset price fluctuations. Installed capital evolves over time according to the following expression:

$$k_t = \frac{1-\delta}{1+g}(k_{t-1} - z_t) + \left(1 - \frac{1-\delta}{1+g}\right) inv_t. \tag{9}$$

The equilibrium condition in the goods market is given by

$$y_t = \frac{C}{Y} c_t + \frac{I}{Y} inv_t, \tag{10}$$

where C/Y is the ratio of steady-state consumption to GDP and I/Y is the ratio of investment to GDP. The total supply of final goods, in turn, is given by

$$y_t = (1-\alpha) l_t + \alpha\,(k_{t-1} - z_t), \tag{11}$$

where α is the share of capital in the production function. Finally, we assume in the first part of our analysis that the central bank follows a simple rule to conduct its monetary policy:

$$i_t = \varphi_i i_{t-1} + (1-\varphi_i)\varphi_\pi \pi_t + (1-\varphi_i)\varphi_y (y_t - y_{t-1} + z_t), \tag{12}$$

where φ_i is the smoothing coefficient, φ_π is the inflation feedback coefficient, and φ_y is the output feedback coefficient. Below, in section 4, we depart from this simple policy rule to analyze the effects of productivity shocks when some of the coefficients of this rule are chosen so as to minimize a particular loss function. The only exogenous process considered is trend productivity, z_t. This variable is subject to independent and identically distributed shocks, $\varepsilon_{z,t}$, and evolves according to

$$z_t = \rho_z z_{t-1} + \varepsilon_{z,t},$$

where $\varepsilon_{z,t} \sim N(0, \sigma_z^2)$, and ρ_z is a persistence parameter.

2. Introducing Adaptive Learning

We depart from rational expectations slightly by assuming that agents form their expectations based on a learning mechanism. We follow the approach discussed in Adam (2005) and Evans and Honkapohja (2001). Let us consider the structural form representation of our model:

$$\mathbf{F}E_t\mathbf{x}_{t+1}+\mathbf{G}\mathbf{x}_t+\mathbf{H}\mathbf{x}_{t-1}+\mathbf{D}\varepsilon_{z,t} = 0, \tag{13}$$

where $\mathbf{x}_t=[y_t,c_t,inv_t,l_t,k_t,n_t,\pi_t,qr_t,wr_t,r_{k,t},i_{k,t},i_t,z_t]'$ corresponds to a vector of endogenous and exogenous variables, and **F**, **G**, **H**, and **D** are matrices containing structural coefficients. E_t is an operator that measures agents' expectations based on their information up to period t. The rational expectations solution of equation (13) is given by the following expression:

$$\mathbf{x}_t = \mathbf{\Omega}\mathbf{x}_{t-1} + \mathbf{\Lambda}\varepsilon_{z,t}, \tag{14}$$

where $\mathbf{\Omega}$ and $\mathbf{\Lambda}$ are invariant matrices whose elements are only functions of the structural parameters of the model.

We deviate from the rational expectations assumption and follow the approach by Marcet and Sargent (1989) and Evans and Honkapohja (2001). In particular, we assume that agents have the following perceived law of motion (PLM) for the endogenous variables:

$$\mathbf{x}_{t+1} = \tilde{\mathbf{\Omega}}_{t-1}\mathbf{x}_t + \tilde{\mathbf{\Xi}}_{t-1}\varepsilon_{z,t} + \mathbf{e}_{t+1}, \tag{15}$$

where $\mathbf{e}_{t+1}$ is orthogonal to $\tilde{\mathbf{\Omega}}_{t-1}\mathbf{x}_t$ and $\tilde{\mathbf{\Xi}}_{t-1}\varepsilon_{z,t}$. This PLM nests the rational expectations solution given by equation (14).[9] Agents forecast future values of $\mathbf{x}_t$ using their PLM with $E_t\mathbf{e}_{t+1} = 0$:

$$E_t\mathbf{x}_{t+1} = \tilde{\mathbf{\Omega}}_{t-1}\mathbf{x}_t + \tilde{\mathbf{\Xi}}_{t-1}\varepsilon_{z,t}\,. \tag{16}$$

The model information assumptions are as follows: in period t, agents observe $\mathbf{x}_{t-1}$ and $\varepsilon_{z,t}$, and then they use $\tilde{\mathbf{\Omega}}_{t-1}$ and $\tilde{\mathbf{\Xi}}_{t-1}$ to form expectations about $\mathbf{x}_{t+1}$. Substituting equation (16) into the structural

9. In particular, the RE solution has a PLM with $\tilde{\mathbf{\Omega}}_{t-1} = \mathbf{\Omega}$, $\tilde{\mathbf{\Xi}}_{t-1} \equiv \bar{0}$ and $\mathbf{e}_{t+1} = \Lambda\varepsilon_{z,t+1}$.

representation of the model (equation 13), we obtain the actual law of motion (ALM) under the previous PLM:

$$\mathbf{x}_t = -(\mathbf{F}\tilde{\boldsymbol{\Omega}}_{t-1} + \mathbf{G})^{-1}[\mathbf{H}\mathbf{x}_{t-1} + (\mathbf{D} + \mathbf{F}\tilde{\boldsymbol{\Xi}}_{t-1})\varepsilon_{z,t}]. \tag{17}$$

As in Evans and Honkapohja (2001) and Orphanides and Williams (2005), we assume agents use recursive least squares with perpetual learning to update their belief regarding the system's law of motion. Under this assumption, we have

$$\begin{aligned}[\tilde{\boldsymbol{\Omega}}_t, \tilde{\boldsymbol{\Xi}}_t] &= [\tilde{\boldsymbol{\Omega}}_{t-1}, \tilde{\boldsymbol{\Xi}}_{t-1}] \\ &\quad + \gamma\left\{\mathbf{R}_{t-1}^{-1}(\mathbf{x}'_{t-1}, \varepsilon_{z,t-1})'\left[\mathbf{x}'_t - (\tilde{\boldsymbol{\Omega}}_{t-1}\mathbf{x}_{t-1} + \tilde{\boldsymbol{\Xi}}_{t-1}\varepsilon_{z,t-1})'\right]\right\}'\end{aligned} \tag{18}$$

and

$$\mathbf{R}_t = \mathbf{R}_{t-1} + \gamma\left[(\mathbf{x}'_{t-1}, \varepsilon_{z,t-1})'(\mathbf{x}'_{t-1}, \varepsilon_{z,t-1}) - \mathbf{R}_{t-1}\right], \tag{19}$$

where the gain parameter γ is constant. At time $t = 0$, we start from the RE equilibrium solution (equation 14): $\tilde{\boldsymbol{\Omega}}_0 = \boldsymbol{\Omega}$ and $\tilde{\boldsymbol{\Xi}}_0 = \bar{0}$, together with $\mathbf{R}_0 = \mathbf{I}$.[10] After a shock hits the economy, the system evolves by iterating over equations (18) and (19). Under the constant-gain assumption, past data is discounted when agents update their expectations. This is equivalent to using weighted least squares with the weights declining geometrically as we move back in time.

By setting a small number for γ, the solution under learning remains close to the starting RE solution. Therefore, the equilibrium path under learning does not significantly differ from the RE equilibrium. If we set γ to a large number, the initial data have a big effect on the estimated matrices $\tilde{\boldsymbol{\Omega}}_t$ and $\tilde{\boldsymbol{\Xi}}_t$, and agents adjust their expectations away from what is implied by the RE equilibrium.

This constant-gain learning mechanism does not guarantee convergence toward the RE equilibrium path after a shock hits the economy as long as $\gamma > 0$. Milani (2007) argues that the asymptotic distribution of these learning beliefs (for $t \to \infty$) approaches the RE beliefs as $\gamma \to 0$. We do not further discuss the E-stability properties of this type of learning mechanism. Evans and Honkapohja (2001, 2009) discuss at length the implications of the constant-gain assumption for the convergence properties of this learning scheme.

10. This assumption constrains our degree of freedom. Other papers that analyze propagation consider an initial equilibrium that is deviated from RE, for example, Milani (2007).

3. Productivity Shocks, Financial Frictions, and Learning

The parametrization of the model turns out to be an important element for the results discussed below. In calibrating the model, we closely follow the parameter values chosen by Christiano and others (2008) and Gilchrist and Saito (2008). The steady-state real interest rate is set to 2.5 percent, whereas the steady-state labor productivity growth rate is assumed to be 1.5 percent, both on an annual basis. The probability of adjusting nominal wages is set to 0.80, while that of prices is fixed at 0.60. These values imply that wages are optimally adjusted every five quarters, and prices are optimally adjusted every two and a half quarters. The weights of past inflation for wage and price indexation are set to 0.1 and 0.8, respectively.

The smoothing coefficient in the Taylor rule is 0.85, and the feedback coefficients for inflation and output are set to 1.75 and 0.25, respectively. These parameters are in line with several empirical studies of policy rules for advanced economies (see Clarida, Galí, and Gertler, 1998; Christiano and others, 2008).

The steady-state external finance premium is fixed at 3.0 percent (annual basis), in line with previous studies (Calstrom and Fuerst, 1997; Gilchrist and Saito, 2008; Bernanke, Gertler, and Gilchrist, 1999). The steady-state leverage ratio is set to 0.90, which falls between the values used by Gilchrist (2004) to characterize high-leverage economies (1.5) and by Gilchrist and Saito (2008) (0.8). Below we discuss the implication of assuming different values for this ratio. The elasticity of the external premium to the leverage ratio is assumed to be 0.065, which is consistent with the range of values used by Bernanke, Gertler, and Gilchrist (1999): 0.065−0.040. Finally, the persistence coefficient of productivity growth is 0.8, which is smaller than the value used by Gilchrist and Saito in their analysis. Table A1 in the appendix provides a detailed description of the values used for all different parameters in the model.

As mentioned above, the constant-gain parameter, γ, governing the weights given to current forecast errors when updating expectations formation is crucial for the dynamics of the system. We set this parameter to 0.025, which represents a minor departure from RE (see Orphanides and Williams, 2005). Slobodyan and Wouters (2009), in their simulation of a DSGE model with learning, assume different values for this gain parameter (0.01, 0.02, and 0.05) corresponding roughly to a regression with a forgetting half-length of 69, 34, and 14 periods. In our case, it corresponds to a regression with a forgetting half-length of 23 periods. Milani (2007) estimates this parameter together with other structural parameters for the United States. He finds values in the range of 0.005 and 0.035, depending on the specification of his model.

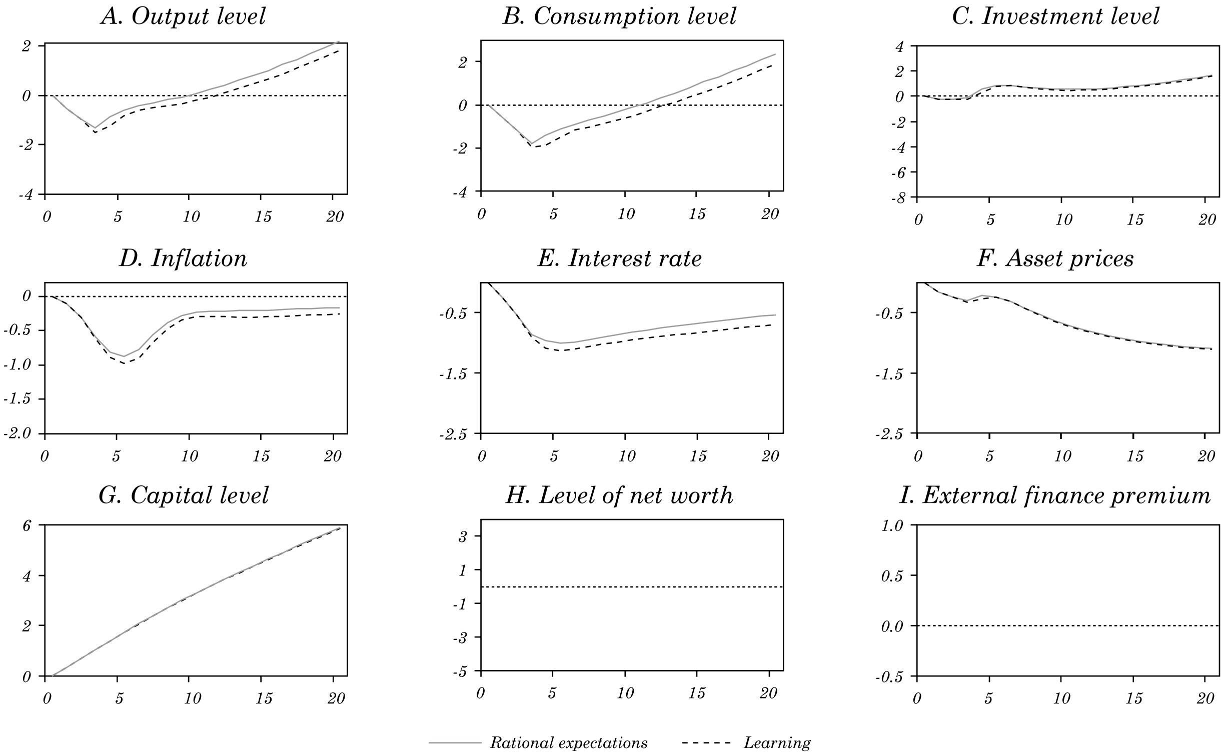
We now turn to the analysis of the effects of a detrimental shock to the productivity trend, comparing the results under RE and under adaptive learning. Before we present the results for the model featuring financial frictions, it is useful to discuss the result obtained under both RE and learning in the standard version of the model. Figure 2 presents the response of different variables to a sequence of three negative productivity trend shocks, each of size 0.5. Having a sequence of shocks is important to generate a differentiated response under learning. If the economy were hit by only one or two consecutive shocks, the adaptive learning approach we are using would imply a very fast convergence toward the RE equilibrium path.

As the figure illustrates, a sequence of negative productivity shocks leads to a transitory fall in output, consumption, and investment.[11] The fall in investment is more muted than that of output and consumption. Inflation decreases for several quarters, and there is a slow decline in asset prices. The monetary policy rate decreases in line with inflation and the slowdown in activity. When agents form their expectations based on adaptive learning, the response in activity is a bit more intense than under RE and the fall in inflation slightly more severe. Moreover, these variables remain below their equilibrium path under RE for several periods. These results are in line with Adam (2005), who finds that output and inflation are persistent under adaptive learning but not under RE in his model. In our case, however, the responses under learning and under RE seem to be quite similar from a quantitative point of view.

We now turn to the case in which financial frictions are present in the economy. Figure 3 displays the responses to the same sequence of negative productivity shocks discussed above, assuming that there is an external finance premium that is a function of the leverage of the firms. Now we observe a sharp difference between the responses under RE and learning. Under RE the fall in activity is larger than in

11. Impulse response functions are expressed in levels rather than deviations from the steady-state balanced growth path.

Figure 2. Response of Variables without the Financial Accelerator (Baseline Calibration)



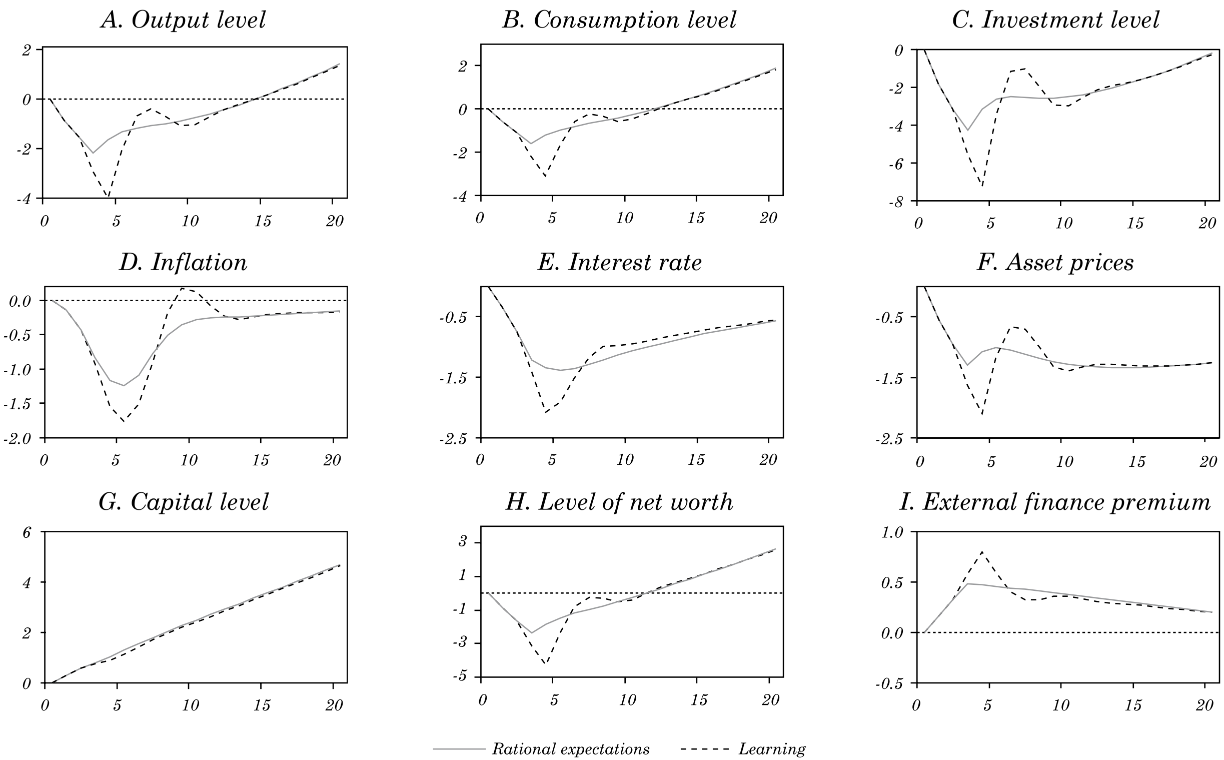
Source: Authors' calculations.

the case without financial frictions, as shown by Bernanke, Gertler, and Gilchrist (1999). However, under learning the fall in activity is exacerbated when financial frictions are present. Inflation also decreases more, and there is an abrupt fall in asset prices. Recovery is much faster following the sharp fall in activity and inflation, so after a few quarters output and inflation are above the levels they would have had under RE. In sum, when financial frictions are present, a small departure from the RE assumption leads to an amplified response of several variables to productivity shocks and an increase in their volatility.

In the above scenario, output falls more under learning and then increases substantially. In particular, it overshoots when compared to the rational expectations scenario (see figure 3). This overshooting is also present in the case of inflation. This result is similar to the findings obtained by Bloom (2009) using a different framework: uncertainty shocks generate short, sharp recessions and fast recoveries. The reason behind this behavior is related to the way in which expectations are determined under this scenario with learning and financial frictions. Given the policy rule in place, agents do not perceive important changes in the policy rate. As a result, inflation and output drop substantially when the external finance premium is increasing. Eventually, there is a turning point at which the interest rate declines and agents modify their expectations. In this later stage, inflation and output overshoot when the real interest rate and the external finance premium decline.

This overshooting is, in part, explained by the way in which monetary policy is conducted. If the central bank reacts more aggressively toward output and inflation (by reducing the degree of policy inertia, φ_i), then the real interest rate will decline more, thus attenuating the decline in output and inflation. In this case, the overshooting will not be present, but output and inflation will still decline more under learning than under rational expectations. Overall, the way in which monetary policy is designed determines how expectations are formed (as we show in the next section). In the presence of learning, a more aggressive monetary policy will induce a faster convergence to the rational expectations equilibrium (see Orphanides and Williams, 2008, 2009). Why do small departures from RE generate such large downturns in activity and inflation in response to productivity shocks in the presence of a financial friction? Figure 4 presents the path of the expected variables four steps ahead

Figure 3. Response of Variables with the Financial Accelerator (Baseline Calibration)



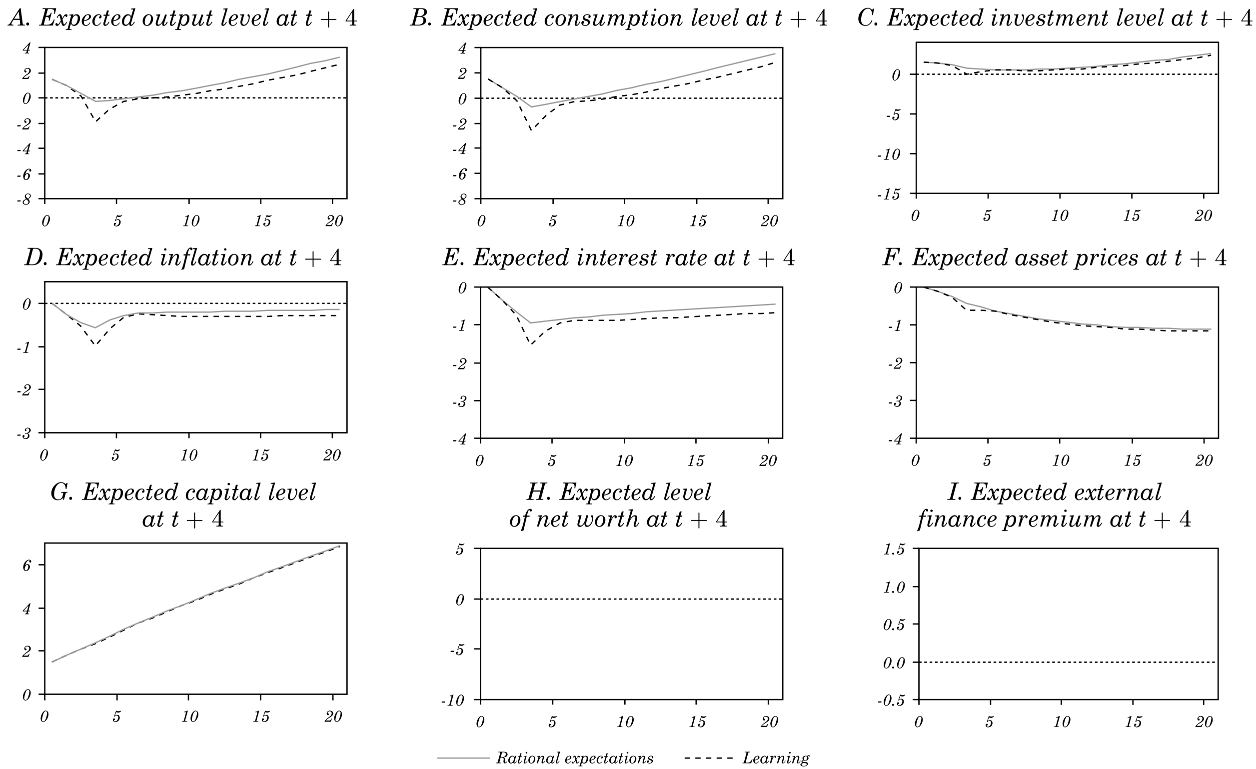
Source: Authors' calculations.

in the model without financial frictions. As the figure shows, the expected drop in activity and inflation is more intense when agents forecast using adaptive learning. However, when we include the financial accelerator mechanism, the expected fall in variables is much more intense, as the fall in net worth leads to an important increase in the expected risk premium (figure 5). This dramatic fall in activity and the increase in the expected risk premium feed back into asset prices, which decrease even further. This amplification mechanism through expectations does not work in the model with RE. Adam, Marcet, and Nicolini (2008) present similar results in a different context. They show that the reinforcing effect between beliefs and stock prices can produce large and persistent deviations of the price-dividend ratio from fundamentals. Thus, if expectations about stock price growth increase in a given period, the actual growth rate of prices has a tendency to increase beyond the fundamental growth rate, amplifying the initial belief of higher stock price growth. They further show that the model under adaptive learning exhibits mean reversion, so that even if expectations are very high or very low at some point, they will eventually return to fundamentals.

We identify two elements that are crucial for the amplified responses under adaptive learning: the size of the shocks and the degree of financial fragility, measured by the steady-state leverage of firms. Figure 6 depicts the difference in the responses to the shocks under RE and under learning for different shock sizes. For relatively small shocks (namely, 0.25) the response of the variables under learning is indistinguishable from that obtained under RE. As the size of the shocks increases, the contraction in activity and the fall in inflation under learning become relatively more intense. The jump in the external finance premium also rises considerably under learning when the shocks are sizable.

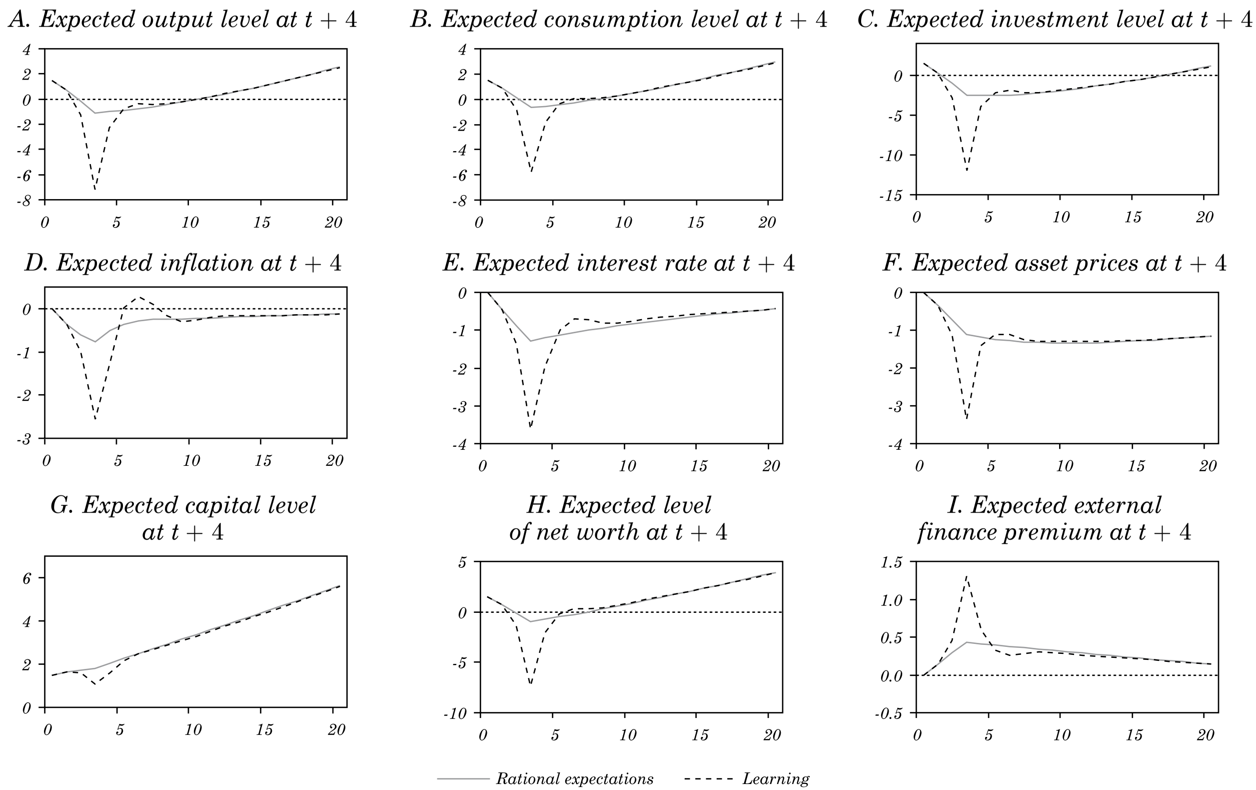
A second amplification mechanism for the transmission of shocks is the degree of financial fragility, measured by the steady-state leverage of the firms. Figure 7 compares the responses under RE and learning for different degrees of leverage for the firms. When the leverage increases, the difference between the response of the external premium under learning and the response under RE also increases. That, in turn, implies that the contraction of output and the fall in inflation that result from the shock are amplified when the economy is financially fragile and agents form their expectations based on a learning mechanism.

Figure 4. Expected Response of Variables Four Periods ahead without the Financial Accelerator (Baseline Calibration)



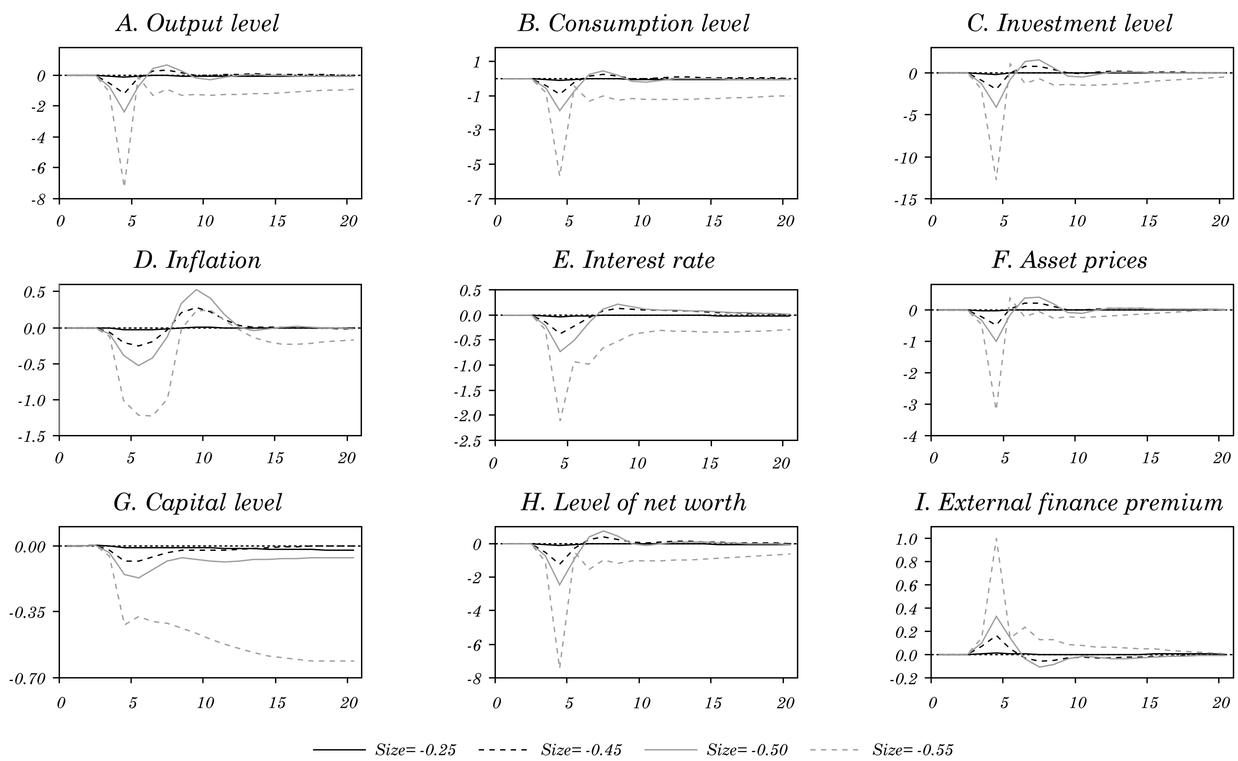
Source: Authors' calculations.

Figure 5. Expected Response of Variables Four Periods ahead with the Financial Accelerator (Baseline Calibration)



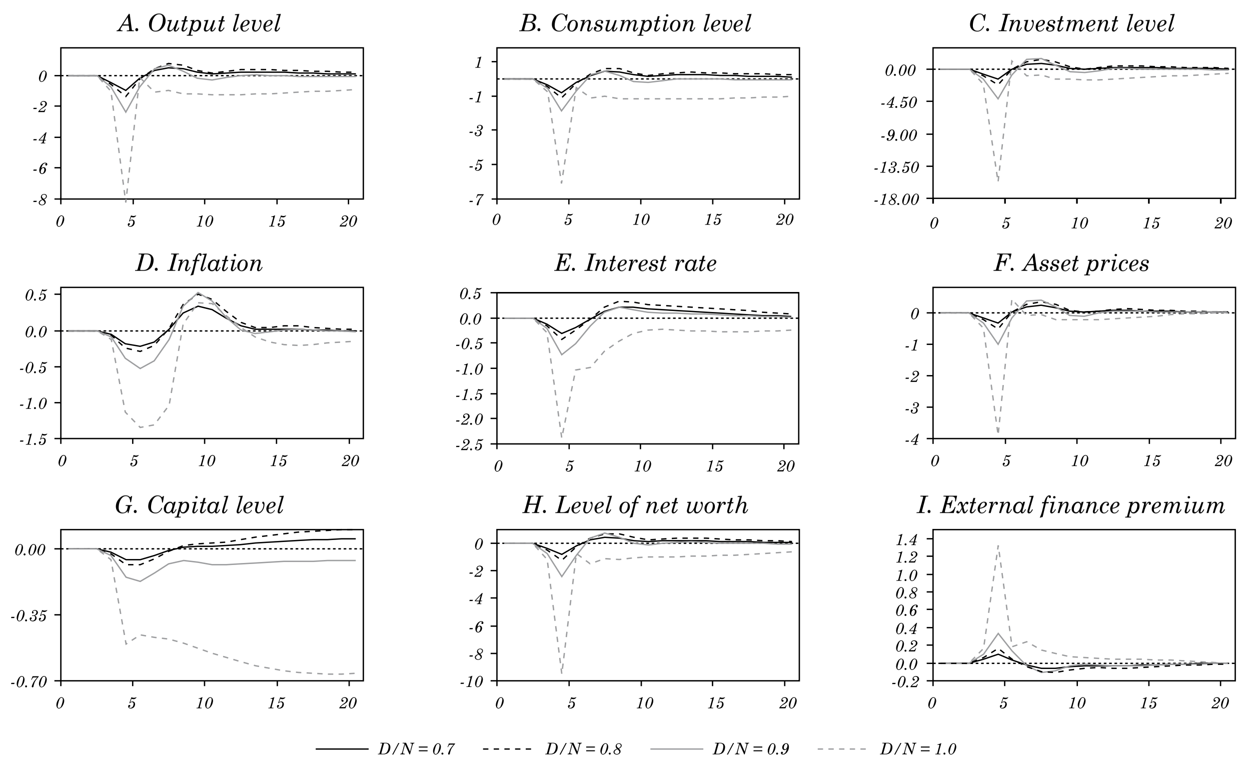
Source: Authors' calculations.

Figure 6. Difference in Response of Variables between Learning and Rational Expectations with the Financial Accelerator under Alternative Sizes of Shocks



Source: Authors' calculations.

Figure 7. Difference in Response of Variables between Learning and RE with the Financial Accelerator under Alternative Leverage Ratios



Source: Authors' calculations.

4. Monetary Policy Response to Asset Price Fluctuations

The housing market bubble in the United States and Europe that generated the conditions for the current crises led to a significant amount of research into whether the interest rate should respond to asset price fluctuations. Most of the theoretical papers found that the basic prescriptions of the inflation targeting approach to conducting monetary policy could deliver optimal outcomes even in the presence of asset price bubbles. Bernanke and Gertler (2001), for example, show that it is desirable for central banks to focus on underlying inflationary pressure and that asset prices become relevant only to the extent they signal potential inflationary or deflationary forces. They also find that rules that directly target asset prices appear to have undesirable side effects. Gilchrist and Saito (2008) extend the analysis of Bernanke and Gertler to discuss the implications of incomplete information on the fundamentals behind asset prices. They find that the gains from responding to the asset price gap (that is, the difference between observed asset prices and the potential level of asset prices in a flexible-price economy without financial market imperfections) are greater when the private sector is uninformed about asset price fundamentals, while the monetary authority is well informed. When monetary policy is less informed about fundamentals than market participants, responding to the wrong asset price gap may be detrimental. Dupor (2005) obtains similar conclusions. He finds that when the central bank has limited information about the nature of asset price movements, it should respond less aggressively to nonfundamental shocks.

Here we perform a preliminary analysis of the implications of endogenously generated asset price bubbles for the conduct of the monetary policy. Rather than looking for a fully optimal policy rule, we compare the economy's responses to the sequence of shocks described above under alternative policy rules. For this, we modify one by one each of the feedback coefficients in the monetary policy equation (12), keeping the degree of persistence, φ_i, constant. The modified coefficient is chosen so as to minimize the following loss criterion:

$$L(T) = \min_{\varphi} \frac{1}{T} \sum_{t=0}^{T} (\hat{y}_t^2 + \pi_t^2), \tag{20}$$

where $\hat{y}_t = \Delta y_t + z_t$. The relative weight of inflation fluctuations is set to one, which is consistent with Orphanides and Williams (2008).[12]

12. In the computations below, we use $T = 21$.

This loss function is not derived from first principles, although it is a standard function used in evaluating the implications of alternative monetary policies rules. Examples of this loss criterion are found in Orphanides and Williams (2008), Adolfson and others (2008a, 2008b), and Justiniano and Preston (2009), among others. The reason for using this criterion is that it reflects the policymaker's preferences for stabilizing an average between output and inflation volatility.

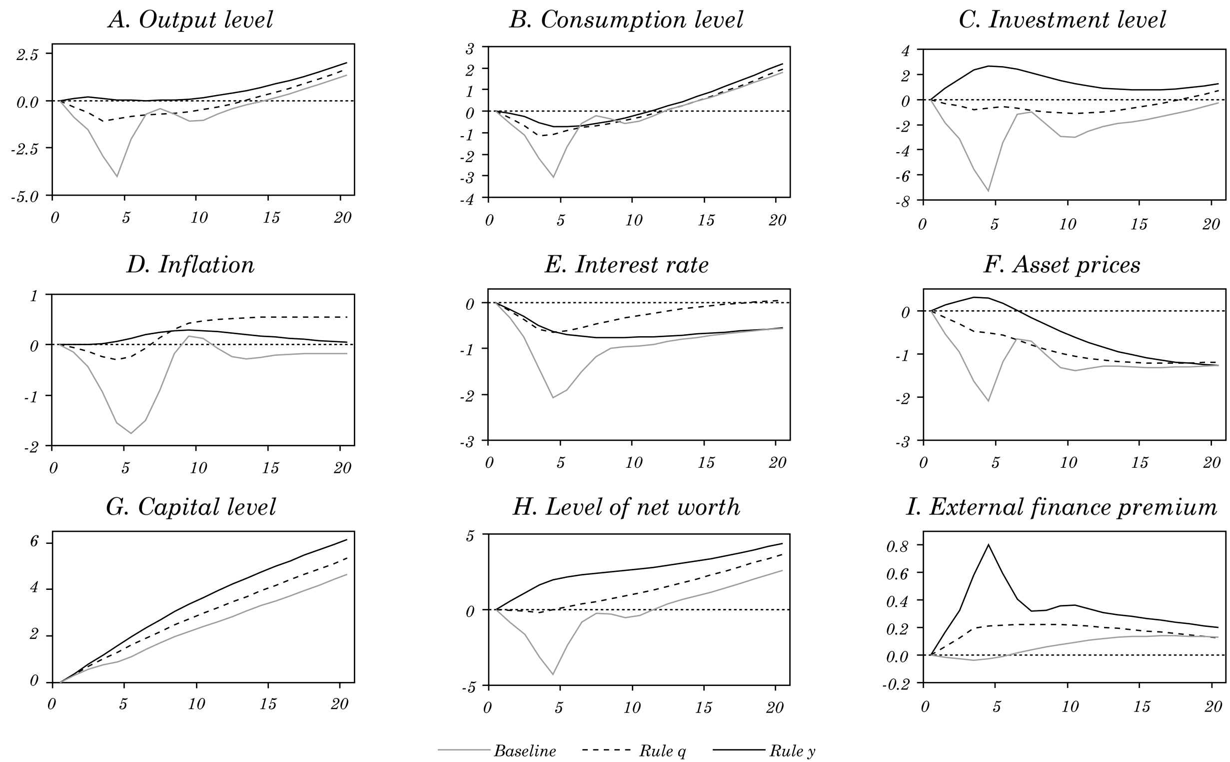
Consider first the case of a policy rule that responds not only to output and inflation, but also to fluctuations in the level of asset prices, qr_t. The value of the corresponding feedback coefficient, φ_q, in the policy rule that minimizes $L(T)$ is 0.14 (rule q in table 1). Following a sequence of negative shocks, the monetary policy response is such that it moderates the fall in asset prices. This, in turn, avoids the decline in net worth and attenuates the increase in the external finance premium (figure 8). As a result, output and inflation are more stable than in the baseline case. Under this rule, however, the monetary authority attempts to sustain the real asset price at its initial level, under circumstances in which the equilibrium price should fall. In this attempt, the monetary policy incubates inflationary pressures that lead to an increase in inflation after some periods.

Table 1. Alternative Policy Rules[a]

Long-run coeff.	*Baseline rule*	*Rule q*	*Rule y*	*Rule Δq*	*Rule π*	*UOSR*
φ_i	0.85	0.85	0.85	0.85	0.85	0.85
φ_π	1.75	1.75	1.75	1.75	**21.17**	1.62
φ_y	0.25	0.25	**0.96**	0.25	0.25	-0.05
φ_q	—	**0.14**	—	—	—	—
$\varphi_{\Delta q}$	—	—	—	**4.05**	—	5.63
$\hat{\sigma}_\pi^2$	0.0486	0.0144	0.0021	0.0066	0.0002	0.0068
$\hat{\sigma}_y^2$	0.6627	0.1287	0.0883	0.0632	0.0845	0.0560
L(T)	0.7113	0.1431	0.0904	0.0698	0.0847	0.0627

Source: Authors' calculations.
a. $\hat{\sigma}_\pi^2$ and $\hat{\sigma}_y^2$ are computed for $T = 21$.

Figure 8. Comparing Alternative Policy Rules



Source: Authors' calculations.

In the second exercise, we consider a policy that responds to fluctuations in output growth (rule *y* in table 1). The optimal feedback coefficient in this case is $\varphi_y = 0.96$. This policy manages to reduce the real interest rate fast enough to initially raise asset prices and reduce the external finance premium. Output is stabilized in the short run, as is inflation. After some quarters, this expansive policy generates a mild increase in inflation, which converges back to its long-run equilibrium level slowly. Output remains somewhat below trend for several quarters, but it is more stable than in the previous cases (figure 8).

Consider now a policy that reacts to changes in asset prices (rule Δq in table 1). The feedback coefficient that minimizes the loss criterion is $\varphi_{\Delta q} = 4.05$. Under this policy rule, asset prices remain nearly constant after the sequence of negative shocks, and the external finance premium increases slightly (figure 9). Output and inflation remain virtually unaltered in the first quarters. This policy turns out to be more expansive over a medium- or long-term horizon than the previous rules. In particular, it is able to reduce output volatility, although it marginally increases inflation volatility when compared to rule *y* (see table 1 and figure 9). Also, this rule induces a smooth decline in asset prices.

Finally, we consider a rule that responds aggressively to inflation deviations (rule π in table 1). The feedback coefficient on inflation that minimizes the loss criterion is $\varphi_\pi = 21.17$. This policy leads to an aggressive reduction of the interest rate in response to the shocks. This reduction in the policy rate avoids a decline in asset prices and the external finance premium declines marginally in the first quarters after the shock. Inflation is almost completely stabilized under this rule (figure 9). This policy, however, generates a higher volatility in output growth than the rule that reacts to changes in the asset price level.

All these alternative policy rules have in common a more aggressive response to output and inflation than the baseline policy. All of them induce a more stable path for asset prices and attenuate the increase in the external finance premium. Real variables therefore tend to be more stable than in the baseline case, and the sharp decline in inflation is avoided. In addition, by avoiding the dramatic fall in inflation, these alternative policy rules succeed at effectively lowering the real interest rate in response to the sequence of shocks.

To check the robustness of our results, we perform an alternative exercise where instead of optimizing just in one dimension (one feedback coefficient at a time), we look for the joint combination of coefficients that minimizes the welfare loss.[13] We follow Justiniano and Preston (2009) by choosing the feedback coefficients starting from several initial points to find the minimum of equation (20). Our results indicate that this unconstrained optimal simple rule (UOSR) considers an aggressive response to the change in asset prices, a feedback coefficient to inflation that is somehow lower than in the baseline case, and a response to output that is nearly zero (table 1). Nevertheless, the UOSR is able to reduce output volatility, mainly because asset prices turn out to be less volatile (see figure 9). This UOSR, like rule Δq, generates more inflation volatility than rule π.

These exercises are far from an optimal monetary policy analysis. First, the loss function is rather ad hoc, and variances are conditional to a particular sequence of shocks. Second, we restrict our analysis to consider only simple rules. Nevertheless, these exercises suggest that a policy rule that responds to changes in asset prices may improve on traditional policy rules that do not consider an endogenous response to financial variables. In any case, all the rules considered here induce a more stable path for the asset price than the one obtained under a simple Taylor rule.

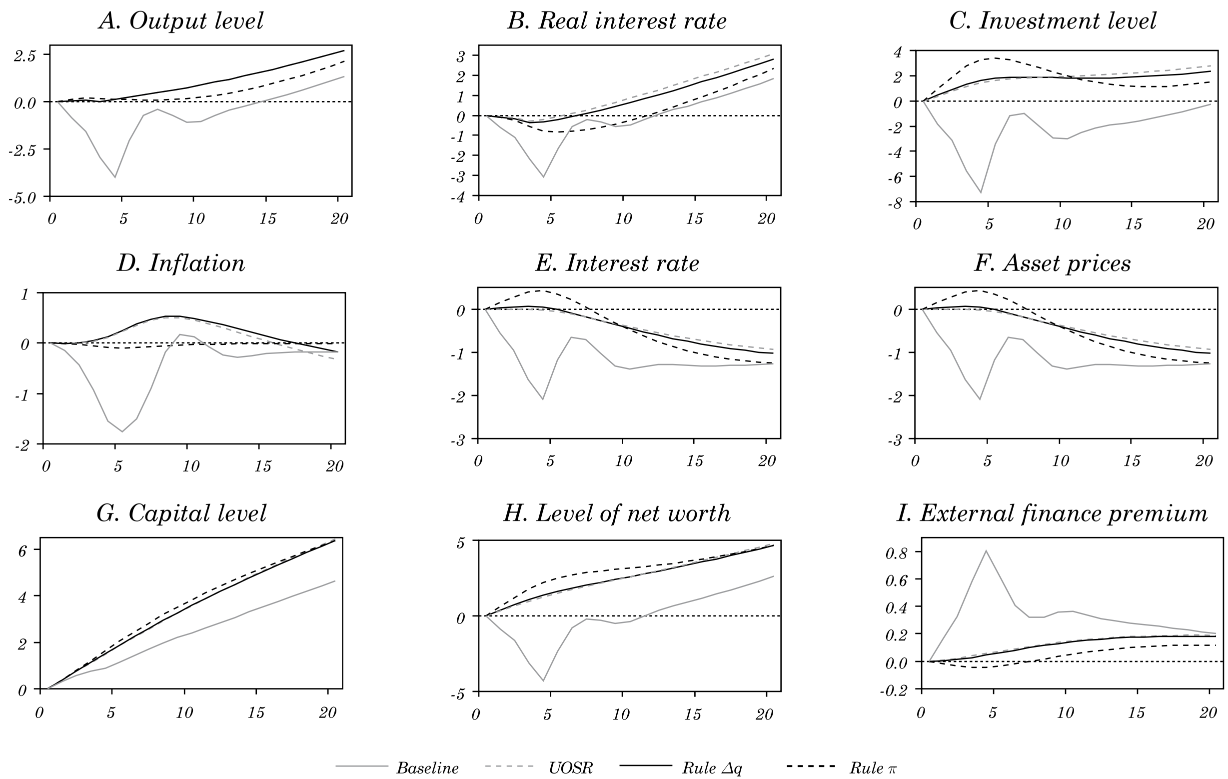
5. Conclusions

Financial frictions have been shown to play an important role in amplifying business cycle fluctuations. In this paper, we show that the financial accelerator mechanism analyzed by Bernanke, Gertler, and Gilchrist (1999) may render even larger business cycle fluctuations and endogenous asset price bubbles in the presence of small departures from the standard rational expectations assumption used in the literature. These large business cycle fluctuations are amplified in a nonlinear way by the size of the shocks and by the degree of financial fragility in the economy, as determined by capital producers' leverage.

Our preliminary results indicate that even in the presence of endogenous bubbles, responding aggressively to inflation reduces output and inflation volatility. If the central bank adjusts its policy instrument in response to asset price fluctuations, it may

13. For this exercise, we impose $\varphi_i = 0.85$ and $\varphi_q = 0$. We also performed alternative exercises allowing for φ_q different from zero, but the basic conclusion did not change.

Figure 9. Alternative Optimal Simple Rules



Source: Authors' calculations.

reduce output volatility and even inflation volatility in the short run. However, such a monetary policy leads to a surge in inflation several periods after the shocks. A policy that aggressively responds to changes in asset prices may marginally reduce output volatility relative to a policy that reacts aggressively to inflation, but at the cost of generating inflationary pressure.

Appendix

Steady State

The return to capital can be expressed as follows:[14]

$$R_K = (1 + r)(1 + \rho_K),$$

where ρ_K is the external finance premium in steady state.

The output-to-capital ratio is

$$\frac{Y}{K} = \frac{R_K - (1-\delta)}{\alpha(1+g)}.$$

The investment-to-capital ratio is

$$\frac{I}{K} = \frac{g+\delta}{1+g}.$$

The investment-to-output ratio is

$$\frac{I}{Y} = \frac{I}{K}\left(\frac{Y}{K}\right)^{-1}.$$

The consumption-to-output ratio is

$$\frac{C}{Y} = 1 - \frac{I}{Y}.$$

Finally, the rental rate of capital is

$$r_K = R_K - (1 + \delta).$$

14. When there is no financial accelerator, we assume $\rho_K = 0$.

Table A1. Baseline Calibration

Name	*Description*	*Value*
r	Steady-state real interest rate	2.5% (annual basis)
g	Steady-state labor productivity growth rate	1.5% (annual basis)
π	Steady-state inflation rate	2.0% (annual basis)
β	Subjective discount factor	0.99 (annual basis)
σ_L	Inverse of the elasticity of the labor supply	1.0
δ	Depreciation rate of capital	10.0% (annual basis)
φ_I	Elasticity of asset prices with respect to I/K	0.25
α	Capital share in the production technology	0.3
ε_L	Elasticity of substitution among labor varieties	21
ϕ_L	Probability of adjusting nominal wages	0.85
χ_L	Weight of past inflation in wages indexation	0.1
ε	Elasticity of substitution among intermediate goods	11
ϕ	Probability of adjusting prices	0.6
χ	Weight of past inflation in price indexation	0.8
φ_i	Smoothing coefficient in the Taylor rule	0.85
φ_π	Inflation coefficient in the Taylor rule	1.75
φ_y	Output coefficient in the Taylor rule	0.25
ρ_K	Steady-state external finance premium	3.0% (annual basis)
$(K-N)/N$	Steady-state leverage ratio	90%
χ_K	Elasticity of external premium to the leverage ratio	0.065
ρ_Z	AR(1) coefficient of the persistent productivity growth	0.8
γ	Constant-gain parameter	0.025

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Heterodox Central Banking

Luis Felipe Céspedes
Central Bank of Chile

Roberto Chang
Rutgers University

Javier García-Cicco
Central Bank of Chile

In response to the current global crisis, the U.S. Federal Reserve and other central banks around the world have implemented diverse policy measures, including purchasing a wide range of securities, lending to financial institutions, intervening in foreign exchange markets, and paying interest on reserves. Some central banks have also reduced monetary policy interest rates to minimum levels (reaching a lower bound) and have announced an explicit commitment to keep interest rates there for a prolonged period. This set of instruments contrasts with a conventional view—embedded in the predominant monetary policy models—in which a central bank controls only a short-term interest rate, such as the Federal Funds rate.

Some of the previous actions may be classified as responses to increasing demand for liquidity in a context of enormous financial uncertainty. Examples of this liquidity provisioning by central banks are the repurchase operations initiated in many economies to provide U.S. dollar liquidity during the period surrounding the bankruptcy of Lehman Brothers. Other actions may be sorted into those attempting to deal with malfunctioning financial markets (insufficient lending to non-financial firms or high lending spreads) and those attempting to enhance the monetary policy stimulus under the lower-bound constraint.

This paper discusses the theoretical and practical aspects of these heterodox policies. In terms of theory, the paper focuses on

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the two alternative arguments that have been offered to rationalize such policies: the desirability of further monetary stimulus when interest rates are already at zero, and the need to unlock financially intermediated credit when it freezes in a crisis. On the first argument, we provide a framework to analyze the theoretical mechanisms through which quantitative easing may be effective to deal with the lower bound constraint. We then show that the effectiveness of such unconventional policies depends crucially on the central bank's ability to commit to future policy, in line with Krugman (1998). Regarding the second argument, we present a model that helps us to introduce a role for unconventional monetary policy, in the context of non-trivial financial intermediation. We then argue that the introduction of financial intermediaries in standard models produces results that challenge conventional wisdom about the effects of non-conventional policies.

In terms of recent practice, we provide evidence arising from the recent experience of central banks that have implemented inflation targets as part of conducting monetary policy. We associate the different monetary policy actions with different phases of the recent financial crisis and with different objectives. In our analysis we focus on evaluating efforts to increase monetary policy stimulus and deal with disrupted financial markets.

The rest of the paper is organized as follows. Section 1 presents a theoretical discussion of two relevant issues that have been at center stage in both policy and academic discussions about unconventional policies during the current crisis: the role of credibility and the importance of financial frictions and bank capital. Section 2 provides a more empirically oriented account of recent events. We first discuss the timing and the type of unconventional policies that have been implemented. We then compare several alternative measures that can be used to assess the monetary policy approach, particularly when the policy rate has reached its lower bound. Finally, we provide descriptive evidence on the effects of these policies on the shape of the yield curve and the lending-deposit spreads. Section 3 concludes.

1. Rationalizing Heterodox Monetary Policy

1.1 Monetary Policy at the Edge: The Role of Credibility

One often mentioned justification for unconventional monetary policy is that the usual monetary instrument—the control of an overnight interest rate in the interbank market—may have reached a limit. In particular, this is the case when a monetary stimulus is deemed to be desirable but the policy rate is a nominal one that cannot be pushed below zero (or a value slightly greater than zero). If the policy rate is already at or close to the lower bound, the central bank must look for alternatives to provide monetary stimulus.

Clearly, the current crisis has brought several countries to a situation in which policy interest rates are close to zero, but expansionary policy appears warranted. Much less clear, however, is whether that fact is sufficient to justify the kind of unconventional policies that we have observed in practice. Can one appeal to the zero-lower-bound problem to rationalize, for example, the striking expansion in the size of the Federal Reserve's balance sheet and the changes in its composition? We argue that the answer can be either affirmative or negative, depending on the policy environment and, above all, on the central bank's ability to commit to future policy.

The starting point of our argument is the observation that currently accepted macroeconomic theory implies that the zero bound on interest rates will rarely, if ever, be a truly binding constraint for a central bank that can perfectly commit to future policy. Recent theories emphasize that a central bank can affect economic decisions not only through the current setting of its policy instrument—for instance, today's interest rate—but also, and perhaps much more effectively, through its impact on the public's expectations regarding the future settings of the instrument. The corollary is that the central bank can always provide some stimulus to the economy, even if the policy rate is at the zero bound, by committing to reducing future policy rates below levels previously expected (which is feasible if the policy rate was expected to be positive at some point in the future).

Thus, for example, Bernanke and Reinhart (2004, p. 85) argue that one of the strategies available for stimulating the economy that does not involve changing the current value of the policy rate is "providing assurance to investors that short rates will be kept lower in the future than they currently expect." The same argument has been embraced recently by the European Central Bank (Bini Smaghi, 2009), the Bank of Canada (Murray, 2009), and others. In fact, even Krugman's (1998) pioneering discussion of Japan implied that the Bank of Japan could have escaped the liquidity trap by promising to keep interest rates sufficiently low for some period, even after inflation had become positive (see also Svensson, 2003).

In short, the zero lower bound on interest rates is unlikely to be a serious constraint on a central bank that can pre-commit to policy. One could conjecture, however, that unconventional policies such as "quantitative easing" or "credit easing" may still be useful to complement conventional policy. It is somewhat surprising, however, to realize that that conjecture is quite unlikely to hold.

This key point has been developed most convincingly by Eggertsson and Woodford (2003). They show that, once a strategy for setting current and future policy rates is in place (for example, using a Taylor-type rule), real allocations and asset prices become independent of whatever the central bank does with the composition or size of its balance sheet during periods in which the policy rate is zero.

It may be worth expanding on the intuition behind this important result, if only to stress its generality. Eggertsson and Woodford's model is a variant of the canonical New Keynesian sticky price model developed by Woodford (2003) and others. In that model, and many others, all asset prices are determined once the equilibrium pricing kernel—or, the stochastic discount factor—is given. Likewise, the stochastic discount factor determines the relevant budget constraint for the household and producer's pricing decisions.

In this context, an interest rate rule can affect aggregate outcomes by establishing a relation between the stochastic discount factor and other variables, such as inflation or the output gap. In equilibrium, an equation as follows expresses the relationship:

$$\begin{aligned}\left(E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}}\right)^{-1} &= 1 + i_t \\ &= \phi(\mathbf{Z}_t),\end{aligned}$$

where β is the average household's discount factor, λ_t is the marginal utility of consumption, P_t the price of consumption, i_t the nominal interest rate for loans between periods t and $t+1$, and ϕ is a function of a vector of variables $\mathbf{Z}_t$, typically inflation and output. The first equality reflects the household's optimal portfolio decisions; here, the stochastic discount factor is given by the random variable $\beta\lambda_{t+1}/\lambda_t$. The second equality says that the central bank sets the interest rate i_t as a function ϕ of the vector of variables $\mathbf{Z}_t$. In equilibrium, then, interest rate policy (for example, a choice of the function ϕ and the vector $\mathbf{Z}_t$) implies a relation between the stochastic discount factor, inflation, and the vector $\mathbf{Z}_t$. Indeed, this is the main (and often the only) way in which interest rate policy affects aggregate outcomes.

If the zero bound on the policy rate i_t were not a binding constraint, a choice of an interest rate rule $\phi(\mathbf{Z}_t)$ would leave no room for "quantitative easing", that is, independent control of the monetary base. Demand would determine the quantity of money, with the central bank adjusting the base as necessary to clear the market (this indeed is what an interest rate rule would mean). In addition, under usual assumptions about fiscal policy, changes in the composition of the central bank's balance sheet—and, more generally, in the consolidated version of the government's balance sheet—are irrelevant for aggregate outcomes. This is because the latter can be shown to depend only on the present value budget constraint of the government, which is given by its initial debt plus the appropriately discounted value of (possibly state-contingent) fiscal deficits.

Eggertsson and Woodford (2003) extend this logic to situations in which the interest rate policy $\phi(\mathbf{Z}_t)$ may prescribe an interest rate of zero under some circumstances—that is, for some values of the vector $\mathbf{Z}_t$. In those cases, they assume that the demand for money is indeterminate (the real demand for money being only bounded below by some satiation level). This allows the central bank to determine the quantity of money independently, in other words, to engage in quantitative easing. They show, however, that aggregate allocations are independent of the details of such quantitative easing. The logic is simple: as we just discussed, quantitative easing could affect aggregate outcomes if it had an impact on the stochastic discount factor, but the latter is pinned down by the function ϕ, as in the absence of the lower-bound problem.

The justification for the last assertion is illuminating. The assertion would be immediate if the marginal utility of consumption λ_t were independent of real money balances. Eggertsson and Woodford assume, however, that utility may depend on real balances in a nonseparable way, so λ_t may depend on M_t/P_t. However, if the interest rate is driven to zero, real balances must exceed the satiation level, which in turn means that the quantity of money no longer has any effect on utility and—all the more certainly—on λ_t.[1] Having established that quantitative easing is irrelevant at zero interest rates, the irrelevance of altering the composition of the central bank's balance sheet follows, as before.

1. It is in this exact sense that money and bonds become perfect substitutes at zero interest rates.

Our discussion stresses that the logic behind the Eggertsson-Woodford irrelevance result is quite general and, hence, extends to a very broad class of models, including those most current. The result, in particular, does not hinge on the absence of imperfectly substitutable assets, which may have led some to suspect that changes in the size and composition of the central bank balance sheets would have portfolio balance effects. Indeed, the absence of portfolio balance effects could be considered a significant flaw, and one could conjecture that models featuring such effects may overturn the irrelevance argument. However, a compelling portfolio balance model of the effects of policies involving the central bank balance sheet has yet to be developed. In addition, the empirical evidence about portfolio balance effects provides little support for them, as stressed by Bernanke and Reinhart (2004, p. 87): "the limited empirical evidence suggests that, within broad classes, assets are close substitutes, so that changes in relative supplies of the scale observed in U.S. experience are unlikely to have a major impact on risk premiums or even term premiums (Reinhart and Sack, 2000)."

To summarize, we have argued that a central bank that can commit in advance to a conventional interest rate policy will generally find that the zero bound on interest rates is not a binding restriction and, in particular, can provide monetary stimulus, even in a liquidity trap, by promising that future policy rate levels will be lower than they would have been otherwise. In addition, such a central bank will find that quantitative easing, portfolio management maneuvers, and other strategies for altering the size and composition of its balance sheet at times of zero interest rates are irrelevant.

Given the above, why is it that central banks have often been unable to come out of deflationary liquidity traps by simply promising expansionary policy in the future? The key conjecture is that such promises may not be credible. Credibility is a crucial constraint in this situation, as several authors have emphasized, starting with Krugman's (1998) analysis of the Japanese recession.

One implication of this observation is that the literature is full of warnings and admonitions about the need for central banks to ensure that announcements of future policy are believable, suggesting that central banks can even "manage expectations" independently of interest rate policy. For example, the *Banque de France* recently stated that one unconventional policy is "influencing the yield curve by guiding expectations" (*Banque de France*, 2009, p. 5). There is little guidance in these statements, however, as to how, precisely, the central bank can independently manage expectations. Bernanke and Reinhart (2004, p. 86) acknowledge this fact, stating that "the central bank's best strategy for building credibility is to build trust by ensuring that its deeds match its words...the shaping of expectations is not an independent policy instrument in the long run."

Others have responded to the credibility issue by emphasizing the need for improving transparency and clear communication of central bank policy intentions. Of course, it is hard to argue with the view that transparency and clear communication are desirable aspects of central bank policy. Aside from the fact that it is not clear why the need for them is greater when interest rates are close to zero than at other times, however, there is no generally accepted theory of how more or less transparency affects monetary transmission channels.

A related claim, of particular relevance to our discussion, is that changes in the size and composition of the central bank balance sheet can help the credibility of the central bank's announcements about future policy. In fact, some authors have claimed that this is the main role of unconventional policies. For example, Bernanke and Reinhart (2004, p. 88) argue that a central bank policy of setting a high target for bank reserves "is more visible, and hence may be more credible, than a purely verbal promise about future short-term interest rates." Likewise, Eggertsson and Woodford (2003) conjecture that "shifts in the portfolio of the central bank could be of some value in making credible to the private sector the central bank's own commitment to a particular kind of future policy... 'Signaling' effects of this kind... might well provide a justification for open market policy when the zero bound binds."

To date, attempts to make these claims more precise have been lacking, but a longstanding theory of monetary policy under imperfect credibility suggests several ways to develop this view. To illustrate, let us examine the implications of a simple model of monetary policy.

1.1.1 Unconventional policy: An illustrative model

We shall extend the model of Jeanne and Svensson (2007, henceforth *JS*). Consider a small open economy with a representative agent that maximizes the discounted expected utility of money holdings and consumption of tradables and non-tradables. The period utility of tradables is log C_t, where C_t is a Cobb-Douglas aggregate of home (*h*) non-tradables and foreign (*f*) tradables,

$$C_t = C_{ht}^{1-\alpha} C_{ft}^{\alpha}.$$

C_{ht} is, in turn, a conventional Dixit-Stiglitz aggregate of domestic varieties. With the world price of foreign tradables normalized to one, the price of consumption is therefore

$$P_t = P_{ht}^{1-\alpha} S_t^{\alpha},$$

where P_{ht} is the price of home non-tradables and S_t the nominal exchange rate.

The representative agent chooses consumption and holdings of money, a world noncontingent bond, and domestic bonds. His sources of income in each period are wages, profits of domestic firms, income from previous investments, and a transfer from the central bank (denoted *Z*, as in *JS*). It turns out that these transfers are not needed for our argument, but let us keep them in for now to preserve the *JS* notation.

There is a central bank that can print domestic currency freely to finance transfers and a portfolio of securities. A bond of maturity k is a promise to pay one unit of consumption at time $t + k$. For simplicity, assume that k can be either one or two, such that there are "short" (one-period) bonds and "long" (two-period) bonds.[2]

Let Q_t^s denote the home currency price at t of a bond promising one unit of consumption at $t + s$, where $s = 1{,}2$. Letting B_t^s be the central bank holdings at the end of period t of the corresponding bond, the central bank's budget constraint is

$$Z_t + Q_t^1 B_t^1 + Q_t^2 B_t^2 = M_t - M_{t-1} + B_{t-1}^1 + Q_t^1 B_{t-1}^2.$$

In contrast with *JS*, who examine the role of foreign exchange intervention, we assume that the central bank keeps zero foreign exchange reserves. Instead, it holds a portfolio of short and long bonds. This means that, in the central bank's budget constraint, the crucial term will be the last one on the right-hand side, which

2. Notice that we assume that bonds are real promises. This is a nontrivial assumption, discussed at length in the working paper version of *JS*.

denotes the current value of long bonds purchased the previous period. Hence, changes in the price of long bonds can be a source of gains or losses for the central bank.

Jeanne and Svensson (2007) prove two results. The first is that a central bank that minimizes a conventional expected discounted value for losses that depends only on inflation and the output gap may be unable to implement an optimal policy to escape from a liquidity trap, if it cannot commit to honoring promises of future policy. The second result is that this commitment problem may be solved if the central bank cares enough about its capital position. The mechanism described by *JS* is for the central bank to initially acquire enough foreign exchange reserves, by either printing domestic currency or reducing transfers to the Treasury. This results in a currency mismatch and implies that, were the central bank to subsequently deviate from a promise of high inflation, the concomitant currency appreciation would result in a capital loss via the fall in the value of the central bank's foreign reserves. This would deter the central bank from reneging on a promise of high inflation, if we can assume that the central bank cares about its capital.

Here, we will describe a similar argument that relies on the management of asset maturities in the central bank's portfolio. While the logic of the mechanism is essentially the same as in *JS,* we will see that there are some interesting differences. First, note that the capital of the central bank is, by definition, the value of its assets minus liabilities:

$$V_t + Q_t^1 B_t^1 + Q_t^2 B_t^2 - M_t,$$

which, using the budget constraint above, can be rewritten as:

$$V_t = -M_{t-1} + B_{t-1}^1 + Q_t^1 B_{t-1}^2 - Z_t.$$

This expresses, in particular, that the capital position of the central bank improves if the price of short bonds, Q_t^1, increases *and* the central bank had a long position in two period bonds at the end of the previous period. This will prove to be crucial.

Before elaborating on this point, let us discuss competitive equilibria. *JS* make the usual assumptions of setting the current account to zero in all periods and making tradable consumption constant. Non-tradable consumption, meanwhile, equals non-tradable output:

$$C_{ht} = Y_t.$$

Non-tradables are produced with only labor and a linear technology, by monopolistically competitive firms that choose prices one period in advance. As is well known, the typical firm (z) chooses a price that is a constant markup over marginal cost:

$$P_{ht}(z) = \frac{\varepsilon}{\varepsilon - 1} E_{t-1} \frac{W_t}{A_t},$$

where ε is the elasticity of substitution between varieties, W_t the wage, and A_t aggregate productivity. Now, optimal labor choice implies that

$$\frac{W_t}{P_{ht}} = \frac{C_{ht}}{1-\alpha} = \frac{Y_t}{1-\alpha},$$

from which firm z's relative price is

$$\frac{P_{ht}(z)}{P_{ht}} = E_{t-1} \frac{Y_t}{Y_t^*},$$

where

$$Y_t^* = \frac{\varepsilon}{\varepsilon - 1}(1-\alpha)A_t$$

is the rate of natural output.

In equilibrium, $P_{ht}(z)/P_{ht}=1$, because all firms are identical, and we arrive at the aggregate supply equation:

$$1 = E_{t-1} \frac{Y_t}{Y_t^*}.$$

Here, the real exchange rate is defined as

$$Q_t = \frac{S_t}{P_{ht}},$$

which, in equilibrium, is given by

$$Q_t = \frac{\alpha / C_{ft}}{(1-\alpha)/C_{ht}} = \frac{\alpha}{(1-\alpha)} \frac{Y_t}{\overline{C}_f},$$

where $\overline{C}_f$ is the constant equilibrium consumption of tradables. Therefore, the real exchange rate depreciates if domestic output increases, which is one source of *JS*'s main results.

To allow for the possibility of a "liquidity trap," assume that there is a nominal bond, and that the nominal interest rate must equal

$$e^{-i_t} = \delta E_t \frac{P_{ht}}{P_{h,t+1}} \frac{Y_t}{Y_{t+1}}$$

from the household's Euler condition, where δ is the discount factor. The real interest rate must then satisfy

$$e^{-r_t} = \delta E_t \left(\frac{Y_t}{Y_{t+1}} \right)^{1-\alpha}.$$

This is a key equation, which states that the real interest rate must fall if output is expected to decline. *JS* consider a situation in which at $t = 1$ the log of productivity is equal to its previous steady state, say a, but we know that it will fall to $b < a$ from period $t = 2$ on. This can lead the economy to a liquidity trap, as we now argue.

Start by assuming that the central bank minimizes a conventional loss function $E\sum \delta^t L_t$, where

$$L_t = \frac{1}{2}[(\pi_t - \pi)^2 + \lambda(y_t - \overline{y}_t)^2],$$

where π is the inflation target and $\overline{y}_t$ is the natural level of output. From hereon, lowercase variables are logarithms of their uppercase counterparts. To see how a liquidity trap may emerge, note that

$$\pi_t = p_t - p_{t-1} = p_{ht} + \alpha q_t - p_{t-1}.$$

Letting the natural real exchange rate be defined in the obvious way,

$$\bar{Q}_t = \frac{\alpha}{(1-\alpha)} \frac{\bar{Y}_t}{\bar{C}_f},$$

we obtain

$$\pi_t = p_{ht} + \alpha \bar{q}_t - p_{t-1} + \alpha(y_t - \bar{y}_t).$$

Under discretion, the policymaker would minimize L_t subject to the preceding equation, which would yield

$$\pi_t = \pi - \frac{\lambda}{\alpha}(y_t - \bar{y}_t).$$

Recalling, however, that there are no unexpected shocks in periods $t = 2$ on, in equilibrium $Y_t = \bar{Y}_t$ for all t except possibly for $t = 1$. Therefore, $\pi_t = \pi$ for $t = 2,3,\ldots$ such that inflation is at the target in all periods, expect possibly in period $t = 1$.

Jeanne and Svensson (2007) show that, if b is sufficiently low relative to a, the economy will fall into a liquidity trap in period one—that is, a situation in which the interest rate i_1 falls to zero, and output falls short of the natural level. This results in lower welfare than under commitment. With commitment, the central bank would promise to increase π_2 over π to spread the cost of the productivity fall between periods 1 and 2. However, in the absence of a commitment device, this promise would not be kept: in period 2, it would be optimal for the central bank to reduce π_2 to the target π.

To see the role of debt management, let us focus on the pricing of bonds of different maturities. Recall that there is no more uncertainty after period one. Hence, by arbitrage,

$$\frac{P_{t+1}}{Q_t^1} = e^{i_t}.$$

This says that the return on one-period bonds must be equal to the return on nominal bonds. Now, recalling that $\pi_t = \pi$ for $t \geq 2$,

$$\frac{P_{t+1}}{Q_t^1} = \frac{P_{t+1}}{P_t}\frac{P_t}{Q_t^1} = e^{i_t} = e^{r^*+\pi},$$

where r^* is the natural real rate of interest,

$$Q_t^1 = e^{-r^*} P_t. \tag{1}$$

Note that this says that the price of one-period bonds is proportional to the price level from period 2 on.

Also, under perfect foresight, arbitrage implies that the price of a two-period bond equals the product of the prices of one-period bonds now and next period:

$$Q_t^2 = Q_t^1 Q_{t+1}^1. \tag{2}$$

These facts now lead us to our main result. Suppose that, at $t = 1$, the central bank learns about a future decline in productivity and sells x short bonds and buys an equivalent amount of long bonds. The amount of long bonds purchased is denoted by $Q_1^1 x + Q_1^2 B_1^2 = 0$, that is

$$B_1^2 = -\frac{Q_1^1}{Q_1^2}x.$$

By construction, this operation has no impact on either the budget constraint or the central bank's capital position at $t = 1$.

If the central bank could commit to the optimal policy (under commitment), the operation would not affect its budget constraint nor its capital position in any subsequent periods either. This is because the arbitrage condition (2) would guarantee that the value of the inherited portfolio would be zero:

$$B_1^1 + Q_2^1 B_1^2 = x + Q_2^1\left(-\frac{Q_1^1}{Q_1^2}x\right) = 0.$$

Notably, this is an instance of Eggertsson and Woodford's irrelevance result: under commitment, open market operations are irrelevant.

But suppose that the central bank has no commitment and can contemplate a deviation from the optimal plan. As shown in *JS* (and intuitively obvious), the central bank would then have an incentive to reduce inflation towards the target, thus cutting P_2 from its optimal level to a lower level, say P_2'. However, since there are no incentives for further deviations, prices of bonds maturing at $t = 3$ would fall, by equation (1), to some level $(Q_2^1)'$. Then the value of the central bank portfolio would be:

$$\begin{aligned} B_1^1 + (Q_2^1)' B_1^2 &= x[1 + (Q_2^1)'(-\frac{Q_1^1}{Q_1^2})] \\ &= x\left[1 - \frac{(Q_2^1)'}{Q_1^2}\right]. \end{aligned}$$

This is less than zero if x is negative and $(Q_2^1)' < Q_2^1$, that is, if the central bank surprisingly changes policy in a way that leads to lower prices. It follows that the deviation is not profitable for the central bank if it cares about its capital position and x is negative and sufficiently large in absolute value.

In other words, the central bank can ensure the credibility of an inflationary policy by changing the composition of its balance sheet, selling short-term bonds and holding long-term bonds. This is crucial to equilibrium, not because such an unconventional measure would change the equilibrium outcome—which is the same as the outcome under commitment—but because the debt structure can change the incentives for the central bank, discouraging deviation from the desired equilibrium: a deflationary surprise would reduce the value of long-term bonds, inflicting a punishment on the central bank.

The argument here is therefore related to the classic Lucas and Stokey (1983) study of optimal policy under time inconsistency. As in that paper, debt maturity is irrelevant under commitment, but can be crucial under discretion.

Our discussion also stresses that the composition of the central bank's balance sheet can be managed in several alternative ways to provide the proper incentives for the central bank. As mentioned, our argument here is similar but not the same as in *JS*, who focused on international reserves management. Compared with their argument, the one presented here is cleaner because we do not need to worry about central bank transfers (denoted Z above), which figure somewhat prominently in *JS*. In fact, we eliminate the transfers completely. On the other hand, we depend on having a rich enough menu of assets, in this case debts with different maturities.

Our analysis provides a concrete setting in which unconventional central bank policy not only helps but is in fact crucial to implementing optimal monetary policy. What is the value of such an exercise? For one thing, it clarifies the sense in which management of the central bank balance sheet can indeed complement conventional interest rate policy, much more effectively than vague statements, such as "the central bank's open market operations should be chosen with a view to signaling the nature of its policy commitments". Indeed, our analysis has not relied on the existence of asymmetric information of any sort, and therefore leaves no room for any kind of signaling.

Moreover, a formal analysis opens the way to interpreting and identifying the validity (or lack thereof) of many claims in the policy literature. To cite but one example, to justify unconventional measures, the Bank of Canada has cited the principle of "prudence", meaning that the Bank should "mitigate financial risks to its balance sheet, which could arise from changes in yields (valuation losses) or from the credit performance of private sector assets (credit losses)," (Bank of Canada, 2009, p. 29). But in the analysis above it is precisely the possibility of such valuation losses that lend credibility to the central bank's promises to keep interest rates low, even as inflation overshoots its target.

Notably, our analysis explains why, for justification's sake, these operations may have to be carried out *by the central bank*, instead of, say, the Treasury. This is relevant, because often the reasons given to justify altering the size and composition of the central bank's balance sheet are really reasons to change fiscal policy rather than central bank policy. Here, the open market operations in play are designed to affect the central bank's incentives, which would not happen if an alternative agency were to carry out such operations.

1.1.2 Alternative solutions to the commitment problem

Our discussion has emphasized that one fruitful way to rationalize unconventional policy may be to see the management of the central bank's portfolio as a commitment device. This perspective also suggests we should look for more general insights in the rich literature on policy under time inconsistency and lack of commitment.

Walsh (1995), for example, emphasized that one way to solve the classical time inconsistency problem in monetary policy is to provide optimal contracts to central bankers, a view that has been associated with the widespread acceptance of inflation targeting in a context of central bank independence.

Arguably, Walsh's view remains quite relevant to solving the credibility problem with zero interest rates too. In the context of the model described in the preceding subsection (and the analysis in *JS*), we mentioned that a critical part of the solution is the assumption that the central bank cares about its capital. But, where does this concern come from? The problem arose because, presumably, the central banker had been assigned (at some point before the start of the analysis) a mandate to minimize a loss function with inflation and the output gap as arguments. A suggestion echoing Walsh's would then be to enlarge that loss function with a term inflicting a penalty on the central banker, if bank capital were to fall below some value.

But if that is in fact the case, one could and should also ask the more general question, posed by Walsh, of what is the optimal contract to the central banker. This would recognize, in particular, that the contract may not entail an inflation target, even if inflation targeting would be optimal under commitment. This issue may, in fact, have gone beyond theory and become quite influential in practice. Specifically, Svensson (2001) has advocated that one way to solve the credibility problem in a liquidity trap may be to switch the objective of the central bank from inflation targeting to price level targeting, and that strategy has actually been embraced by Sweden. Our analysis suggests that this reform may be understood as a way to modify the loss function assigned to the central banker, to provide the correct incentives for implementing the optimal monetary policy.

1.2 Financial Frictions, Bank Capital, and Heterodox Policy

An alternative justification for central banks resorting to new policy instruments has been that the recent crisis involved a combination of skyrocketing interest rate spreads, frozen credit markets, and paralyzed financial institutions. In this context, it was clear that the traditional monetary policy tool—that is, the supply of bank reserves to target an overnight interbank interest rate—seemed to have become completely ineffective. In particular, additional liquidity in the interbank market was hoarded by the banks, apparently in some cases in an effort to reconstitute their severely impaired capital levels. Thus, several central banks stepped into credit markets and started expanding the size and scope of rediscounting operations, swapping questionable assets for safer government debt and, in some cases, lending directly to the private sector.

These developments have stimulated a small but growing literature attempting to understand the interaction of unconventional monetary policies with financial imperfections and the behavior of the banking system. As the discussion suggests, significant progress on this front will require not only analyzing the implications of endowing the monetary authorities with a policy arsenal that includes more than interest rate control, but also introducing a nontrivial banking system into current theory. This will demand, in turn, dropping the crucial assumption of frictionless financial markets that currently pervades dominant models.[3]

Unfortunately, no theory of banks exists yet that is both widely accepted and tractable enough to be embedded into the stochastic dynamic models that characterize modern monetary theory. As a result, recent attempts have been as much about this modeling issue as about the effects of unconventional policy. For example, an influential study by Christiano, Motto, and Rostagno (2007) models banks, following what Freixas and Rochet (2008) call the "industrial organization" approach. In contrast, in Gertler and Karadi (2009), banks are agents that borrow from households and lend to firms, subject to a moral hazard problem. Similarly, Cúrdia and Woodford (2010) modify the basic New Keynesian model by assuming that households differ in their preferences, thus creating a social function for financial intermediation.

One initial conclusion of these studies of relevance to monetary policy is that augmenting a standard Taylor rule to respond mechanically to changes in the spread between lending and deposit rates may not be optimal. How effective this action is, will depend on the type of shock that generates the increase in the spread. Now, in terms of credit policy—that is, direct lending by the central bank to non-financial firms—this policy would be optimal if private financial markets are sufficiently impaired (Cúrdia and Woodford, forthcoming; Gertler and Karadi, 2009).

However, the state of affairs is such that it may be premature to try to draw firm conclusions from these studies, and indeed the papers just cited are still being refined and may change substantially.

3. Needless to say, the analysis in the previous subsection may require significant changes if perfect financial markets are not assumed.

Nevertheless, they represent a shifting perspective that is likely to stay and, hence, is worth discussing in more detail. To do so, we discuss next a related model of ours, designed to illustrate several of the issues involved.

1.2.1 An illustrative model

This model is a stochastic discrete time version of Edwards and Végh (1997), with one crucial modification: bank lending is constrained by bank capital. This change is not only warranted by current events but also implies, as we will see, a substantial departure in terms of model solution and dynamics.

Consider an infinite horizon small open economy. There is only one good in each period, freely traded and with a world price that we assume to be constant (at one) in terms of a world currency.

The economy is populated by a representative household that maximizes

$$E\sum_t \beta^t \left[\log c_t + \log(1-l_t)\right],$$

where c_t and l_t denote consumption and labor effort, and β is the household's discount factor.

To motivate a demand for bank deposits, we assume that deposits are necessary for transactions. This results in a deposit-in-advance constraint

$$d_t \geq \alpha c_t,$$

where α is a fixed parameter and d_t denotes bank deposits. Deposits pay interest, which can be expressed in real terms as:

$$1+r_t^d = (1+i_t^d)\frac{P_t}{P_{t+1}},$$

where i_t^d is the nominal interest rate paid on deposits, and r_t^d is the corresponding real interest rate.

The household owns domestic firms and banks, and receives transfers from or pays taxes to the government. Hence its flow budget constraint is given by:

$$\Omega_t^f + \Omega_t^b + T_t + w_t l_t + (1+r_{t-1}^d)d_{t-1} = d_t + c_t,$$

where Ω^b_t and Ω^f_t are profits from banks and firms, respectively, T_t denotes government transfers (or taxes, if negative), and w_t is the real wage. For simplicity, we are assuming that the household cannot lend or borrow in the world market. Our arguments extend easily if the household can lend but not borrow in the world market, as we shall see.

Let $\lambda_t\omega_t$ and λ_t be the Lagrange multipliers associated with the deposit-in-advance constraint and the flow budget constraint, respectively. Optimal household behavior is then given by the first-order conditions:

$$\frac{1}{c_t} = \lambda_t(1+\alpha\omega_t),$$

$$\frac{1}{1-l_t} = \lambda_t w_t,$$

$$\lambda_t = \beta E_t \lambda_{t+1}(1+r^d_t) + \lambda_t\omega_t.$$

These have natural interpretations. In particular, the first condition emphasizes that the household equates the marginal utility of consumption to its shadow cost, inclusive of the cost of the deposit-in-advance constraint. Likewise, the third condition emphasizes that the return to deposits must include the benefit from relaxing the deposit-in-advance constraint.

We now turn to production. There is a continuum of identical domestic firms, each able to produce tradables with a linear technology that employs only labor:

$$y_t = A_t l_t,$$

where A_t is an exogenous productivity shock.

The typical firm maximizes the appropriately discounted value of dividends:

$$E\sum_t \beta^t \lambda_t \Omega^f_t,$$

where flow profits are given by:

$$\Omega^f_t = A_t l_t - w_t l_t + h_t - (1+r^l_{t-1})h_{t-1}.$$

To motivate a demand for bank loans, we introduce a working capital assumption in which the firm must borrow a fraction γ of the wage bill from banks, such that

$$h_t \geq \gamma w_t l_t,$$

where h_t denotes the amount that the firm must borrow. The real interest rate on loans is denoted r_t^l, with:

$$1 + r_t^l = (1 + i_t^l)\frac{P_t}{P_{t+1}}.$$

In each period the firm chooses l_t and h_t. Letting ϕ_t be the multiplier on the finance constraint, the first-order conditions for the firm's problem are

$$A_t = w_t(1 + \gamma\phi_t),$$
$$1 + \phi_t = E_t\beta\frac{\lambda_{t+1}}{\lambda_t}(1 + r_t^l).$$

Note that the first condition stresses that the cost of labor must include the financial cost associated with the working capital constraint.

Next, turn to the banking sector. As in Edwards and Végh (1997), banks are modeled following an industrial organization approach. This is appealing, because that approach implies that there will be spreads between deposit and lending rates. But, as mentioned, we depart from Edwards and Végh (1997) by assuming that bank lending is constrained by bank capital.

Banks maximize

$$E\sum_t \beta^t \lambda_t \Omega_t^b,$$

where

$$\Omega_t^b = (1 + r_{t-1}^l)z_{t-1} + f_{t-1}\frac{P_{t-1}}{P_t} + d_t + x_t - (1 + r_{t-1})x_{t-1}$$
$$-z_t - f_t - (1 + r_{t-1}^d)d_{t-1} - \xi_t\eta(z_t, d_t),$$

z_t denotes credit to firms, f_t required reserves, x_t foreign borrowing, and r_t the cost of foreign borrowing. We also assume a reserve requirement

$$f_t \geq \delta d_t,$$

where δ is the required reserves coefficient. Finally, we assume that leverage is limited:

$$z_t \leq \chi n_t,$$

where the bank's capital, n_t, is given by

$$n_t = f_t + z_t - d_t - x_t.$$

The leverage ratio χ, which could be time varying, is the key innovation of this model relative to Edwards and Végh (1997) and others (such as Catão and Rodriguez, 2000). One could rationalize the leverage constraint as a shortcut to modeling agency problems of the type emphasized by Kiyotaki and Moore (1997) and, more recently, Gertler and Karadi (2009). We assume χ is greater than one, and reflects either regulation or agency issues.

Finally, $\xi_t \eta(z_t, d_t)$ is the resource cost of "producing" deposits and credit. We use the functional form for $\eta(.)$ proposed by Edwards and Végh (1997), but introduce a parameter κ that determines the weight of firm credit in the bank's cost function:

$$\eta = \sqrt{\kappa z^2 + (1-\kappa) d^2}.$$

Assume that the reserve requirement holds with equality, and let θ_t be the multiplier of the leverage requirement. The first-order conditions are

$$(1-\delta) - \xi_t \eta_2(z_t, d_t) - \theta_t \chi (1-\delta) = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1 + r_t^d - \delta \frac{P_t}{P_{t+1}}),$$

$$1 - \theta_t \chi = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1 + r_t), \tag{4}$$

$$1 + \xi_t \eta_1(z_t, d_t) - \theta_t(\chi - 1) = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1 + r_t^l).$$

The model is closed by a specification of government policy. Clearly, we have set up the model so that we can discuss the effects of unconventional policy on allocations and prices, including the volume of bank intermediation and credit spreads.

For now, assume the simplest: the government rebates to households the gains from imposing reserve requirements. Also, assume that $\xi_t \eta(z_t, d_t)$ is paid to the government as in Edwards and Végh (1997), perhaps because it represents monitoring services. Then

$$T_t = f_t - f_{t-1} \frac{P_{t-1}}{P_t} + \xi_t \eta(z_t, d_t).$$

To finish, we need a specification for inflation policy. Here the government controls $P_t / P_{t-1} = \Pi_t$. This matters, despite flexible prices, because required reserves are paying the inflation tax. With these assumptions, in equilibrium, the economy's overall constraint reduces to

$$(1 + r_{t-1}) x_{t-1} = A_t l_t - c_t + x_t,$$

whose interpretation is clear: the repayment on foreign borrowing is equal to the trade surplus plus new borrowing.

Finally, we need to make an assumption about the world interest rate r_t. For now, assume it is constant at r^*. Also, we will assume $\beta(1 + r^*) < 1$. The need for this becomes apparent upon examination of the nonstochastic steady state. In steady state, the bank's optimality condition for the amount to borrow in the world market, given by equation (4), reduces to

$$1 - \beta(1 + r^*) = \theta\chi. \tag{5}$$

As we are about to solve for a linear approximation of the dynamics around the steady state, we need to make a decision as to whether the leverage constraint binds in steady state. We will assume that it does, which requires that θ be strictly positive in steady state. Hence $\beta(1+r^*)$ must be less than one.

The interpretation of the Lagrange multiplier, θ, is illuminating: it is the shadow cost to banks of the leverage requirement. Accordingly, if the leverage coefficient χ increases, θ must fall. This is natural, since a higher χ allows banks to increase leverage.

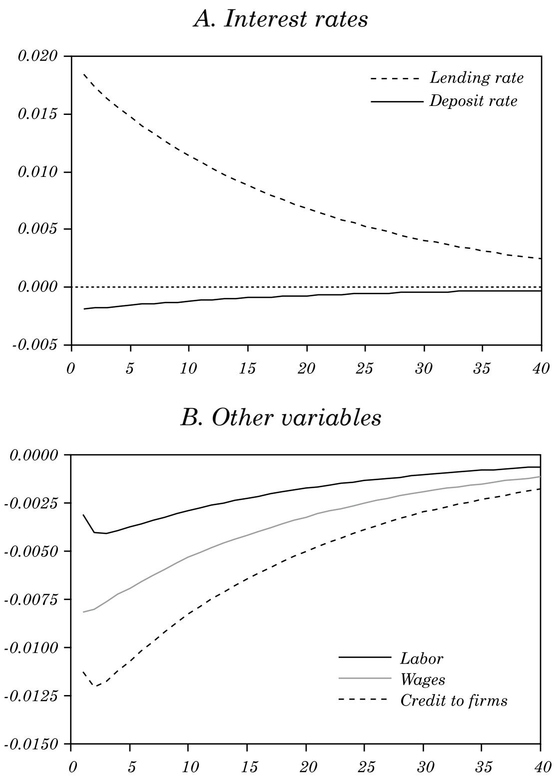
The model can be calibrated and solved in the usual way. Then one can examine the implications of alternative policies of interest. For illustrative purposes, we assume a world interest rate of 2 percent, a reserve requirement coefficient (δ) of 10 percent, and a leverage ratio (χ) equal to 3. The household's deposit requirement (α) is assumed to be 0.2 while the fraction of the wage bill that firms must borrow is assumed to equal 0.5. The remaining parameters are presented in table 1. Our parametrization implies that the steady state lending-deposit interest rate spread is equal to 7.7 percent. In the steady state, the economy's external debt makes up 30 percent of total lending to firms, deposits 41 percent, and the remainder is financed with the banks' own net worth.

Table 1. Parameter Values

Parameter	*Description*	*Value*
δ	Reserve ratio requirement	0.10
χ	Leverage ratio	3.00
α	Household deposit requirement	0.20
γ	Fraction of wage bill firms must borrow	0.50
β	Discount factor	0.971
r_t	World interest rate	0.02
κ	Weight on firm credit in bank's costs	0.80
ϱ	Policy rule parameter	−2.00
Π	Inflation rate (P_{t+1}/P_t)	1.00
ρ_A	Persistence of shock to A	0.95
ρ_ξ	Persistence of shock to ξ	0.95
ρ_r	Persistence of shock to r	0.95

To evaluate the dynamics of the economy, we study the impulse response functions of the model's main variables in response to shocks to the world interest rate and banking costs. Figure 1 displays the impulse responses of the calibrated model to a 1 percent shock to the bank cost ξ. As Edwards and Végh (1997) stress, this can be interpreted as a domestic shock—a change in regulation or shocks to the underlying banking technology—or as an external shock, such as an international financial crisis. Panel A shows that a shock to the bank's cost function is associated with an increase in the real lending rate and a fall in the deposit rate. The increase in banking costs increases the marginal cost of extending credit. On the deposit side, the increase in producing deposits reduces the deposit rate paid to consumers. This reduction in the deposit rate increases the price of consumption. On the lending side, the increase in the marginal cost of producing loans increases the lending rate. In equilibrium, the lending spread increases. This is in line with intuition and is consistent with Edwards and Végh's discussion. Panel B shows that the result is an aggregate contraction, expressed in a fall in credit and, concomitantly, labor employment and wages.

Figure 1. Adjustment Paths Following a Shock to Bank Costs

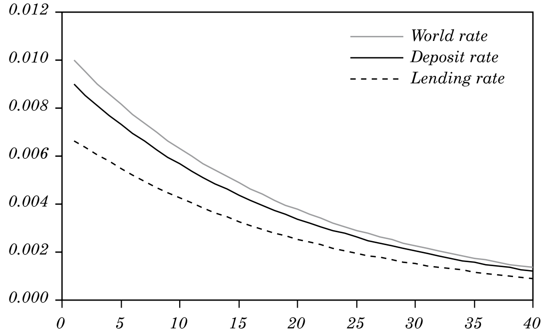


Source: Authors' calculations.

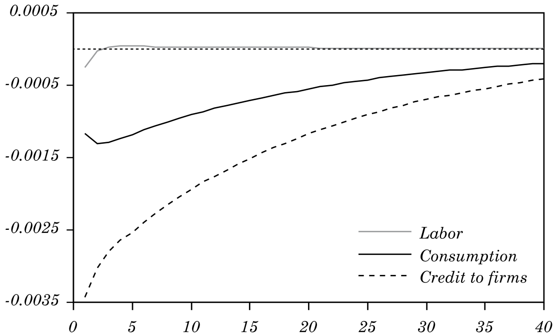
Figure 2 displays impulse responses to a one-hundred-basis-point increase in the world interest rate. Panel A shows that both domestic lending and deposit rates increase as a result. Interestingly, deposit rates increase more than lending rates, such that the spread between the two shrinks. The increase in the world interest rate increases the cost of external borrowing. Banks will try to substitute this external lending by increasing the deposit rate. The lending rate increases, but by less than the deposit rate, as the higher world interest rate has a negative wealth effect on the economy that reduces consumption and lending in equilibrium. Panel B shows that credit and consumption fall persistently. Besides a small initial drop, labor employment is essentially unaffected.

Figure 2. Adjustment Paths Following a Shock to World Interest Rates

A. Interest rates



B. Other variables



Source: Authors' calculations.

In this model, we can examine the effects of different unconventional policies. For example, one might conjecture that a policy of reducing reserve requirements when spreads increase could be stabilizing. To analyze this conjecture in our model, we drop the assumption of a constant δ, and assume instead that

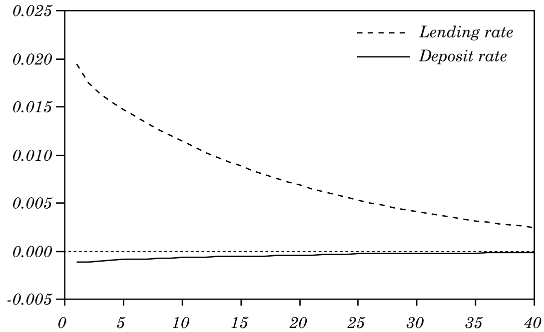
$$\delta_t = \overline{\delta} + \varrho(r_t^l - r_t^d),$$

where $\overline{\delta}$ is the steady state value of δ_t and ϱ governs the sensitivity of the reserve coefficient's response to the domestic spread.

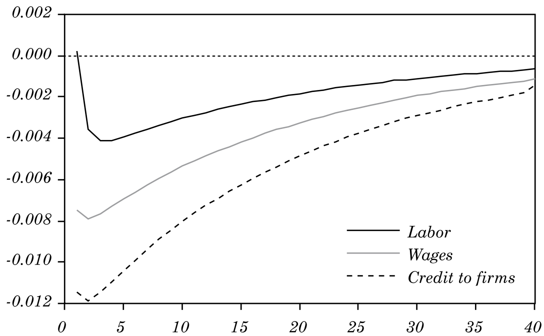
Figures 3 and 4 display the impulse responses to the same shocks as those presented in figures 1 and 2, namely shocks to the banking

Figure 3. Adjustment Paths Following a Shock to Bank Costs When the Reserve Requirement is Endogenous

A. Interest rates



B. Other variables

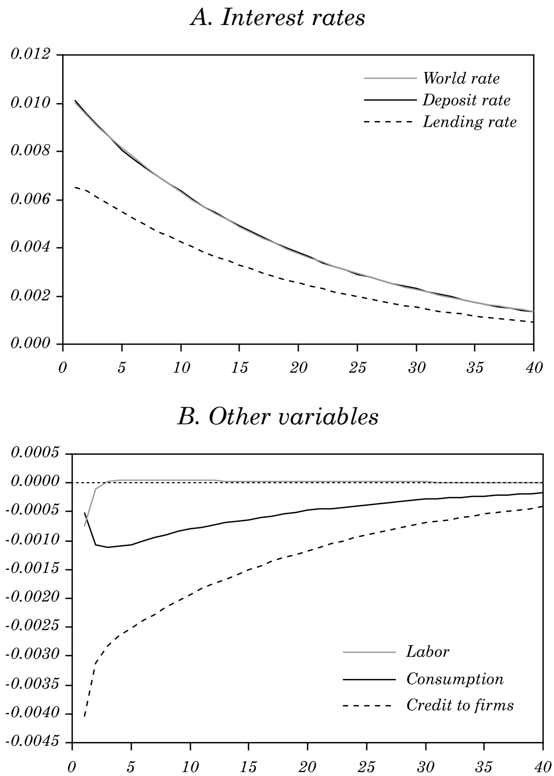


Source: Authors' calculations.

cost function and to the world interest rate. Panel A in figures 1 and 3 are quite similar, suggesting that reducing reserve requirements in response to increases in the domestic spread may have little impact on deposit and lending rates. Comparing panel B in figures 1 and 3, however, reveals that this policy significantly stabilizes credit and labor employment on impact, although for this parametrization the stabilizing effect lasts for only one period. The reduction in the reserve requirement slightly mitigates the impact of higher marginal costs in the production of deposits and loans.

Figure 4, panel A shows that the reserve requirement policy also has negligible effects on the response of domestic interest rates

Figure 4. Adjustment Paths Following a Shock to World Interest Rates When the Reserve Requirement is Endogenous



Source: Authors' calculations.

to an increase in the world rate. Panel B, however, shows that the policy has somewhat surprising real effects: credit falls by more and consumption by less than without the policy. The reason is that the policy rule makes δ_t increase—not fall—in response to an increase in the world interest rate: such a shock makes domestic lending rates and deposit rates increase, but their difference falls.

There are a number of lessons here. The effect of an "obvious" policy is not obvious and depends delicately on the details of both model and policy. However, our model clarifies and provides useful information about the different channels. For example, given our discussion, one could conjecture that the problem is that δ_t is responding to the domestic spread, but that it may be better for δ_t to respond to the international spread instead, such that

$$\delta_t = \overline{\delta} + \varrho(r_t^l - r_t),$$

where r_t is the world rate of interest. But here such a change is probably of little help, because r_t^l increases by less than r_t in response to a shock to the latter, and hence δ_t would also increase (perversely) with the modified policy.

More generally, the model here is an example of the kind of theory that needs to be developed to be able to discuss consistently the unconventional policies that have been implemented in practice. Only with this kind of framework can we trace the effects of policies that respond to interest rate spreads or prescriptions to inject equity into banks. In contrast, standard models are silent about these issues, because their assumption of a perfect financial market clouds perception of financial intermediation.

2. Heterodox Monetary Policy: Recent Experience and Evidence

From the previous section, we have concluded that quantitative easing—outright purchases of assets by the central bank and changes in the central bank portfolio—appears relevant only if it helps to increase the credibility of a given path for the monetary policy rate. We have also noted that it is premature to conclude that credit easing is useful as a policy in and of itself or as a commitment device for a particular monetary policy trajectory. Nevertheless, credit policy may be seen as necessary in the case of disrupted financial markets or as a complement to traditional monetary policy actions in particular cases.

With this in mind, we present some evidence regarding monetary policy actions in the recent financial crisis, as some countries reached the effective lower bound on nominal interest rates. We restrict our analysis to countries with some formal or quasi-formal inflation target to provide a more adequate comparison.

2.1 Recent Experience with Unconventional Monetary Policy

Starting with the subprime mortgage crisis, we have witnessed an unprecedented period of monetary policy activism. Even though the original trigger for the various kinds of interventions can be traced to the international financial crisis, the objectives and immediate motivations are somehow different. In the period prior to the fall of Lehman Brothers, monetary policy rates in most countries aimed to control inflation, which was running high due to high energy and commodity prices. At the same time, governments took actions to provide liquidity in foreign currency markets. After the Lehman bankruptcy, things changed. Liquidity provision intensified, while the rapid fall in commodity prices opened the door for aggressive cuts to interest rates. In this period, some central banks also implemented credit policies to address malfunctioning financial markets. As interest rate cuts intensified, some countries reached a lower bound for the monetary policy rate. At this point, we saw some central banks implementing additional unconventional policies to reinforce the credibility of the announcement that interest rates would be kept low for a long time.

2.1.1 The pre-Lehman-bankruptcy period

The outbreak of the mortgage-backed-security crisis was the beginning of a period of significant tensions in financial markets around the world. These tensions were initially limited to the United States and the United Kingdom, but expanded to other developed economies during the first half of 2008. In most cases, they led to the need to inject significant amounts of liquidity in foreign currency markets. The basic objective of the liquidity provision measures was to reduce pressure on short-term U.S. dollar funding markets. In particular, from September 2007 to September 2008, many central banks implemented different varieties of U.S. dollar repurchase transactions. Sometimes these operations were complemented by reciprocal swap agreements between the U.S. Federal Reserve and other central banks.

In the same period, monetary policy in most central banks focused on dealing with rising inflation due to the shock from commodity prices. In fact, during this period many countries increased interest rates as they implemented measures to inject liquidity in domestic financial markets. Nevertheless, those countries most exposed to the subprime mortgage crisis—Canada, the United Kingdom, and the United States—started reducing policy interest rates as credit conditions tightened and the macroeconomic outlook worsened.

2.1.2 The post-Lehman-bankruptcy period

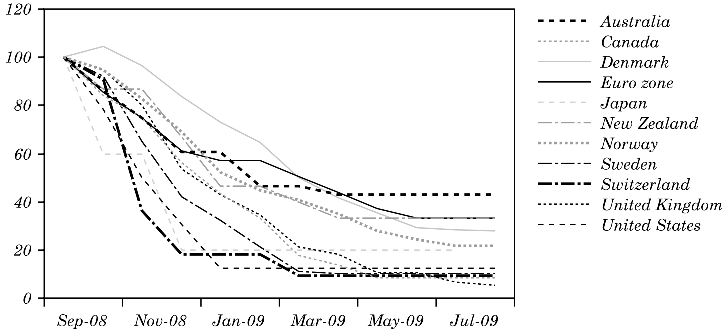
The Lehman Brothers bankruptcy in September 2008 triggered a new phase in monetary policy. The demand for liquidity intensified significantly, causing central banks around the world to either introduce or intensify previous efforts to provide liquidity.

This is also the period in which we started to observe a clear shift towards an expansionary monetary policy stance. With inflationary pressures subsiding due to a marked decline in energy and other commodity prices, and the intensification of the financial crisis that increased the downside risks to growth and thus to price stability, some easing of global monetary conditions was warranted. In line with this outlook, a group of countries aggressively cut the monetary policy rate in the fourth quarter of 2008, as shown in figure 5. Others stopped raising interest rates due to the worsening economic outlook. An additional signal of the perceived magnitude of events facing the world was the unprecedented joint action taken by a group of major central banks on 8 October 2008: a coordinated cut to interest rates. This measure involved the Bank of Canada, the Bank of England, the European Central Bank, the Federal Reserve, the Sveriges Riksbank, and the Swiss National Bank. The Bank of Japan expressed its strong support.

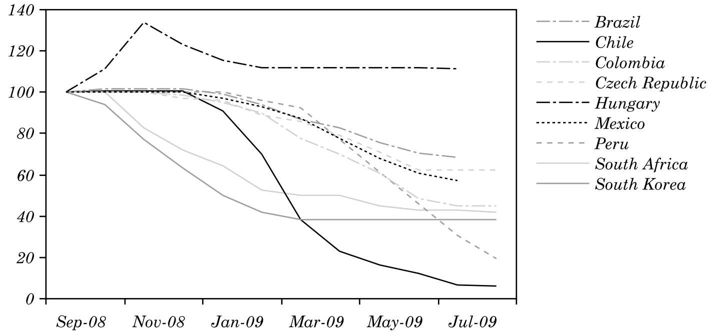
During this period, financial conditions deteriorated markedly. The combination of high uncertainty, lower growth perspectives and commodity prices, and the worsening international financial conditions gave rise to very restrictive credit conditions. Lending spreads increased significantly, as shown in figure 6, and credit to firms became quite scarce. In this scenario, many central banks

Figure 5. Monetary Policy Rates Since Lehman

A. Developed economies



B. Emerging market economies

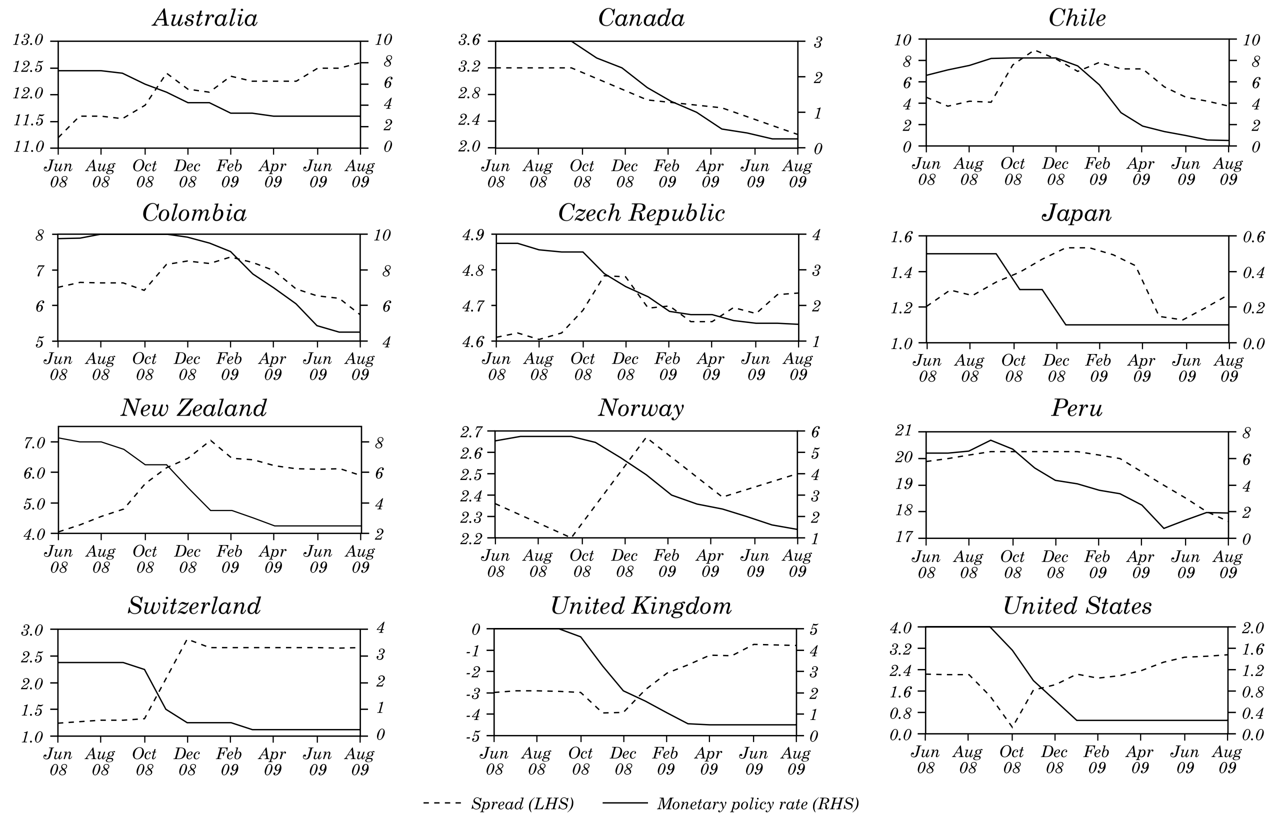


Sources: Bloomberg and national central banks.

contemplated the possibility of disruptions in the monetary policy transmission channel. This explains why, in some cases, monetary policy focused initially on restoring the functionality of financial market rather than on reducing interest rates. Also, some countries did not reduce interest rates until it was clear that inflation pressures had been mitigated. As commodity prices started to fall in the last quarter of 2008, inflation also plunged.

In the scenario of tight credit conditions, some countries implemented asset purchase programs, while others started lending to banks, accepting commercial paper as collateral. The asset purchase programs sought to push up the price of Treasury bills. For countries with more severe financial market disruptions, the asset purchase programs involved buying private assets directly (for instance, in the

Figure 6. Lending-Deposit Spread and Monetary Policy Rates[a]



Sources: Bloomberg and national central banks.

a. The left axis indicates the lending-deposit spread; the right axis plots the monetary policy rate. The data for Canada and Norway are quarterly.

United States and the United Kingdom) or through special funds (for instance, in South Korea and Switzerland). Now, the most common action to improve the supply of loans to the corporate sector was to expand the list of acceptable collateral in operations with the central bank to include commercial paper, corporate securities, asset-backed securities, mortgage securities, and securities with lower credit ratings. In some cases, the easing of collateral requirements was complemented by the introduction of special credit facilities to eligible financial institutions against selected collateral, mainly commercial paper. Additionally, some central banks broadened eligible counterparties for liquidity provision operations.

As of January 2009, all central banks in our sample had started lowering their policy interest rates. At that point it became clear that the deterioration in world activity, the reduction in commodity prices, and more negative output gaps were giving rise to deflationary concerns. Many central banks revised their inflation forecasts downward by significant amounts. As a result, actions to inject liquidity to financial markets continued, but liquidity concerns subsided. Instead, the focus of monetary policy shifted to the financial crisis' effects on economic activity. Some countries also hit the lower bound in this period and implemented measures to deal with this problem.

At this point, some countries engaged in exchange rate intervention. In particular, and in line with the search for ways to deal with the lack of monetary policy stimulus at the lower bound, developed countries started buying dollars to avoid further appreciation of their currencies. Additionally, some central banks started buying bonds issued by private-sector borrowers. One special feature of these interventions was that many central banks stated clearly that unconventional measures did not compromise medium- and long-term price stability.

Even though some central banks recognized that financial systems were well prepared to face the turbulence, the financial crisis' effect on credit provision was evident. As mentioned before, that led some central banks to establish loan facilities to increase access to credit with longer duration.

Tight credit conditions led many central banks to open new facilities to financial intermediaries, to stimulate bank lending to non-financial companies. Many central banks were concerned about direct lending. The Riksbank stated on 28 November that it "should not lend directly to non-financial companies, because that would be a departure from the Riksbank's traditional role as the banks' bank."

That position led the Riksbank to lend to financial intermediaries instead of lending directly to non-financial firms.[4]

For the group of countries that reached the lower bound, in addition to announcing this fact, a new communication instrument joined the traditional monetary policy announcement: central banks indicated that the interest rate was going to be kept at that level for a long time. Moreover, some central banks opened credit facilities at fixed rates with maturities consistent with the announcement that the monetary policy rate would remain at the lower bound for a prolonged period of time. This was a clear indication that central banks were using mechanisms to increase the credibility of their announcements.

Regarding the period of time during which interest rates were going to be kept constant, some central banks were very explicit (beyond those that had already published their monetary policy rate path). For example, the Bank of Canada announced in April 2009 that it was cutting its monetary policy rate to 0.25 percent and committed to holding that rate until the end of the second quarter of 2010. Other central banks announced exchange rate interventions to prevent any appreciation of the exchange rate or to restore the level of foreign currency reserves.

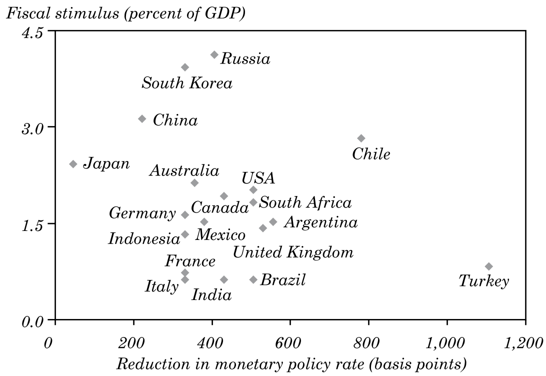
Finally, it is worth noting that most of the aggressive policies implemented by central banks were followed by important fiscal stimulus packages, as figure 7 illustrates for a selected group of countries.

2.2 Alternative Measures of Monetary Conditions

As we have seen, central banks around the world have recently engaged in many unconventional operations. Excluding those exclusively oriented to restoring liquidity, we can associate other measures with the need to reinforce monetary policy stimulus to the economy, particularly in the presence of the lower bound, and with the need to unlock financial markets, a key channel of the monetary policy transmission process. In normal times, changes in the monetary policy rate are generally used as a sufficient statistic to describe the monetary policy stance. This practice presents a challenge when this rate reaches its lower bound and it is interesting to analyze different measures to characterize monetary conditions. In the next section, we describe a number of exercises trying to quantify

4. They did so by offering loans to banks using commercial paper as collateral.

Figure 7. Fiscal Stimulus and Monetary Policy Rates



Sources: Bloomberg, national central banks, and ministries of finance.

the monetary policy stance after September 2008. In particular, we analyze the size and composition of central bank balance sheets, and the Monetary Conditions Index. We then go on to evaluate the effectiveness of unconventional monetary policy actions. Before going into this exercise, we will present estimations for the monetary policy interest rates implied by Taylor rules. From this exercise we can evaluate the potential magnitude of the need to generate additional monetary policy stimulus at the lower bound.

2.2.1 Taylor rules

To evaluate the need for monetary policy stimulus we perform a simple exercise in which we compare the observed behavior of monetary policy rates against the path implied by a Taylor rule. For countries that have reached the lower bound, the difference between these two paths can indicate that a further monetary impulse is warranted. We proceed by estimating a rule where the current value of the monetary policy rate responds to a three-month-lagged value of this rate, the output gap (measured as a deviation from a Hodrick-Prescott (HP) trend) and the annual rate of inflation in the consumer price index.[5] Additionally, we also consider the possibility

5. The results are robust when using deviations of observed inflation from the target, for those countries that announce an explicit target.

of the policy rate reacting to either nominal (against the U.S. dollar) or real (multilateral) annual exchange rate depreciations. The estimation was performed using data until 2007, and the resulting coefficients were used to compute the implied paths for the Taylor rule from that date onward.[6]

Columns three to five in table 2 display the percentage reduction in the policy rate obtained for different specifications of the Taylor rule estimated from September 2008 to the last available observation, while the second column reports the actual change for comparison. The results do not show a clear pattern. Only for Japan, Sweden, Switzerland, the United States and, to a lesser extent, the euro area, does the Taylor rule indicate a bigger reduction than was actually observed.[7] For the other countries, the predicted changes in these three columns either approached or were significantly smaller than actual reductions.

A concern about the results based on a rule that contains a smoothing parameter is that this backward-looking component may not be appropriate to describe behavior when the lower bound is binding. One would expect this coefficient to change (probably moving closer to zero) as the rate approaches the lower bound—particularly in a period of sudden financial distress—since the monetary authority will be less concerned about reducing the volatility in interest rates than in regular times. One way to control for this effect is to use a long-run Taylor rule in which the interest rate depends solely on inflation and the output gap. The coefficients for these variables are those estimated in the baseline case and adjusted by $(1-\rho_i)$, with ρ_i being the estimated coefficient on the lagged policy rate. That is, if the originally estimated rule is

$$i_t = \rho_i i_{t-1} + \rho_\pi \pi_t + \rho_y \tilde{y}_t,$$

then the long-run effect of a change in π_t and $\tilde{y}_t$ are, respectively, $\rho_\pi/(1-\rho_i)$ and $\rho_{\tilde{y}}/(1-\rho_i)$, provided $|\rho_i|<1$. In this way, this alternative

6. We used the iterative generalized method of moments for the estimation, using as instruments the lagged values of the regressors and current and lagged values of oil prices and the Commodity Research Bureau commodity price index. In an attempt to make results robust to the lag selection for the instruments, we estimated each equation using from two to twelve lags for monthly data (one to four for quarterly), and use the median across the different alternatives of each coefficients to make the out-of-sample forecast.

7. Rudebusch (2009), for instance, finds a similar result for the United States, although using forecasts from the Federal Open Market Committee meetings to compute the predicted path instead of actual data as we do.

Table 2. Taylor Rules[a]
Percentage reduction

Country	*Data*	*Baseline, nominal exchange rate*	*Baseline, real exchange rate*	*Baseline, nominal exchange rate*	*Long-run, nominal exchange rate*
Australia	50	32	31	30	71
Canada	92	90	84	84	171
Chile	88	59	58	58	104
Colombia	51	40	42	43	102
Euro zone	67	81	67	68	288
Japan	80	108	112	112	150
New Zealand	49	9	9	9	41
Norway	72	50	51	54	17
South Korea	62	55	55	55	30
Sweden	89	126	127	124	260
Switzerland	99	103	117	103	149
United Kingdom	90	85	85	81	101
United States	88	128	128	–	347

Source: Authors' calculations.
a. Data are monthly and run from September 2008 to August 2009 for all countries except the following: Australia, New Zealand, and Switzerland (quarterly data, ending in the first quarter of 2009); and Canada, Japan, and South Korea (quarterly data in the case of rules including the real exchange rate). Chile was estimated using data from July 2001 on, to account for the change in the policy instrument. The long-run Taylor rule applied involved multiplying coefficients for the output gap and inflation by $1/(1-\rho_i)$, with ρ_i being the estimated coefficient on the lagged policy rate.

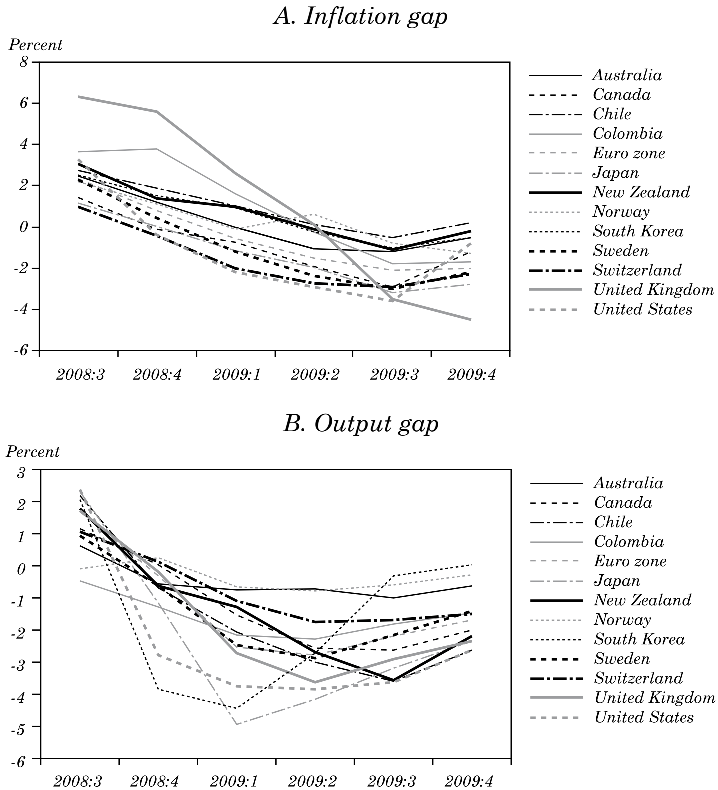
assumes that the response to inflation and the output gap is the same as historically described, once we adjust for the persistence of interest rates.

The sixth column in table 2 computes the implied reduction using the long-run rule.[8] With a few exceptions, results appear more conclusive in this case: the long-run rule recommends a much lower rate than the observed one. For instance, if we compute the average reduction that this rule implies for countries that have maintained a low policy rate, we obtain a reduction of 140 percent, while this same statistic for the other countries (not shown in the table) is 46 percent. Additionally, it is interesting to notice that for those countries that have decreased and maintained the rate at a low level but at a value significantly greater than zero (such as Australia, New Zealand, Norway, and South Korea), the Taylor rule implies—with the exception of Australia—that the policy rate should be above its actual level. In particular, the average observed reduction within this group was 58 percent, while the rule suggested an average reduction close to 40 percent. Moreover, these are the only countries in this sample for which this long-run rule would not have predicted a negative interest rate. On the other hand, for those that have reached a bound close to zero, the mean observed reduction was 83 percent, while the Taylor rule suggested a drop of nearly 186 percent, on average. In particular, the biggest differences between the actual change in the policy rate and that implied by the rule are for the United States, the euro area and Sweden, while for Chile, Colombia and the United Kingdom the rule would have recommended driving the rate to a value just below zero.

To check for the robustness of our results we do a simple exercise in which we compute a common-parameter Taylor rule for the countries under analysis. In particular we compute an implicit monetary policy rate from the following Taylor rule: $i_t = i + \rho_\pi(\pi_t - \pi) + \rho_y \tilde{y}_t$, where i corresponds to the average rate in the past 10 years, and π corresponds to the inflation target. This is equivalent to having a common central banker for these countries. We use quarterly output data to obtain a common measure of activity. In figure 8 we show the arguments of our Taylor rule: the deviation of inflation from the target and the output gap. The output gap is computed using the HP filter.

8. Results are similar if we include measures of exchange rates in the rule.

Figure 8. Deviation of Inflation from Target and Output Gap



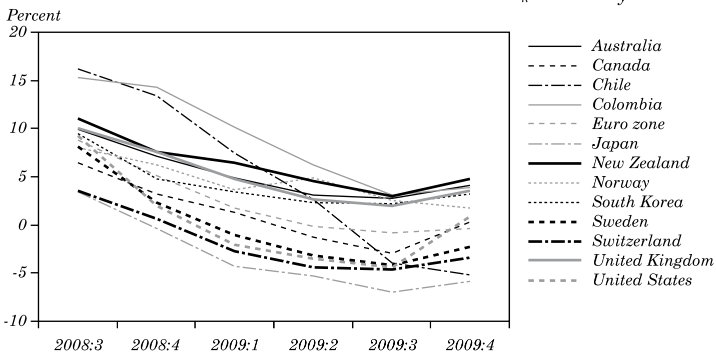
Source: Authors' calculations.

As can be seen, all the countries in our sample had inflation rates above the inflation target prior to September 2008.[9] This is consistent with monetary policy rate management before the Lehman bankruptcy. In some cases, this deviation persisted at a lower intensity through the last quarter of 2008. Nevertheless, the general picture is that inflation plunged below target after the third quarter of 2008, in most cases between the fourth quarter of 2008 and the third quarter of 2009. Furthermore, all countries in the sample were experiencing a negative output gap by the first quarter of 2009.

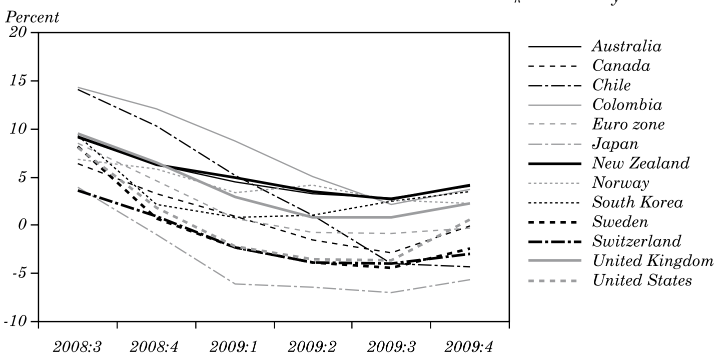
9. In the cases of the United States and the euro area, we use implicit targets of 2 percent and 1.5 percent, respectively.

Figure 9. Monetary Policy Rate Implied by Common-Parameter Taylor Rules

A. MPR Taylor rule (common parameters) ρ_π=1.75, ρ_y=0.5



B. MPR Taylor rule (common parameters) ρ_π=1.25, ρ_y=1.00



Source: Authors' calculations.

Next, we use the previous information to estimate monetary policy rates for two different Taylor rules, presented in figure 9. The results indicate that our common-parameter monetary policy rate was negative or just above zero at some point in time for all the countries that reached the lower bound. Only the euro zone exhibits a negative estimated monetary policy rate, while the effective interest rate is significantly higher than zero.

This exercise clearly does not take into account the forward-looking nature of monetary policy. However, it is useful to note that the rapid deterioration in the economic environment called for a swift monetary policy reaction, like the one observed, and that countries reaching the lower bound needed significant additional monetary policy stimulus.

2.2.2 Balance sheets

For those countries that reached the lower bound and, more generally, those countries implementing unconventional monetary policy actions, the interest rate is not the only—and perhaps not the best—aggregate indicator of monetary policy actions. In principle, an alternative way to quantify the monetary policy impulse is to examine the evolution of monetary aggregates. However, given that most policies implemented during this current crisis entailed more than simply printing money, it is probably more appropriate to look at the evolution and composition of the central bank's balance sheet. Moreover, we have argued that the size and composition of the central bank balance sheet can be relevant to dealing with lack of credibility arising at the lower bound, at least from a theoretical perspective.

For those countries that reached a bound as they dropped policy rates, table 3 shows the percentage change in total assets, liabilities, and capital—that is, assets minus liabilities—comparing both the mean values in 2007 with those of August 2008, and the change from August 2008 to September 2009. Except for Australia, all these countries have increased their asset positions since August 2008. The mean and median of these changes reached 56 percent and 20 percent, respectively. In addition, it also seems that after September 2008, total asset growth accelerated over the recent past, with the sole exception being the European Central Bank, whose assets increased proportionately more in early 2008. The most dramatic increases occurred in Sweden, the United Kingdom, and the United States. Liabilities posted a similar, rising trend.

Another potentially useful measure involves central bank capital. On one hand, one can argue that increasing the capital level may be useful in coping with a financial crisis, for it might, for instance, reduce the likelihood of a run against the local currency. On the other hand, however, a possible way to increase the expectations about future inflation to deal with a zero bound situation is to increase the size of bank liabilities proportionally more than asset holdings. For instance, if the central bank is concerned with its level of capital at some point, it will have incentives to produce inflation in the future. In this sense, it is not clear what the policy

Table 3. Central Bank's Assets and Liabilities
Percentage change

	Assets		*Liabilities*		*Capital*	
Country	*Mean 2007 to Aug 2008*	*Aug 2008 to Sept 2009*	*Mean 2007 to Aug 2008*	*Aug 2008 to Sept 2009*	*Mean 2007 to Aug 2008*	*Aug 2008 to Sept 2009*
Australia	−6.8	−2.9	−7.2	−3.5	0	5.5
Canada	10.6	33.7	10.4	33.9	116.8	−11.3
Chile	25.0	41.9	20.7	19.2	2.9	138.2
Colombia	0.8	17.9	12.3	14.7	−28.3	30.8
Euro zone	11.0	1.6	11.1	0.8	9.7	12.9
Japan	−2.7	6.4	−3.0	6.7	1.8	0.8
New Zealand	12.8	18.6	−84.8	−6.3	793.5	22.0
Norway	6.7	18.0	−6.5	2.4	11.9	23.2
South Korea	10.2	19.3	−10.8	16.6	680.5	33.1
Sweden	−0.1	240.9	−1.7	334.6	4.0	9.0
Switzerland	17.7	50.2	43.9	84.6	−4.7	5.9
United Kingdom	2.7	142.8	4.0	146.1	−30.5	11.7
United States	1.4	139.8	0.7	145.2	18.3	26.5

Source: National central banks.

recommendation should be during a crisis like the recent one. The evidence presented in table 3 suggests that central banks decided to increase the value of their capital after August 2008. The only exception is the Bank of Canada, whose capital has fallen by nearly 11 percent, although the value of its capital had more than doubled in the first part of 2008. Also, the Bank of Japan has presented a mild increase in assets over liabilities (under 1 percent) since August 2008. At the other extreme, the Central Bank of Chile increased its capital by more than 100 percent, breaking a downward trend apparent in previous years.

While the size of the central bank's balance sheet may be a good approximation for its monetary policy stance, portfolio composition offers another dimension worth considering, given that most unconventional policies involved buying assets that are not part of the usual holdings. Table 4 presents a simple breakdown of the asset side of central bank balance sheets. For most countries, the table shows the shares of foreign assets, domestic credit to the government (mainly composed of Treasury bonds) and other domestic credit.[10] To better understand the size of these changes, for each country the table displays the mean in 2007 and compositions in August 2008 and September 2009.

The evidence does not show a clear pattern in the actions taken by these central banks. Some countries do not appear to have significantly changed the composition of their assets during the sample. This is the case for Japan, the euro area and, to a lesser extent, Australia, which decreased its foreign assets in favor of other domestic credit in early 2008, but reversed the change in the latter part of the sample. For others, the change has been more dramatic. In most cases, central banks have reduced the share of foreign assets in their portfolio. Exceptions are Canada, which continues to hold a negligible amount of foreign assets and has increased domestic credit to the private sector while reducing its holdings of government assets, and Colombia, which has increased this share by almost ten percent since 2007 by reducing both components of domestic credit. South Korea and Switzerland have increased their holdings of government assets proportionally more, while New Zealand, Norway, and Sweden significantly raised domestic credit to the private sector.

10. We present a different breakdown for the United Kingdom and the United States, details of which are explained in a footnote to table 4.

Table 4. Central Bank Asset Composition

				Domestic credit					
	Foreign assets			Government			Other		
Country	*Mean 2007*	*August 2008*	*September 2009*	*Mean 2007*	*August 2008*	*September 2009*	*Mean 2007*	*August 2008*	*September 2009*
Australia	59.2	47.5	59.8	0	0	0	39.5	51.1	38.8
Canada[a]	0	0	0	95.7	96.5	61.2	3.8	0.1	38.4
Chile	78	80.5	69.7	0	0	0	15.8	11.3	9.9
Colombia	74.5	85.2	82.1	3.5	0.4	0.7	11.1	3.6	6.9
Euro zone	23.9	23.4	20	11.1	10.4	11.9	56.7	57.3	57.7
Japan	4.6	5	4.8	65.5	60.9	58.5	28.8	32.9	35.6
New Zealand	77.7	67	61.9	20.2	17.9	12.1	1.8	0	25.7
Norway	14.9	10.4	9.9	82.9	85.6	87.4	2	1.8	2.6
South Korea	93.5	93.6	83.9	4.3	4.6	10	2.2	1.7	6.1
Sweden	94.8	97.5	50.5	0	0	0	3.2	0.6	48.5
Switzerland	70.9	59.4	60.1	0	0	10.9	28.3	39.8	28.6
United Kingdom[b]	26.3	36.5	0	20.9	23.6	17.4	52.8	39.8	82.6
United States[c]	87	53.6	35.9	0	0	38.4	4.1	29.1	21.9

Source: National central banks.
a. For Canada, foreign assets are just foreign currency deposits.
b. For the United Kingdom, the columns are, respectively, short-term repos, long-term repos and bonds, and other.
c. For the United States, the columns are, respectively, Treasury securities, other securities held outright, and all liquidity facilities.

Finally, in terms of the countries with a different breakdown, both the Federal Reserve and the Bank of England have drastically altered the composition of their assets. For the former, the shares of U.S. treasuries decreased by more than 50 percent, increasing instead the portion devoted to other overnight securities and liquidity facilities, which by 2007 represented a negligible part of its portfolio. The Bank of England posted a striking reduction in short-term repos to almost zero, which were replaced by a rise in bonds and other domestic credit.

2.2.3 The Monetary Conditions Index

An additional measure of monetary expansivity that we explore is the Monetary Conditions Index (MCI), which became popular in the mid-1990s for its use at the Bank of Canada and the Reserve Bank of New Zealand, among others.[11] The idea of this index is that the monetary policy stance cannot be properly captured by looking at the monetary policy rate alone—particularly for a small open economy—and that the real interest and exchange rates better summarize monetary conditions. This index is calculated as

$$MCI_t = \omega(r_t - r_0) + (1 - \omega)(q_t - q_0),$$

where r_t is the interest rate, q_t is the real exchange rate (an increase is an appreciation), r_0 and q_0 are the values in the base year, and ω is the relative weight on the real interest rate.[12] Therefore, a rise in the index implies a tighter monetary condition. Although the usefulness of this index has been subject to debate (see, for instance, Stevens, 1998; Gerlach and Smets, 2000), most of the arguments for and against were based on analyzing "normal" times, so it is worth exploring its virtues to account for monetary conditions during a zero-bound period.

Table 5 presents the percentage change in the MCI between September 2008 and September 2009 for each of the countries that reached a lower bound in their policy rate. For comparison, we also report the historical mean and median annual change and the observed reduction in the policy rate. In general, the index has fallen significantly since September 2008. The exceptions are the United

11. See, for instance, Freeman (1995).

12. These weights are a function of the importance of these variables in explaining fluctuations in output. We followed the implementation suggested in Deutsche Bundesbank (1999).

Table 5. Monetary Conditions Index
Percentage points[a]

Country	Change in the MCI	Historical annual change: Mean	Historical annual change: Median	Reduction in the MPR
Australia	−2.43	−0.03	−0.26	50
Canada	−1.23	−0.06	−0.11	92
Chile	−3.15	0.85	0.75	88
Colombia	−1.66	−0.45	0.20	51
Euro zone	−0.42	−0.05	−0.14	67
Japan	−0.04	−0.08	−0.12	80
New Zealand	−2.26	0.01	0.04	36
Norway	−1.58	0.12	−0.01	72
South Korea	−3.15	0.55	0.16	62
Sweden	−0.87	−0.14	−0.30	89
Switzerland	−1.02	0.06	−0.05	99
United Kingdom	−0.01	−0.01	−0.04	90
United States	2.41	−0.12	−0.05	88

Source: Authors' calculations.
a. Columns two and five are the percentage change between September 2008 and September 2009.

States, Japan, the United Kingdom, and the euro area.[13] Moreover, the size of the drop seems to be significantly bigger than the average size of the annual historical change in this coefficient, particularly in the cases of Australia, Chile, New Zealand, and South Korea.

2.2.4 Comparing the different measures

These alternative measures allow us to identify policy expansivity from different relevant perspectives. A final issue that we assess is the extent to which they reflect the same phenomena. To answer this question, table 6 shows the cross-country correlation between: the observed reduction in the monetary policy rate; the drop implied by the Taylor rule, both in its baseline and long-run specifications; the change in total assets and liabilities; the change in the share of other domestic credit and foreign assets between the average for

13. That the index does not perform properly in these countries is, in principle, not necessarily an important concern. As mentioned, the index was originally developed to represent the monetary stance of a small open economy, which is clearly not the case for these economies.

Table 6. Correlations of Different Measures of Monetary Expansion

	Drop in monetary policy rate	*Drop in Taylor rule*	*Drop in long-run Taylor rule*	*Rise in assets*	*Rise in liabilities*	*Change in share others*	*Change in foreign assets*	*Change in MCI*
Monetary policy rate	1							
Taylor rule	0.83	1						
Long-run Taylor rule	0.46	0.78	1					
Assets	0.52	0.63	0.50	1				
Liabilities	0.53	0.67	0.52	0.98	1			
Share others	0.28	0.41	0.32	0.72	0.70	1		
Foreign assets	−0.38	−0.57	−0.56	−0.87	−0.81	−0.61	1	
MCI	0.44	0.73	0.76	0.46	0.43	0.34	−0.57	1
LR TR — MPR	0.48	0.89	0.84	0.56	0.62	0.40	−0.58	0.78

Source: Authors' calculations.

2007 and September 2009; and the difference between the percentage reduction in the policy rate implied by the long-run Taylor rule and the observed reduction in that rate.[14]

The correlations between the observed drop in the monetary policy rate, the changes implied by the Taylor rule, the change in assets and liabilities, and asset composition all have the expected sign, except for the Monetary Conditions Index.[15] In particular, we can see a high correlation between changes in both assets and liabilities with the reductions implied by the Taylor rule, and with the difference between the rule-based and observed reductions. Both indicators for the change in the central bank portfolio composition also seem to be related to the changes implied by the Taylor rule, particularly with the change in foreign assets, which has historically been the most important part of central bank assets.[16]

2.3 On the Effects of Heterodox Policies

As a final exercise, we present some descriptive evidence of the effects that these unconventional policies have had on a set of variables relevant to monetary policy transmission, which have remained at center stage in policy discussions during the current crisis. In particular, we attempt to assess changes generated after policy announcements in the shape of the yield curve, and in lending-deposit spreads.

For a group of 12 central banks that reached a bound on their policy rates, we analyzed their press releases since mid-2007, identifying 56 policy announcements concerning unconventional measures.[17] For each of these events, we used daily data for government bonds at all available maturities to compute the slope of the yield curve one week before the announcement and one and two weeks after it, and then calculated the change in slope.[18] For the

14. These three are comparisons between September 2008 and the last available observation. For the United Kingdom and the United States, the items are those described in table 4.

15. These results for the MCI are robust if we exclude the euro area, Japan, the United Kingdom, and the United States.

16. Treasuries for the U.S. and short-term repos for the United Kingdom.

17. This group includes Australia, Canada, Chile, the euro area, Japan, New Zealand, Norway, South Korea, Sweden, Switzerland, the United Kingdom, and the United States.

18. Two different announcements can be part of the same event if they have occurred within two business weeks. While this is clearly not a rigorous econometric event study due to the limited size of our sample, this exercise should at least give us a rough idea of the impact of the announcement. A proper characterization of the causal effects of these policies is beyond the scope of this paper, mainly because not enough time has passed to have a relevant sample to attempt to measure them.

lending-deposit spread our data are more limited, and we computed the difference in the spread between its average one month before and one month after the announcement.[19]

To analyze results, we grouped announcements into five broad categories: asset purchases and direct lending to financial firms; expanding list of eligible collateral; paying interest on reserves; swap lines with other central banks; and term loan and/or liquidity facilities.[20] We also categorized the different yield curve slopes into three groups, according to the maturity of the longest bond in the comparison: up to six months; from six months to two years; and more than two years.[21] The purpose of this categorization of the different slopes was to represent the short, medium (generally associated with the monetary policy horizon), and long runs.

Table 7 presents the average change (across events) in the grouped tranches of the yield curve for each of the categories described, and the number of events in each group.[22] While there is a significant dispersion within each group, it appears that policies of asset purchases and term loan and liquidity facilities generated a reduction of between 10 and 20 basis points in the medium part of the yield curve, while generating increases in the slope at short horizons. On the other hand, measures expanding the list of eligible collateral seem to have had an insignificant impact during the first week after the announcement. In addition, the creation of swap lines with other central banks appears to have increased the slope at terms between six months and two years, while also increasing the shorter part of the curve after two weeks. Finally, the two cases in our sample of central banks paying interest on reserves were followed by decreases in the slope at short terms. Overall, it seems that the effects on the longer part of the curve have been minor, on average.

While the results reported in table 7 are a good first approximation to the data, they pool observations for different periods in a sample that has been characterized by different levels of financial volatility. In an attempt to control for the different phases in the observed

19. The data are the average monthly rate, and for some of the more recent dates we are missing observations.

20. A list describing each of the announcements included can be found in the appendix.

21. Unfortunately, the same maturity structure is not available for all countries, which forced us to make this grouping to compare the results.

22. A missing value in the table implies that for the country that has implemented the particular policy we do not have data on bonds within that particular maturity in the yield curve.

Table 7. Effects of Policies in the Yield Curve and Lending-Deposit Spread[a]
Average across events, change in basis points

			Term structure			
Measure type	*Number of obs.*	*Weeks after*	*Up to 6 months*	*6 months to 2 years*	*Over 2 years*	*Lending-deposit spread*
Asset purchases and direct lending to financial firms	12	1	7	−19	−5	4
		2	3	−11	−5	
Expand list of collateral	10	1	1	−1	3	5
		2	39	2	1	
Interest on reserves	2	1	−4	6	20	
		2	−25	1		
Swap line with other central bank	6	1	−1	14	4	35
		2	22	17	3	
Term loan and liquidity facilities	26	1	15	−12	2	12.7
		2	25	−11	2	

Source: Authors' calculations.
a. For the term structure (columns 4−6), the table shows the average across observations of the change in the slopes between the observation one week before the announcement of the policy and either one or two weeks after, in basis points. For the Lending-deposit spread (column 7), we used the change in the spread (in basis points) between its average one month before and one after the announcement.

implementation of unconventional policies, we split the observations into different time frames to see whether these observed co-movements differ over time.

Table 8 reports the results for three different time frames: before September 2008; between September and December of 2008; and after January 2009.[23] In terms of asset purchases, the minor reduction in the slope for the first part of the curve observed in the full sample contrasts with quite an important rise characterizing the three events that occurred between September and December of 2008, but for the other nine events the impact on the short part of the curve was mildly negative.[24]

A similar pattern can be observed for policies that extend the list of eligible collateral. Before September 2008, these types of announcements were associated with reductions in the slope of the short part of the yield curve, while after that month this tranche of the slope increased after the press release. In terms of policies introducing term loans and liquidity facilities, it seems that the flattening of the yield curve was more evident when these measures were implemented between September and December 2008 than after that period.

Another potentially useful split of the sample is reported in table 9. Here we distinguish between policies that were implemented before or after the rate had reached its lower bound. While we can see that unconventional policies were mainly implemented before the central bank chose to drive the policy rate to a low value, some differences are still apparent. In terms of policies in the asset purchase group, it seems that those implemented after the lower bound was reached were associated with stronger flattening effects on the yield curve. On the other hand, the opposite seems to be the case for policies creating term loans and liquidity facilities.

Finally, table 7 shows that unconventional measures were followed by increases in the lending-deposit spread, on average. However, the different time frame breakdowns in tables 8 and 9 reveal some exceptions. In particular, asset purchases seem to have been associated with increases in the spread only between

23. We do not show the results for policies in the group "paying interest on reserves" because the two observations in our sample occurred in the same time frame (between September and December of 2008). The same is true for the categories missing in the next table.

24. These numbers are mainly driven by the Canadian government's announcement that it would purchase up to 25 billion dollars in National Housing Act mortgage-backed securities.

Table 8. Effects of Policies on Yield Curve and Lending-Deposit Spread: Different Time Frames
Average across events, change in basis points

				Term structure			
Measure type	*Time frame*	*Number of obs.*	*Weeks after*	*Up to 6 months*	*6 months to 2 years*	*Over 2 years*	*Lending-deposit spread*
Asset purchases and direct lending to financial firms	Before Sept-08	1	1	−6		4	−3
			2	−9		5	
	Sept-08 to Dec-08	3	1	115	−19	−2	28
			2	70	−11	0	
	After Jan-09	8	1	−2		−8	−5
			2	−1		−8	
Expand list of collateral	Before Sept-08	2	1	−9	1	−1	−43
			2	−13	2	0	
	Sept-08 to Dec-08	6	1	5	−6	4	25
			2	56	2	1	
	After Jan-09	2	1		3	2	3
			2		3	1	
Swap line with other central bank	Sept-08 to Dec-08	4	1	−1	−6	7	7
			2	22	3	5	
	After Jan-09	2	1		33	1	77
			2		32	1	
Term loan and liquidity facilities	Before Sept-08	1	1	15		6	61
			2	5		5	
	Sept-08 to Dec-08	19	1	22	−14	3	7
			2	42	−13	2	
	After Jan-09	6	1	1	−5	1	29
			2	0	−6	−1	

Source: Authors' calculations.

September and December 2008. Moreover, there appears to be a marked difference in the observed behavior of the spread, depending on whether the rate was at its lower bound or not. Additionally, the two announcements of expansions to the list of eligible collateral implemented before September 2008—both by the Bank of Canada—were apparently associated with reductions in this spread as well. Nevertheless, it is worth repeating that the frequency of the data on these spreads is probably not the most suitable to analyze the effects of these types of events.

Overall, it seems that announcements of asset purchases, direct lending, term loan and liquidity facilities produced a reduction in the slope of the yield curve over medium horizons. For other types of announcements the evidence is less clear. These effects seem to have been more marked between September and December 2008 for both of the aforementioned categories. On the other hand, while the reduction in the slope generated by asset purchases and direct lending was apparently stronger after the policy rate reached the lower bound, the impact of term loan and liquidity facilities was stronger before reaching the lower bound. In contrast, the effect of both types of policies on the lending-deposit spread was more pronounced after the lower bound was reached.

3. Conclusions

Motivated by the numerous unconventional monetary policies that have been implemented during the current crisis, a new wave of research in monetary policy has emerged to analyze the scope and desirability of this heterodox behavior among central banks. The discussion is far from being settled and will probably keep both theorists and applied economists busy for years to come.

In this context, the goals of this paper were twofold. On one hand, we provided a theoretical analysis of the mechanisms relevant to understanding the effects of these unconventional policies that can be used as a framework for an ex post evaluation of the measures that have been implemented. In particular, we first discussed the role of credibility in implementing inflationary goals once the nominal interest rate reaches its lower bound, paying particular attention to the importance of the central bank's balance sheet. In addition, we presented a model that has at its core a financial imperfection that highlights the role of bank capital and the relevance of alternative credit policies that can be used to deal with financial distress.

Table 9. Effects of Policies on Yield Curve and Lending-Deposit Spread: Different Time Frames
Average across events, change in basis points

				Term structure			
Measure type	*MPR bound*	*Number of obs.*	*Weeks after*	*Up to 6 months*	*6 months to 2 years*	*Over 2 years*	*Lending-deposit spread*
Asset purchases and direct lending to financial firms	Before	4	1	-6		0	36
			2	-6		2	
	After	8	1	11	-19	-9	-14
			2	7	-11	-9	
Expand list of collateral	Before	9	1	1	-1	3	5
			2	39	2	1	
	After	1	1		3	0	
			2		3	-1	
Term loan and liquidity facilities	Before	22	1	21	-14	3	14
			2	36	-14	2	
	After	4	1	1	7	0	-3
			2	0	6	-2	

Source: Authors' calculations.

We also reviewed evidence regarding the recent experience of central banks that implement inflation-targeting regimes. We first described the timing and the type of unconventional policies that have been implemented. Second, we explored several alternative measures to assess the expansivity of monetary policy in a situation where the policy rate has reached its lower bound. Finally, we presented some descriptive evidence on the effect that the implemented policies have had on the shape of the yield curve and the lending-deposit spread, two variables that are relevant for the propagation of monetary policy.

APPENDIX

Notes on Data Sources and Available Sample Periods

Monetary policy rates: Central bank websites and Bloomberg; daily observations from January 2007 to September 2009. Monthly and quarterly averages were used in calculations.

Interest rates and yields: The International Monetary Fund's *International Financial Statistics* (IFS), Bloomberg and Central bank websites. Lending and borrowing rates correspond to monthly average rates. Yields correspond to daily nominal government bonds (Bloomberg query "GGR").

GDP, CPI, and industrial production:[25] The source of this data is the IFS. All series are seasonally adjusted. Consumer price index inflation corresponds to the quarterly annual percentage change. The GDP gap is computed as the percentage deviation from the Hodrick-Prescott trend. The price of oil employed corresponds to the West Texas Intermediate price in current U.S. dollars. The real and nominal exchange rates are from the IFS. Commodity prices correspond to the Commodity Research Bureau/Reuters U.S. spot price for all commodities.

25. For Australia, New Zealand, and Switzerland we used quarterly data for estimation purposes. The quarterly data set starts in 1980 Q1 for Australia, Canada, Denmark, Japan, Mexico, Norway, South Korea, Sweden, Switzerland, the United Kingdom, and the United States. For Brazil the data set starts in 1996 Q4, for Chile 1996 Q1, for Colombia 1994 Q1, for the Czech Republic 1993 Q1, for the euro area 1999 Q1, for Hungary 1985 Q1, and for Peru 1995 Q4. For all the countries in our sample the data set ends in 2009 Q1, except for Colombia whose data set ends in 2008 Q4. For monthly estimations, data sets start in January 1980 for Brazil, Canada, Denmark, Japan, Norway, South Korea, the United Kingdom, and the United States. For Switzerland, the data set starts in January 1995 and finishes in December 2007, for Chile the data set starts in July 1987, for Mexico in May 1981, for South Africa in December 1989, for the Czech Republic in January 1993, for Colombia in March 1995, for Peru in October 1995, for the euro area in January 1999, and for Hungary in October 1999. All the data sets end between May 2009 and August 2009, except for Switzerland whose data set finishes in December 2007.

Table A1. Timeline of Policy Announcements

Country	*Date*	*Measure*	*Type*
Australia	24-Sep-08	Domestic term deposit facility.	Term loan and/or liquidity facilities
	29-Sep-08	Swap facility with U.S. Federal Reserve.	Swap line with other central bank
	8-Oct-08	Expansion of domestic market facilities.	Term loan and/or liquidity facilities
	6-Nov-08	Domestic market dealing arrangements.	Term loan and/or liquidity facilities
	4-Feb-09	Reserve Bank of Australia and U.S. Federal Reserve swap facility.	Swap line with other central bank
	2-Mar-09	Domestic market dealing arrangements.	Term loan and/or liquidity facilities
Canada	15-Aug-07	Temporarily expands list of collateral eligible for SPRA transactions.	Expand list of collaterals
	31-Mar-08	Accepting asset-backed commercial paper (ABCP) as collateral for the Bank of Canada's standing liquidity facility.	Expand list of collaterals
	10-Oct-08	The federal government announced that it would purchase up to $25 billion in National Housing Act mortgage-backed securities.	Asset purchase and/or direct lending to financial firms
Chile	29-Sep-08	Reserve accumulation program was terminated, U.S. dollar 1-month repo operations announced (sales of U.S. dollar spot and purchases of 1-month U.S. dollar forward contracts through competitive auctions).	Term loan and/or liquidity facilities
	10-Oct-08	Broadening of eligible collateral for money market operations to include CDs; U.S. dollar repo program extended to six months.	Expand list of collaterals
	10-Dec-08	Extension of liquidity measures for all of 2009.	Term loan and/or liquidity facilities
		Enhancement of liquidity facility through credit lines accepting a broader range of collateral for longer tenors.	Expand list of collaterals
	9-Jul-09	Monetary policy rate at lower bound, short-term liquidity facility, suspension of debt emission of long maturities.	Term loan and/or liquidity facilities

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
Euro zone	26-Sep-08	Measures designed to address elevated pressures in the short-term U.S. dollar funding markets.	Term loan and/or liquidity facilities
	29-Sep-08	Conduct of a special term refinancing operation.	Term loan and/or liquidity facilities
	7-Oct-08	U.S. dollar liquidity-providing operations.	Term loan and/or liquidity facilities
	18-Dec-08	Tender procedures and the standing facilities corridor.	Term loan and/or liquidity facilities
	6-Apr-09	Eurosystem central banks announce expanded swap arrangements.	Swap line with other central bank
	7-May-09	Longer-term refinancing operations. ECB decides to enhance its set of non-standard measures.	Term loan and/or liquidity facilities
	4-Jun-09	Covered bonds purchase for 60 billion euro.	Other
	8-Jul-09	The European Investment Bank is made an eligible counterparty.	Expand list of collaterals
Japan	14-Oct-08	Increase in the frequency and size of repo operations. Steps to facilitate corporate financing.	Other
	31-Oct-08	Introduction of lending facilities.	Term loan and/or liquidity facilities
New Zealand	12-Oct-08	Deposit guarantee scheme introduced.	Other
	29-Oct-08	Reserve Bank of New Zealand (RBNZ) and Federal Reserve announce U.S. dollar facility.	Term loan and/or liquidity facilities
	7-Nov-08	RBNZ announces new facilities.	Term loan and/or liquidity facilities
	12-Dec-08	RBNZ announces further liquidity measures.	Term loan and/or liquidity facilities
	13-Jan-09	Tuesday OMO to accept corporate and asset-backed securities.	Expand list of collaterals
Norway	24-Sep-08	Central banks announce expanded swap facilities with U.S. Federal Reserve.	Swap line with other central bank
	12-Oct-08	Two-year F-loan for small banks.	Term loan and/or liquidity facilities
	29-Oct-08	Easing collateral requirements.	Expand list of collaterals

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
South Korea	27-Oct-08	Increase of aggregate credit; remuneration of reserves.	Interest on reserves
	8-Nov-08	Broadening eligible collaterals for open market operations (OMOs).	Expand list of collaterals
		Liquidity provisions to financial institutions.	Term loan and/or liquidity facilities
Sweden	22-Sep-08	Changed collateral requirements for credit in the Riksbank's funds transfer system (RIX).	Expand list of collaterals
	24-Sep-08	Central banks announce swap facilities with U.S. Federal Reserve.	Swap line with other central bank
	29-Sep-08	Riksbank announces new swap facility in U.S. dollars.	Term loan and/or liquidity facilities
	2-Oct-08	Riksbank lends 60 billion krona over three months.	Term loan and/or liquidity facilities
	6-Oct-08	Increased loans and longer maturity.	Term loan and/or liquidity facilities
	8-Oct-08	Changed collateral requirement for credit in RIX.	Expand list of collaterals
Switzerland	26-Sep-08	Measures taken by central banks to calm the money markets. 30 billion U.S. dollar swap line with the Federal Reserve to provide dollars in Swiss market.	Swap line with other central bank
	29-Sep-08	Swap line with the Federal Reserve increased to 60 billion U.S. dollars and extended to April 2009.	Swap line with other central bank
	15-Oct-08	Swiss National Bank (SNB) and ECB cooperate to provide Swiss franc liquidity.	Term loan and/or liquidity facilities
	16-Oct-08	Steps to strengthen the Swiss financial system. SNB finances transfers of UBS's illiquid assets.	Asset purchase and/or direct lending to financial firms
	18-Dec-08	SNB stab fund acquires first tranche of assets from UBS.	Asset purchase and/or direct lending to financial firms
	25-Jun-09	SNB continues to provide Swiss francs through euro-franc foreign exchange swaps.	Term loan and/or liquidity facilities

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
United Kingdom	19-Jan-09	Bank of England (BoE) announces 50 billion pound purchase of high-quality private sector assets.	Asset purchase and/or direct lending to financial firms
	9-Apr-09	BoE reduces bank rate to 0.5 percent and continues asset purchase facility with 75 billion pounds.	Asset purchase and/or direct lending to financial firms
	7-May-09	BoE maintains bank rate at 0.5 percent and increases size of asset purchase program by 50 billion pounds to 125 billion pounds.	Asset purchase and/or direct lending to financial firms
	4-Jun-09	BoE maintains bank rate at 0.5 percent and continues with 125 billion pound asset purchase program.	Asset purchase and/or direct lending to financial firms
	8-Jun-09	Asset purchase to be expanded to include secured commercial papers.	Asset purchase and/or direct lending to financial firms
	9-Jul-09	BoE maintains bank rate at 0.5 percent and continues with 125 billion pound asset purchase program.	Asset purchase and/or direct lending to financial firms
	6-Aug-09	BoE maintains bank rate at 0.5 percent and increases size of asset purchase program by 50 billion pounds to 175 billion pounds.	Asset purchase and/or direct lending to financial firms
	10-Sep-09	BoE maintains bank rate at 0.5 percent and continues with 175 billion pound asset purchase program.	Asset purchase and/or direct lending to financial firms

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
United States	21-Dec-07	Federal Reserve intends to continue term-auction facilities (TAFs) as necessary.	Term loan and/or liquidity facilities
	13-Jul-08	Lending to Fannie Mae and Freddie Mac at the primary credit rate is authorized.	Asset purchase and/or direct lending to financial firms
	19-Sep-08	Asset-backed commercial paper money market fund liquidity facility (AMFL) or "the facility" established.	Term loan and/or liquidity facilities
	6-Oct-08	Fed will begin to pay interest on depository institutions' required and excess reserve balances and increase the TAF.	Interest on reserves
	2-Dec-08	Extension of three liquidity facilities through 30 April 2009: the primary dealer credit facility (PDCF), the AMLF, and the term securities lending facility (TSLF)	Term loan and/or liquidity facilities
	10-Feb-09	Federal Reserve expands term asset-backed securities loan facility (TALF) and accepts wider set of collateral; announces willingness to expand TALF to 1 trillion U.S. dollars.	Term loan and/or liquidity facilities
	18-Mar-09	Fed increases balance sheet by purchasing a further 750 billion dollars of asset-backed securities from agencies, bringing the year's total purchases up to 1.25 trillion dollars. Announcement of program to buy 300 billion dollars worth of Treasury securities.	Asset purchase and/or direct lending to financial firms
	25-Jun-09	Extension of liquidity facilities and swap lines.	Term loan and/or liquidity facilities

Source: National central banks.

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Inflation Targeting in Financially Stable Economies: Has it Been Flexible Enough?

Mauricio Calani
University of Pennsylvania

Kevin Cowan
Central Bank of Chile

Pablo García S.
International Monetary Fund

The international financial crisis and Great Recession of 2008–09 called for a range of significant policy measures by central banks, beyond aggressive interest rate cuts. Measures have ranged from improving international coordination to purchasing local private loan portfolios and direct intervention in both foreign currency forward and spot markets. For formal inflation-targeting (IT) central banks, a natural question has arisen about whether IT frameworks have been flexible enough to accommodate these diverse policy responses in such a challenging environment, or whether IT restricted their room of maneuver. In this paper we explore the experience of nine IT central banks that did not face

At the time of writing, Mauricio Calani and Pablo García were affiliated with the Central Bank of Chile.

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systemic financial problems, to assess the dimensions in which policy responded to global financial turmoil. Our sample includes economies from around the globe, namely the experiences of Australia, Brazil, Chile, Colombia, Indonesia, Mexico, New Zealand, Peru, and South Korea.

The paper presents two pieces of evidence on the policy actions of these central banks. First, we compare actual monetary policy decisions with estimates from conventionally specified Taylor rules for these economies, using data up to the starting point of the crisis period (the Lehman Brothers collapse). We find large deviations from the rule that cannot be reconciled using plausible expected evolutions of inflation and the output gap. Instead, we find support for an interpretation that accounts for a shift in the weight of past decisions on current decisions—namely, lower persistence. This interpretation points towards considerable policy flexibility within the IT framework. Second, we construct a unique daily history of unconventional measures adopted by these nine central banks. These measures include local and foreign currency facilities, swap or liquidity lines with international organizations such as the Federal Reserve or the International Monetary Fund (IMF), and direct exchange rate interventions undertaken in the midst of the financial debacle. We assess the impact of these policy announcements on key money market variables: local currency interest rates, U.S. dollar onshore interest rates, and nominal exchange rates. We also go on to assess the market impact at the time of implementation. In some cases, the immediate impact of unconventional policies is apparent. However, in other cases, the policy mixes and timing effects are too complex to pinpoint the success of individual measures. Taken as a whole though, these non-monetary policy measures were successful in calming market tensions. The heterogeneity of policy choices reveals the evolving concerns of central banks during the crisis.

1. Assessing Monetary Policy Responses During the Crisis

Taylor (1993) suggested that simple linear reaction functions can describe monetary policy actions reasonably well, by relating the policy rate with the output gap and deviations of inflation from the target. Judd and Rudebusch (1998) suggested this basic description could be improved by controlling for persistence or inertia. Persistent interest rate patterns can arise from several sources, such as forward-looking expectations, uncertainty about data, and uncertainty about monetary policy transmission (Sack and Wieland, 2000). Moreover, Woodford (2003) and others have argued that predictable and gradual monetary policy actions are consistent with optimal monetary policymaking in the framework of dynamic stochastic general equilibrium models with price stickiness.

In this context, inflation targeting—narrowly interpreted as following Taylor-type rules—means that large changes in interest rates, such as those observed in our sample of central banks, arise from major changes in the underlying arguments, from severely reducing its persistence, or from other reasons. We find evidence supporting the second explanation, showing that interest rates that rigorously followed a standard Taylor rule would, by and large, have surpassed actual monetary policy actions during the severe liquidity crisis following the Lehman Brothers bankruptcy into 2009, but that shifting the persistence parameter in the rule allows for a more precise tracking of actual policy.

1.1 Has Monetary Policy Deviated from Previous Patterns?

Let us represent monetary policy decisions with the following Taylor rule:

$$r_t = \gamma + \rho r_{t-1} + (1-\rho)\left[\gamma_\pi(\pi_{t-1} - \pi^*) + \gamma_x(x_{t-1} - x^*)\right], \tag{1}$$

where r_t is the monetary policy rate at time t, π_t is the 12-month inflation rate, and x_t is the 12-month growth rate of the industrial production index.[1] The parameter γ is a constant, ρ is the persistence coefficient, and γ_π and γ_x are the relative weights on the inflation and output gaps, respectively. In this specification, π_t^* stands for the inflation target, and x_t^* acts as a proxy for the natural output growth rate. We proceed to estimate equation (1) for each of our

1. The estimation uses the annual growth rate of industrial production instead of an output-level gap, due to the lack of long historical monthly time series that could be used to confidently estimate the level of these output gaps. This specification follows Walsh's (2003) view that optimal monetary policy can be thought of as reacting to changes in the output gap instead of its level. For this last variable, and unlike the widely used HP filter (or any other filter for that matter), we choose not to use past, current and future values of growth to infer trend growth, x_t^*, but we use the simple mean of annual industrial production growth over the last 24 months, which has performed satisfactorily in this same context (Moura and de Carvalho, 2009).

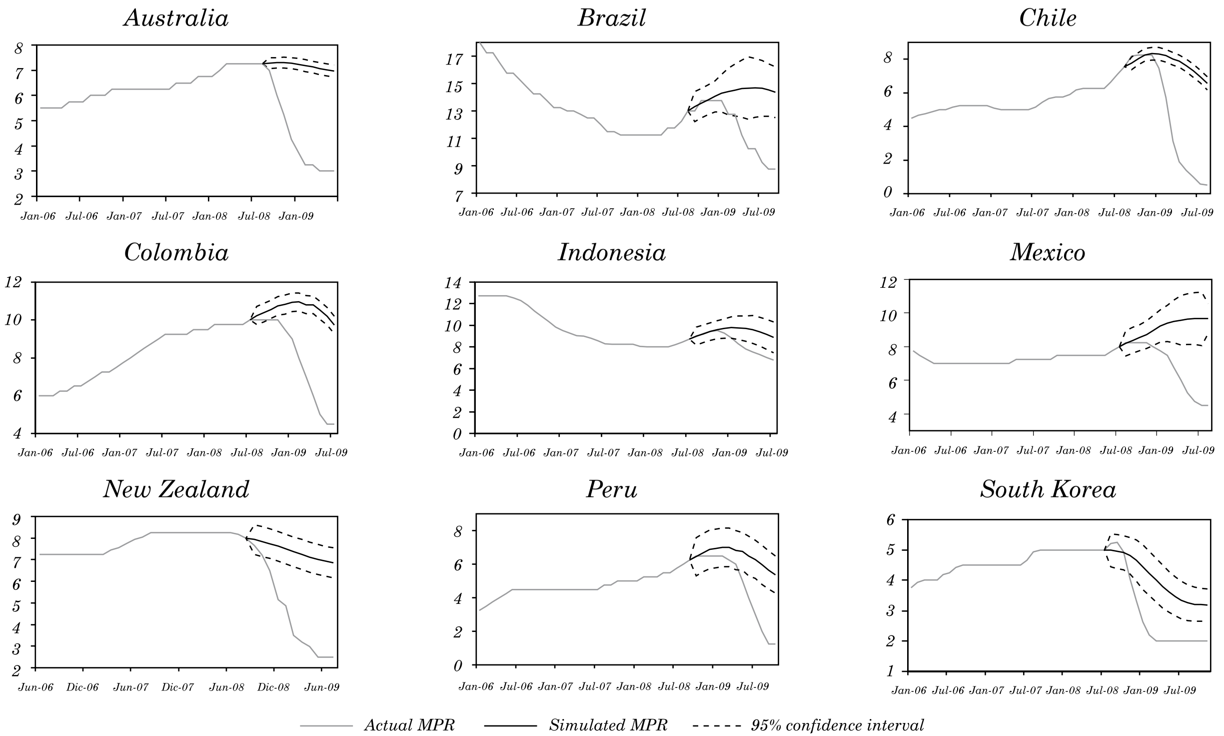
selected economies up to the moment when aggressive monetary policy easing began, typically in the fourth quarter of 2008. Then we dynamically forecast the path for policy rates, given the actual evolution of inflation and industrial production growth, and we compare the resulting policy path with actual policy. Any large and statistically significant deviation of actual monetary policy away from the estimated path after the global financial crisis hit would suggest a break in the way monetary policy reacts to deviations of target variables.

Figure 1 shows the significant deviations from prescribed rule-based policy actions for the nine economies. The gray lines show actual monetary policy response by central banks, while black lines show the conditional point forecasts (solid line) and their 95 percent confidence intervals (dashed lines). It is clear that, all in all, the monetary policy response was significantly different from the predictions arising from simple Taylor rules such as equation (1), estimated for normal times. This result holds qualitatively and—more importantly—quantitatively, if we choose to vary the sample period used for parameter estimation. Note that Australia, New Zealand, Chile, and Colombia post the largest differences between simulated and actual monetary policy rates (MPRs).

Figure 2 summarizes the resulting gaps between the actual path followed by effective MPRs and the ones simulated using the evolution of inflation and the output (growth) gap. A number of observations are in order. First, these gaps are quite large, ranging from 200 to 700 basis points. Second, the timing of the gaps indicates that Australia, New Zealand, and South Korea started to deviate from policy rule prescriptions earlier than Latin American economies (and Indonesia). We confirm this observation estimating a Markov switching model, which allows for two states in equation (1) (explained in detail in the rest of this section), thereby providing an estimated regime shift. Results of this robustness exercise are presented in appendix 1.[2]

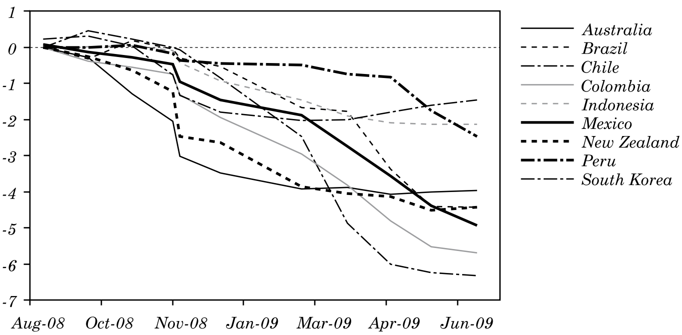
2. We estimate the two-state version of equation (1), $r_t = \gamma + \rho_{S_t} r_{t-1} + (1-\rho_{S_t})[\gamma_\pi(\pi_{t-1}-\pi^*) + \gamma_x(x_{t-1}-x^*)]$, where $\rho_{S_t} = \rho_0 1(S_t=0) + \rho_1 1(S_t=1)$ and ρ_0 stands for high persistence and ρ_1 stands for low persistence. Figure A1 presents the path of actual monetary policy interest rates in dashed lines (left axis) and the probability of being in a high persistence state, $\Pr(S_t = 0)$ in solid lines (right axis). We understand earlier reaction to the financial shock as being an earlier change from a high probability of being in the high-persistence state to one of being in the low-persistence state. Our initial observation is then confirmed, as Australia, New Zealand, and South Korea are the very first countries to be in state $S_t = 1$, followed by Chile, Colombia, Mexico, and Peru, and much later by Indonesia.

Figure 1. Effective and Simulated Monetary Policy Responses in Selected Economies



Source: Authors' calculations.

Figure 2. Gap between Actual and Simulated Monetary Policy Rates



Source: Authors' calculations.

Nevertheless, by the second quarter of 2009 the gaps in Latin American economies had widened significantly more than in the other cases. Third, the shape of the policy deviation indicates a gradual start and a gradual end to the aggressive easing of policy in Latin American economies, whereas in Australia, New Zealand, and South Korea the earlier deviation appeared much more suddenly.[3]

The different policy paths between the latter group and Latin America (plus Indonesia), could be accounted for by the state of the policy cycle at the time. The earlier start for the former group appears consistent with relatively tight policies having been in place, as indicated by flat or falling prescribed policy rates from the conventional Taylor rule at the start of the period under question. In contrast, most of the other economies had rising prescribed rates at the time of the Lehman bankruptcy. Moreover, the shape of the deviations for Latin American economies also reflects a more gradual start and end of the easing cycle than in Asia and the Pacific, likely associated with the earlier recovery in Asia-Pacific economies.

Alternatively, more anxiety about exchange rate fluctuations in Latin American monetary policy making could account for a more gradual initial reaction, which turned aggressive as developing conditions indicated that monetary policy was not worsening turbulence in the foreign exchange market. In contrast, in Australia,

3. This observation is also confirmed in figure A1. Australia, South Korea, and, to a lesser extent, New Zealand and Chile exhibit a reversal in their highly persistent state, $S_t = 0$, after a brief time spent in the low-persistence state $S_t = 1$.

New Zealand, and South Korea, where policymakers were probably less concerned about exchange rate fluctuations, the easing of policy could be—and indeed was—swifter.

Differences in the monetary policy transmission mechanism could also explain the magnitude of the maximum deviation from simulated policy paths. We note that the significance of floating interest rate mortgages in Australia makes for a more potent transmission mechanism, while in Latin America, with less developed mortgage markets, monetary policy would have needed more aggressiveness to achieve similar macroeconomic impact.

1.2 Activism or Dovishness?

Several interpretations could explain the fact that monetary policy has been more aggressive than the standard prescription of a simple policy rule estimated for normal times. In particular, in light of the perception that optimal policy should be predictable, a first take on these results is that monetary policy in these IT countries has deviated significantly from standard monetary policy recommendations and that, therefore, the monetary policy framework itself has deviated from a "pure" IT regime. We argue against this view, on several counts.

First, a specification such as equation (1) is a simple rendering of reality, abstracting many aspects of optimal monetary policy. Although it has been widely shown that simple monetary policy rules lead to economic outcomes—in terms of inflation and output volatility—that do not differ substantially from optimal policy rules, this doesn't necessarily hold true in the event of large shocks.[4] Faced with large shocks, the linearity assumptions that permit the equivalence between simple policy rules and more complex optimal rules break down. It may be the case that under the special circumstances experienced from the last quarter of 2008 onward, the optimal policy response should deviate from a simple policy rule such as equation (1). This deviation would be consistent with the traditional view on optimal policy and Svensson's (2009) view that financial factors play a major role by affecting the transmission mechanism and thus monetary policy needs to react more forcefully when faced with a financial shock.

Second, the assumption that current monetary policy actions do not affect current macroeconomic outcomes—valid in normal

4. See Clarida, Galí, and Gertler (2001), as well as Schmitt-Grohé and Uribe (2006).

times—might not hold under financial distress. Indeed, standard reaction functions such as equation (1) identify the policy reaction by assuming that the arguments on the right-hand side of the equation are not themselves determined by current monetary policy decisions. In normal times, price stickiness and policy lags make this true. However, under financial stress, planning horizons shorten and confidence about the future becomes a paramount determinant of current spending and pricing decisions. This confidence, in turn, becomes largely dependent on policy actions and signaling.

Thus, we can think that the economic counterfactual would have been a smooth and gradually adjusting monetary policy, combined with a much more protracted and severe economic downturn. In a structural sense, the gap between simulated and actual monetary policy paths could actually represent the magnitude of the confidence shock to output and prices, which is currently driving the cycle. Policy, then, has to adjust quickly to prevent this large deflationary shock from affecting economic activity and prices.

A proper interpretation and quantification of the latter channel would require a structural, model-based approach that could help simulate the performance of an economy hit by a large shock, under the assumption of optimal policy versus simple rule-based policy. This goes beyond the scope of this study, but other contributors to this volume touch on this issue. Moreover, it is supported by recent views on optimal monetary policy design amidst financial turbulence or stress, such as those presented in Cúrdia and Woodford (2010), Taylor (2008a), and Taylor (2008b). In the context of our reduced-form analysis, we posit two extreme assumptions about what drives the shift in the monetary policy response in these economies. The first is that monetary policy has become more *activist,* in the sense of reducing the weight of past decisions on current decisions.[5] Hence, this activism can be interpreted as reducing the persistence of the policy rule. The second assumption is that monetary policy became more *dovish*, tending to increase the weight of the output gap on the reaction function.

Returning to our baseline policy rule in equation (1), the stylized fact found in the previous section is that observed monetary policy, ro_t, can be seen as the prescription from the rule plus a shock ε_t:

$$ro_t = r_t + \varepsilon_t = \gamma + \rho r_{t-1} + (1-\rho)\left[\gamma_\pi(\pi_{t-1} - \pi^*) + \gamma_x(x_{t-1} - x^*)\right] + \varepsilon_t.$$

5. We are reluctant to use the term "hawkish," as the literature has related this term to strong inflation aversion alone.

The activist interpretation identifies the shock ε_t as a shift (reduction) in the persistence parameter ρ, while the dovish interpretation implies a shift (increase) in the weight of the output gap γ_x. To obtain a sense of whether our simulations support one or the other, we followed the simple expedient of minimizing the squared deviations of actual policy from a simulated path with either a changing persistence or a changing weight on the output gap. For each country this provides us with a new set of estimates for persistence and sensitivity to the output gap, consistent with a policy path that attempts to closely fit actual events. The result of these exercises for all nine economies is presented in figure 3.

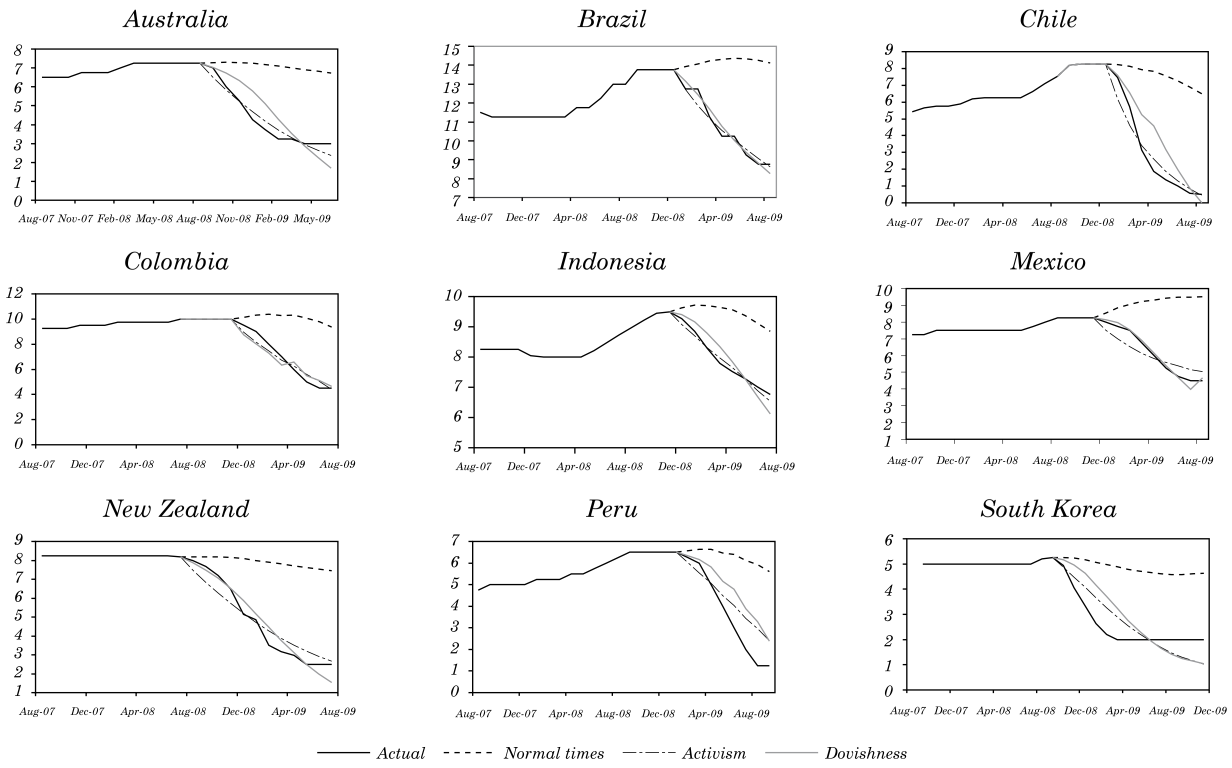
Table 1 presents four columns summarizing this exercise. The first two present the value of the minimized quadratic loss function that penalizes deviations from actual policy by changing either persistence (column 1), or the output gap parameter (column 2). The third column shows the ratio of these last two numbers, and reveals that by changing the persistence parameter in (1), we can approximate actual policy more closely than if we adjust the output parameter for Australia, Chile, Colombia, Indonesia, and South Korea. For New Zealand and Peru the two loss functions are extremely similar, and only for Brazil and Mexico does adjusting the output weight parameter outperform adjusting the persistence parameter. More importantly, columns 5 and 6 show the ratio of the simulated and estimated persistence parameter and output weight parameter, respectively. It is evident that the parameter ρ must be reduced by 6 to 24 percent to approximate actual data. On the other hand, the change in γ_x that is required to approximate actual monetary policy actions is at least an order of magnitude greater. This degree of dovishness is simply too extreme to be plausible.

In a second exercise we take our estimations of equation (1) and compute the values for the change in inflation deviations and/or output growth deviations consistent with both actual monetary policy action and the estimation of equation (1) for normal times. Specifically, we take the long run representation of equation (1) and subtract its lag to obtain

$$\Delta r_t = \frac{\alpha}{1-\rho}\Delta(\pi_t - \pi^*) + \frac{\beta}{1-\rho}\Delta(y_t - y^*). \tag{2}$$

From equation (2) we compute the necessary change of inflation deviation, $\Delta(\pi_t - \pi^*)^{simulated}$, consistent with the decrease in the

Figure 3. Activist (Persistence) and Dovish (Output Gap) Simulated Paths for Monetary Policy



Source: Authors' calculations.

Table 1. Activism versus Dovishness in Monetary Policy

	Loss function			*Required changes*	
	Activism	*Dovishness*	*(1) / (2)*	*Simul. ρ/Est. ρ*	*Simul. β_2/ Est. β_2*
Country	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Australia	1.42	9.26	0.15	0.89	12.00
Brazil	1.15	1.00	1.16	0.90	58.00
Chile	3.84	16.95	0.23	0.74	6.81
Colombia	2.12	3.50	0.61	0.87	6.36
Indonesia	0.16	1.25	0.13	0.93	25.50
South Korea	6.59	11.99	0.55	0.93	3.64

Source: Authors' calculations.

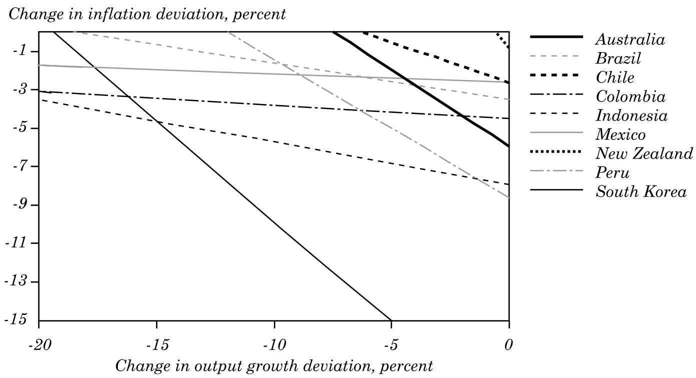
MPR and actual realization of $\Delta(y_t - y^*)$. This inflation deviation is compared to actual $\Delta(\pi_t - \pi^*)^{data}$ and its difference is the intercept with the vertical axis in figure 4. We do the same to compute the difference between simulated and actual output growth deviations consistent with actual change in inflation deviation and the monetary policy rate, which is graphed as the intercept with the horizontal axis in figure 4. The linearity of equation (2) allows us to extrapolate those combinations of exceeding deflationary and contractionary shocks that are necessary for central banks to lower their MPRs as they did, using normal-time Taylor-type reaction rules.

Figure 4 directly suggests that either inflation or output growth should have been radically lower for them alone to account for the central banks' observed reaction, as they aggressively lowered interest rates. All in all, these arguments support our claim that flexibility—that is, temporarily abandoning the persistence of the past—was the most likely and important characteristic of IT implementation in the period of financial stress.

2. Assessing Non-monetary Policy Responses

As discussed above, the central banks included in this study all engaged in a number of non-monetary policy actions. Before addressing the more general issue of whether these measures were consistent with a framework based on inflation targeting (IT), we tackle the more concrete aspect of whether or not these measures

Figure 4. Required Differences in Output (Growth) Gap and Inflation Deviations, Consistent with Actual Monetary Policy Actions



Source: Authors' calculations.

had any measurable and statistically significant correlation with key financial variables.

To narrow the scope of this issue, we focus on the more direct concerns of central banks: money market liquidity and the exchange rate. As mentioned in the introduction, the selection of financially-stable IT economies allows us to avoid the thorny issue of the optimality of central banks' assessments of credit risk during financial crises, the required coordination with the Treasury, and the impact of credit-easing or quantitative-easing policies on a broad set of asset prices, such as house prices, long-term interest rates, and equities.

2.1 Empirical Approach

We compile the daily history of unorthodox non-monetary policy measures undertaken by nine central banks and assess their partial correlation with three variables: short-term (one-month) local currency money market interest rates; short-term (one-month) U.S. dollar local interest rates; and the bilateral exchange rate against the U.S. dollar. Ishi and others (2009) follow a similar line of research to explain the reasons behind implementation of certain measures and their effectiveness. In principle, the outbreak of financial turmoil affected all three markets, as the tightening of U.S. dollar liquidity worldwide was reflected in onshore U.S. dollar markets, the transmission of financial shocks, high global volatility, and uncertainty regarding authorities' capacity to respond in a timely and effective manner. This, in turn, should have led in varying degrees to higher local currency money market spreads. Finally, the sudden stop of capital inflows, or more generally the prevalence of home-bias effects, stressed the external financing available to several economies. Flight to quality—with the U.S. dollar's role as a reserve currency—only reinforced this phenomenon, depreciating bilateral exchange rates against the dollar worldwide.

Policy responses varied enormously, but can be classified in three groups, corresponding to the three variables discussed above. Some measures aimed to ease U.S. dollar liquidity, such as foreign exchange swaps between central banks and between central banks and local financial or non-financial corporations. Others aimed to ease local money market tensions, such as deposit guarantees, extensions of the tenors of standard repo operations and/or the broadening of eligible collateral. Finally, we can think of the third set of measures as aiming to directly affect exchange rate parities, namely direct foreign exchange reserve sales or purchases.

Most measures targeting a particular market indirectly affected other markets. This can be clarified with a number of examples. Take, for instance, the extension of term lending in local currency. This should, of course, directly impact local money market interest rates, but not necessarily local U.S. dollar money market interest rates. If the magnitude of the impact on local money market interest rates is large enough, then the exchange rate should also react through the uncovered interest rate parity condition. On the other hand, an intervention in the foreign exchange market should affect the bilateral dollar exchange rate, while having an ambiguous effect on local currency money markets, depending on the degree and characteristics of the sterilization of the spot sale. Moreover, the foreign exchange intervention should have opposite effects on local U.S. dollar money market rates, depending on whether the intervention is performed in the spot or the forward markets.

Thus, given the diversity of non-monetary policy measures undertaken by our selected IT central banks, in principle one should allow for specific measures potentially affecting different dimensions. The specifications selected for the empirical exercise follow this eclectic approach. In each case, we allow for the selected extraordinary policy variables (represented by dummies) to influence all three variables. We control for standard global financial variables, which in some cases are specific to the selected variable, and in other cases are common across variables.[6] Each non-monetary policy measure specific to an economy is identified with a dummy variable. As per the discussion above, we do not exclude the possibility that these non-monetary policy measures could have had an effect on all three variables. Moreover, we allow for an initial announcement effect and a more lasting implementation effect from these measures.

We are also aware of the endogeneity issues involved in this specification: the timing of implementation is indeed endogenous to the tensions in the different financial markets and thus our endogenous variables. We proceed, however, based on three factors. First, we believe that the estimated correlations are informative for policy discussion. Second, the bias, if any, in the estimated coefficients is against finding significant results. Third, the endogeneity problem is to some extent ameliorated by the fact that global developments and not specific local events were at the root of local financial turbulence in the selected economies.

2.1.1 Functional forms

Nominal exchange rate. Equation (3) is the specification for the bilateral nominal exchange rate (NER) against the U.S. dollar. It relates the logarithm of the exchange rate, e_t, to (i) variables that capture international financial market stress: the logarithm of the VIX index, the London interbank offered rate (LIBOR)-OIS spread, and a dummy for the period after the bankruptcy of Lehman Brothers; (ii) the logarithm of the effective nominal multilateral U.S. dollar exchange rate, USD_t; and (iii) the logarithm of the commodity price index, CRB_t, provided by the Commodity Research Bureau.

$$\begin{aligned}\ln(e_t) = {} & \alpha_o + \alpha_{vix}\ln(VIX_t) + \alpha_{USD}\ln(USD_t) \\ & + \alpha_{CRB}\ln(CRB_t) + \alpha_{l-bro}D_t^{l-bro} + \alpha_{lOIS}(r_t^* - OIS_t^*) \\ & + \sum_i (\alpha_d^i D_t^i + \alpha_{d-a}^i \Delta D_t^i) + \vartheta_t.\end{aligned} \tag{3}$$

6. For instance, the commodity price index is used as a control for the nominal exchange rate specification, but is not considered in the local interest rate specification. Controls that are common to all three specifications include a constant dummy that captures the stress that started after Lehman Brothers collapsed, the VIX index, and the LIBOR-OIS spread.

We include specific non-monetary policy variables through dummies that are equal to one during their implementation, as well as their change to capture the initial effect of their announcement. We consider only the initial change, and not the pre-announced lapsing of the measures, in those cases where this was part of the initial announcement.

Local currency money market. Equation (4) presents the specification for the local money market interest rate. It relates the short-term (30-day) local currency deposit rate (or LIBOR), i_t, to the current overnight interbank rate (most often the policy rate), r_t, the expected interbank rate 20 working days ahead (measured by an interest rate swap where available), the local U.S. dollar money market rate, i_t^*, and the same variables used in equation (3) to capture international financial stress. As in equation (3), we include the full set of dummies for exceptional measures and their respective announcements.

$$i_t = \beta_0 + \beta_r r_t + \beta_{re} r_{t+20} + \beta_{i^*} i_t^* + \beta_{vix} \ln(VIX_t) + \\ \beta_{l-bro} D_t^{l-bro} + \beta_{l-OIS}(r_t^* - OIS_t^*) + \sum_i (\beta_d^i D_t^i + \beta_{da}^i \Delta D_t^i) + \varepsilon_t. \tag{4}$$

Local U.S. dollar money market. Several countries in our sample saw large deviations of U.S. dollar interest rates in domestic markets, with respect to those in key offshore financial markets after October 2008. For economies fully integrated into global financial markets, one would not expect this to happen, as domestic U.S. dollar interest rates should exactly match risk-adjusted U.S. dollar rates in international financial markets. Note, however, that in most countries in our sample, financial integration is imperfect due to both regulatory restrictions and underdevelopment of some key financial markets. Moreover, during the recent financial crisis, many of the agents that are able to arbitrage differences between international and local U.S. dollar rates in normal times were unwilling or unable to do so. The severity of the turmoil increased concerns about counterparty risk and made funding liquidity risk paramount, probably hindering these trades. Following the latter idea, Hui and others (2009) document large deviations from corresponding dollar LIBOR rates, and argue precisely that funding liquidity risk (LIBOR-OIS spreads) can explain such deviations.

Equation (5), then, models the local U.S. dollar rate by relating the short-term (30-day) local U.S. dollar rate, i_t^*, to the current local money market rate, i_t, the 30-day U.S. dollar LIBOR, r_t^*, the financial stress variables, and the policy dummies:

$$
\begin{aligned}
i_t^* = {} & \delta_0 + \delta_i i_t + \delta_r r_t^* + \delta_{vix} \ln(VIX_t) + \delta_{l-bro} D_t^{l-bro} \\
& + \delta_{l-OIS}(r_t^* - OIS_t^*) + \sum_i (\delta_d^i D_t^i + \delta_{da}^i \Delta D_t^i) + \nu_t .
\end{aligned} \tag{5}
$$

Equations (3) through (5) are not derived from any optimizing behavior, but offer the great advantage of providing a framework flexible enough to assess the wide variety of measures undertaken by our selection of central banks. Moreover, simple extensions of these equations allow us to, for instance, test whether these policy measures also affected the sensitivity of the interest rates and the exchange rate to global factors, such as the VIX, the multilateral dollar exchange rate, and commodity prices.

In what follows we present the results of estimating equations (3) through (5) for a number of economies that follow IT frameworks: Australia, Brazil, Chile, Colombia, Indonesia, Mexico, New Zealand, Peru, and South Korea. In each case, we provide a brief description of the rationale for the policy measures undertaken in 2008 and 2009, a list of these measures, and how we label these with dummies. We then estimate and comment on the results of these estimations.

2.1.2 The data

Before proceeding to the details of estimations, it is worth discussing the specifics of the selected data set. All data are daily, and the estimation was performed for the period of January 2007 to August 2009. The nominal exchange rate and the macro-financial controls selected—such as the VIX index, the one-month U.S. dollar LIBOR, the LIBOR-OIS spread, and the multilateral nominal value of U.S. dollar commodity prices—were easily obtained from the usual sources. For local money market interest rates and local onshore U.S. dollar interest rates, however, there are no easily available, standard data sets. Money market infrastructure and practices differ widely between economies, such that variables must be selected very carefully. Regarding local currency money market interest rates, we proceeded to select a LIBOR-type interest rate, that is, a term (one-month) interbank interest rate. In some cases, such as Australia and New Zealand, the one-month LIBOR in local currency is readily available, whereas for other economies it is not. For instance, for

Chile we used the prime one-month deposit rate, which in practice is very similar to a money market rate, although more than banks participate in its pricing. Table A1 in the appendix presents the details of the local money market rates selected for each economy, along with their Bloomberg tickers.

The collection of short-term onshore U.S. dollar local interest rate data is a challenge, as it is unavailable for most economies. We proceeded, therefore, by constructing a proxy for local dollar liquidity interest rates using forward prices and the covered interest rate parity condition under the assumption of arbitrage and no transaction costs, expressed as follows:

$$F = S \times \frac{(1+i)}{(1+i^{*})}, \tag{6}$$

where F is the forward exchange rate at a given tenor, S is the spot nominal exchange rate, i and i^{*} are the local currency and U.S. dollar interest rates for the same tenor. Thus, by knowing the spot and forward exchange rates and the local currency interest rates it is possible to infer the implicit U.S. dollar interest rate, which is the onshore U.S. dollar interest rate:

$$i^{*} = (1+i) \times \frac{S}{F} - 1. \tag{7}$$

In practice, bid-ask spreads and tenor standards for the measurement of interest rates differ. On the one hand, bid-ask spreads can be as high as 10 percent in some economies, while the standard tenors can be calendar days (360 or 365 days) or working days (252 for instance). Hence, the implicit onshore U.S. dollar rate we calculate follows the expression

$$i_b^{on} = \left[\frac{S_a}{F_a}(1+i_b T) - 1 \right] \frac{1}{T},$$

where S_a and F_a are the spot and forward exchange rates, i_b is the local currency deposit interest rate and T is a time factor adjusted for the tenor standard. Using this procedure we constructed onshore U.S. dollar interest rates at 1, 3, and 12 months, from January 2007 to the end of October 2009. All data is from Bloomberg, and specific details are presented in appendix figure A1.

It is noteworthy to highlight the situation of certain Asian economies that took a number of measures following the financial crisis of the late nineties that led to the segmentation of onshore and offshore foreign exchange markets. In those cases, we considered the onshore forwards for our calculations.

2.2 Results

2.2.1 Chile

The sequencing of measures is presented in table 2a. Prior to the collapse of Lehman Brothers, the Central Bank of Chile had put in

Table 2a. Extraordinary Actions in Chile

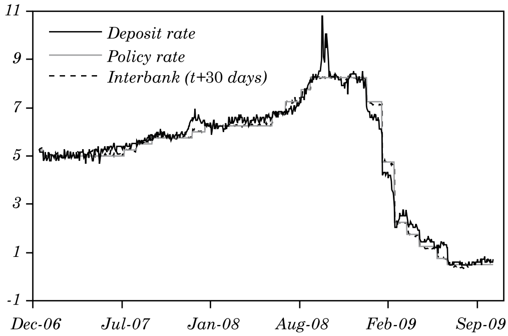
Start	*End*	*Extraordinary action*
14-Apr-08	12-Dec-08	Central Bank of Chile decides to increase U.S. dollar reserves by 8 billion dollars: 50 million per day through competitive auctions with sterilization.
29-Sep-08		Interruption of international reserve accumulation process (70 percent of goal achieved).
30-Sep-08		Currency swap auctions.
10-Oct-08		Extension of liquidity-providing operations: extension of currency swaps from one to six months; seven day repo facilities in pesos with bank deposits as collateral.
10-Oct-08	8-Apr-09	Banks' reserve requirement denomination constraint is relaxed for U.S. dollar liabilities.
3-Dec-08		Extension of liquidity providing operations: currency swaps up to 180 days.
10-Dec-08	31-Dec-09	Extension of liquidity providing operations: currency swaps up to 180 days; repo operations to 28 days using central bank bonds as collateral and to seven days using bank deposits.
15-Dec-08	31-Dec-09	Repo operations to 28 days using bank deposits as collateral.
1-Jan-09	31-Dec-09	Eligible collateral assets for 28 day liquidity facility broadened to include government bonds and bank deposits.
10-Jul-09		As of 15 July 2009, term liquidity facility (FLAP) introduced at 90 and 180 days.
30-Dec-08	26-Jan-10	Liquidity credit line in pesos for banking enterprises with collateral. New credit line for banks.

Source: Authors' compilation from Central Bank of Chile reports.

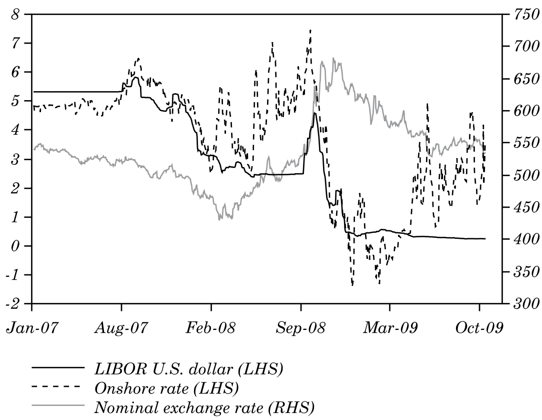
place a reserve accumulation program. This program was cut short on 29 September 2008 as acute dollar liquidity shortages became apparent globally. What followed was a number of liquidity provision measures in both U.S. dollars and local currency. Foreign currency swaps were implemented, in the form of sales of foreign exchange in the spot market with a simultaneous repo of foreign exchange. In terms of domestic currency, term repos in local currency (at a floating interest rate) were implemented, and the set of collaterals broadened to include time deposits. All these measures were in place by October 2008. Moreover, to enhance the monetary policy stimulus in the

Figure 5. Key Money Market Variables in Chile

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Central Bank of Chile.

Table 2b. Estimation Results for Chile[a]

	Deposit rate	
Interbank rate	0.663 [37.13]***	
Expected rate (t+20)	0.245 [12.46]***	
Log (VIX_t)	−0.122 [2.10]**	
LIBOR U.S. dollar	−0.057 [3.55]***	
Onshore rate	0.016 [1.45]	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve accumulation	−0.248 [5.17]***	0.334 [1.46]
Currency swap options	0.721 [5.28]***	−0.237 [0.71]
Currency swap operations extended and repo	−1.187 [11.49]***	1.372 [5.78]***
Term liquidity facility	−0.285 [3.41]***	−0.144 [0.60]
Financial stress		
Lehman Brothers	0.17 [1.95]*	
LIBOR-OIS	0.313 [7.21]***	
Constant	1.049 [5.19]***	
Observations		613
R^2		0.99

Table 2b. (continued)

	Onshore rate	
Deposit rate	−0.083	
	[2.50]**	
LIBOR U.S. dollar	0.629	
	[11.22]***	
Log (VIX_t)	0.222	
	[1.00]	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve accumulation	1.034	−1.134
	[5.82]***	[1.25]
Currency swap options	0.015	−0.128
	[0.03]	[0.10]
Currency swap operations extended and repo	−2.594	1.126
	[6.86]***	[1.20]
Term liquidity facility	1.491	0.726
	[5.90]***	[0.78]
Financial stress		
Lehman Brothers	0.725	
	[2.14]**	
LIBOR-OIS	0.52	
	[3.10]***	
Constant	1.465	
	[1.88]*	
Observations		649
R^2		0.80

Table 2b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.059 [13.06]***	
Log (CRB_t)	−0.357 [8.88]***	
Log (VIX_t)	0.004 [0.58]	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve accumulation	0.056 [12.74]***	−0.063 [2.00]**
Currency swap options	0.011 [0.68]	−0.046 [1.00]
Currency swap operations extended and repo	−0.005 [0.36]	0 [0.01]
Term liquidity facility	0.028 [3.08]***	−0.036 [1.10]
Financial stress		
Lehman Brothers	−0.014 [1.32]	
LIBOR-OIS	0.046 [11.37]***	
Constant	13.201 [62.90]***	
Observations		680
R^2		0.90

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets.

context of a binding zero lower bound, a term (six-month) lending facility at the fixed policy rate was implemented in July 2009.

One policy dummy identifies the accumulation of reserves in 2008 prior to the crisis, a second dummy identifies the implementation of foreign currency swaps in late September, and a third identifies the same operations implemented by the middle of October, broadened to include time deposits as collateral for money market operations. A fourth dummy represents term lending at a fixed rate implemented in July 2009. Table 2b presents the results of these estimations. We also include dummies for the announcement of each program.

The specifications yield the expected results regarding the controls for each case. The effective nominal U.S. dollar exchange rate and the commodities index have a large and significant effect on the bilateral peso-dollar exchange rate, the VIX index does not impact the nominal exchange rate and dollar liquidity conditions once the LIBOR-OIS spread is included, while the U.S. dollar LIBOR also affects local dollar liquidity conditions.

On policy measures, the 2008 reserve accumulation program significantly influenced the nominal exchange rate, while increasing the local U.S. dollar rates and local money market rates in the baseline specifications. The more aggressive foreign exchange swap program had an important effect on local money market conditions, reducing peso and dollar rates as expected. Local U.S. dollar interest rates fell by close to 250 basis points while local currency deposit rates fell by close to 100 basis points. Finally, the term lending facility implemented in July 2009 significantly influenced interest rates. Peso rates fell by 30 basis points, while onshore rates rose.

2.2.2 Brazil

The October 2008 financial crisis led to a sizeable increase in capital outflows, and reduced Brazilian companies' access to foreign lines of credit. This prompted authorities to apply significant measures to bolster domestic liquidity and facilitate access to U.S. dollar liquidity. By the end of September, the central bank had already phased out its reverse foreign exchange swap operations—which amounted to the purchase of a forward U.S. dollar position and therefore increased the U.S. dollar position in its balance sheet—and also stopped buying U.S. dollars on the spot market. By early October, the central bank started to unwind its forward U.S. dollar position, as a first reaction to the financial crisis. Moreover, to further bolster the foreign liquidity buffer, the central bank received authorization to undertake currency swap agreements with foreign central banks on 21 October, paving the way for a 30 billion U.S. dollar swap arrangement with the U.S. Federal Reserve in late October. This was extended for six months into late June 2010, and has not been tapped. In terms of forex intervention, most measures have been implemented through these foreign exchange swaps, and only partially through spot sales.

Table 3a. Extraordinary Actions in Brazil

Start	*End*	*Extraordinary action*
21-Dec-07	29-Sep-08	Central Bank of Brazil (CBB) carries out reverse foreign exchange swap auctions.
6-Oct-09	28-Apr-09	CBB offers traditional foreign exchange swap on a daily basis.
8-Oct-08		Direct U.S. dollar spot purchase.
21-Oct-08		CBB authorized to swap currency with foreign central banks.
30-Oct-08	30-Oct-09	Agreement for up to 30 billion U.S. dollars with the Federal Reserve Bank of New York.
5-May-09		CBB carries out reverse foreign exchange swap auctions.
30-Jun-09	1-Feb-10	Ceiling on foreign exchange swaps with the Federal Reserve raised to 30 billion U.S. dollars.

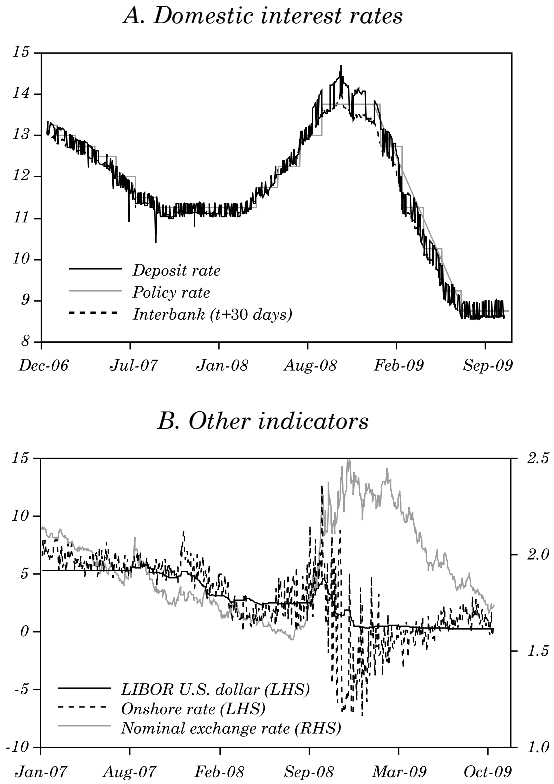
Source: Authors' compilation from Central Bank of Brazil reports.

In terms of local financing, the central bank took measures both to facilitate exporting firms' access to credit lines and to ease other strains on local currency liquidity. The former involved implementing credit lines for exporters. The banking system reduced the large reserve requirements on deposits, successfully raising domestic liquidity to 100 billion reales in the last quarter of 2008, that is, two-thirds of base money.[7] To contain financial stress in the most exposed segments of the banking system, incentives were provided to encourage larger institutions to reduce their reserve requirements by acquiring smaller institutions' credit portfolios. Table 3a reveals the sequence of these different policy measures.

7. See OECD (2010).

To assess the impact of these measures we identify six policy dummies: reverse foreign exchange swap operations; traditional foreign exchange swap operations; spot interventions in the foreign exchange market; the announcement of the dollar-real swap between the central bank and the Federal Reserve; the implementation of credit lines to exporters; and the reduction in the compulsory reserve requirement. These policy dummies take the value of 1 while the measures are in place. Dummies are also included on announcement.

Figure 6. Key Money Market Variables in Brazil



Sources: Bloomberg and Central Bank of Brazil.

Table 3b shows the results of the estimation. With regards to the effects on the exchange rate, the reverse swap operations—for example, increasing the long U.S. dollar position prior to the crisis and after May 2010—seem to have kept the nominal exchange rate weaker, but the traditional swaps do not seem to have stemmed depreciation in any statistically significant way. The swap agreement with the Federal Reserve does appear to have been significant from both a statistical and an economic point of view, appreciating the nominal exchange rate by almost 6 percent. The measures designed to bolster domestic liquidity and access to credit both point to depreciating the currency.

In terms of domestic liquidity, the measures seem less relevant, although policy measures seem to have eased foreign liquidity. U.S. dollar interest rates reacted most significantly to the swap agreement with the Federal Reserve (a reduction of more than 300 basis points), while spot sales also had an impact. This is consistent with the findings of Stone and others (2009), who find that both the announcement and the implementation of foreign exchange easing reduced the local cost of dollar borrowing. Neither foreign exchange swaps nor credit lines to exporters significantly affected this variable.

Table 3b. Estimation Results for Brazil[a]

	Deposit rate	
Interbank rate	−0.058 [1.19]	
Expected rate (t+20)	1.12 [23.06]***	
Log (VIX_t)	0.013 [0.25]	
LIBOR U.S. dollar	0.031 [2.88]***	
Onshore rate	−0.005 [1.12]	
Non-monetary policy actions	*Implemented*	*Announced*
Reverse swaps	−0.056 [0.99]	−0.266 [1.27]
Traditional swaps	0.037 [0.54]	0.085 [0.56]
Spot intervention	−0.061 [1.11]	−0.571 [2.68]***
Possibility of foreign exchange swaps with Federal Reserve	0.026 [0.30]	0.052 [0.25]
Credit line expansion	−0.076 [0.95]	0 [.]
Compulsory reserve requirement	0.408 [3.64]***	0.08 [0.37]
Financial stress		
Lehman Brothers		−0.197 [2.69]***
LIBOR-OIS		0.02 [0.53]
Constant		−0.66 [2.67]***
Observations		653
R^2		0.98

Table 3b. (continued)

	Onshore rate	
Deposit rate	−0.106	
	[1.08]	
LIBOR U.S. dollar	1.208	
	[16.88]***	
Log (VIX_t)	−0.044	
	[0.10]	
Non-monetary policy actions	*Implemented*	*Announced*
Reverse swaps	−0.543	0.174
	[1.13]	[0.10]
Traditional swaps	−0.303	0.447
	[0.56]	[0.34]
Spot intervention	−1.065	8.365
	[2.40]**	[4.64]***
Possibility of foreign exchange swaps with Federal Reserve	−3.08	−4.447
	[4.30]***	[2.48]**
Credit line expansion	−0.443	0
	[0.72]	[.]
Compulsory reserve requirement	0.641	−0.396
	[0.68]	[0.21]
Financial stress		
Lehman Brothers	1.817	
	[3.03]***	
LIBOR-OIS	−0.661	
	[2.12]**	
Constant	2.316	
	[1.17]	
Observations	680	
R^2	0.74	

Table 3b. (continued)

	Nominal exchange rate	
Log (U.S. dollar multilateral exchange rate)	−1.104	
	[15.13]***	
Log (CRB_t)	−0.586	
	[16.42]***	
Log (VIX_t)	0.012	
	[2.15]**	
Non-monetary policy actions	*Implemented*	*Announced*
Reverse swaps	0.022	−0.001
	[3.23]***	[0.04]
Traditional swaps	−0.006	0.044
	[0.80]	[2.34]**
Spot intervention	0.006	0.103
	[0.96]	[3.93]***
Possibility of foreign exchange swaps with Federal Reserve	−0.059	−0.025
	[5.64]***	[0.95]
Credit line expansion	0.033	0
	[3.76]***	[.]
Compulsory reserve requirement	0.029	−0.004
	[1.98]**	[0.14]
Financial stress		
Lehman Brothers	0.016	
	[1.77]*	
LIBOR-OIS	0.001	
	[0.16]	
Constant	9.125	
	[46.44]***	
Observations	680	
R^2	0.96	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets

2.2.3 Colombia

The impact of the October 2008 financial crisis on the Colombian foreign exchange and short-term money markets was mild compared to other countries in our sample. The interbank overnight interest rates remained close to the policy rate. Indeed, the spread between short-term deposit interest rates and the actual or expected policy rate (as measured by the OIS market) did not increase in late 2008. Similarly, the implied dollar rates in forward contracts rose in late 2008 to almost 100 basis points above LIBOR. It is therefore not surprising that the Central Bank of Colombia did not implement liquidity provision programs in U.S. dollars in response to rising spreads on Colombian U.S. dollar-denominated bonds, and simply eliminated capital controls. In terms of domestic liquidity provisions, in October the central bank reduced reserve requirements on local currency deposits, announced 14- and 30-day repo operations, and an outright purchase of government bonds. In June, the central bank had implemented a reserve accumulation program, purchasing 20 million U.S. dollars per day in competitive auctions. After conditions in international financial markets changed in October, the program was suspended. Finally, in April, Colombian authorities secured a contingent credit line facility from the IMF.

Table 4a. Extraordinary Actions in Colombia

Start	*End*	*Extraordinary action*
20-Jun-08		Modification of international reserve accumulation program to 20 million U.S. dollars per day through competitive auction.
9-Oct-08		Elimination of unremunerated reserve requirement and cancellation of international reserve accumulation program.
24-Oct-08		Reduction of cash position requirements in pesos. Repo operations of 14 to 30 days in pesos. Purchase of treasury bonds worth 500 billion pesos.
20-Apr-09		Contingent credit line petition to the IMF (10.4 billion U.S. dollars).
28-Aug-09		IMF special drawing rights made available worth 890 million U.S. dollars.

Source: Authors' compilation from Central Bank of Colombia reports.

Table 4b. Estimation results for Colombia[a]

	Deposit rate	
Interbank rate	0.877	
	[39.18]***	
Expected rate (t+20)	0.085	
	[3.53]***	
Log (VIX_t)	0.051	
	[1.13]	
LIBOR U.S. dollar	0.078	
	[6.75]***	
Onshore rate	−0.039	
	[6.27]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	0.186	−0.146
	[7.13]***	[1.03]
Repo and reserve requirement	−0.086	0.042
	[1.86]*	[0.29]
Contingent credit line with IMF		0.114
		[0.81]
Financial stress		
Lehman Brothers	−0.077	
	[1.59]	
LIBOR-OIS	0.009	
	[0.38]	
Constant	−0.067	
	[0.59]	
Observations	576	
R^2	0.99	

Table 4b. (continued)

	Onshore rate	
Deposit rate	0.984 [16.83]***	
LIBOR U.S. dollar	1.142 [25.40]***	
Log (VIX_t)	−2.811 [11.33]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	1.46 [8.33]***	−1.102 [1.08]
Repo and reserve requirement	2.821 [9.42]***	−0.197 [0.19]
Contingent credit line with IMF		0.034 [0.03]
Financial stress		
Lehman Brothers	2.486 [7.63]***	
LIBOR-OIS	−1.107 [7.16]***	
Constant	−2.204 [3.03]***	
Observations	626	
R^2	0.72	

Table 4b. (continued)

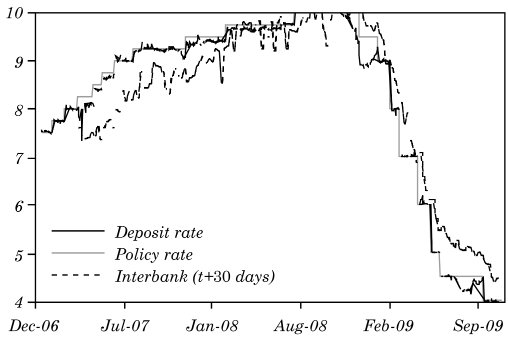
Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.147	
	[13.83]***	
Log (CRB_t)	−0.405	
	[10.12]***	
Log (VIX_t)	0.033	
	[4.96]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	−0.003	−0.067
	[0.65]	[2.05]**
Repo and reserve requirement	−0.097	0.024
	[9.91]***	[0.71]
Contingent credit line with IMF		0.034
		[1.06]
Financial stress		
Lehman Brothers	0.032	
	[3.39]***	
LIBOR-OIS	0.014	
	[3.60]***	
Constant	15.206	
	[77.98]***	
Observations	680	
R^2	0.90	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets.

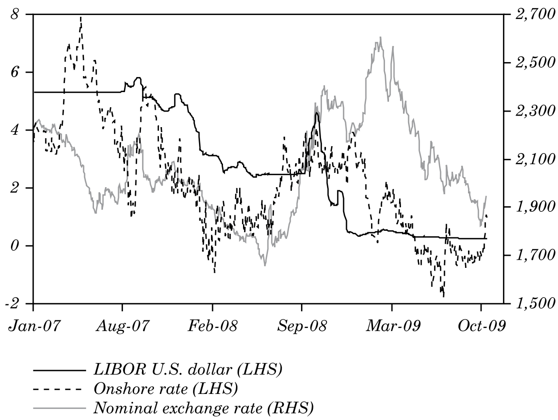
To assess the impact of these measures, we identify three policy dummies: (i) the reserve accumulation program; (ii) the changes in reserve requirements and repo operations; and (iii) the contingent credit line announcement. The non-significant coefficients on foreign volatility measures (such as the logarithm of the VIX index) and on the liquidity premium in U.S. interbank rates in the estimation for Colombian interbank rates is consistent with international financial conditions having little impact on domestic money markets. In terms of policies, the domestic liquidity measures correlate with lower interbank rates, as expected. The positive estimated coefficient on the reserve accumulation program dummy, however, is surprising.

Figure 7. Key Money Market Variables in Colombia

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Central Bank of Colombia.

In terms of onshore dollar rates, these move in line with LIBOR in our sample as expected, rising significantly after the financial crisis deepened (captured by the Lehman Brothers collapse dummy). However, unlike onshore rates in Chile and other countries, we actually find a negative correlation between these rates and the VIX and LIBOR-OIS spread. In terms of policies, domestic dollar rates were higher in the reserve accumulation period.

Results for the exchange rate are closer to our priors. In this period the dollar-peso exchange rate moved due to changes in the dollar's value against other countries, depreciating after the financial crisis deepened in October, as well as in those periods in which the VIX was rising. We find that the announcement—and not the implementation itself—of the reserve accumulation process appreciated the NER, as well as the domestic liquidity provision measures, as arbitrage conditions would predict.

2.2.4 Mexico

The October financial crisis significantly affected peso/dollar markets in Mexico. In Mexico, falling global demand for emerging market assets interacted with rising demand from the corporate sector for dollar-denominated assets, as companies rushed to cover unhedged dollar positions that had built up over the period of exchange rate stability (see Kamil and others, 2009). The result was a significant reduction in turnover in peso-dollar markets and remarkable peso depreciation. Companies' higher demand for U.S. dollar assets also explains why, during the last quarter of 2008, the implicit onshore dollar rate in Mexico fell. Increased demand to buy dollars in future markets pushed up forward rates relative to spot rates, depressing the implicit dollar rate. This led the Bank of Mexico to start selling international reserves through several extraordinary auctions in October and a daily auction program that began in early October and continued through June 2009. This program initially set the minimum price at 2 percent above the previous day's exchange rate, to reduce volatility. This minimum price was eliminated in March.

Lack of a swap market for overnight interbank rates makes it difficult to precisely determine whether Mexico experienced rising tensions in peso money markets in this period. The available data suggests this was not the case. Indeed, 28-day interbank rates actually fell in October, driven by investors reducing their positions in long-term government paper, and switching to short-term debt instruments. In this context, the extraordinary liquidity facilities implemented by the Bank of Mexico in October (and extended in December) can be seen as a preventative measure to help local institutions manage liquidity.

Table 5a. Extraordinary Actions in Mexico

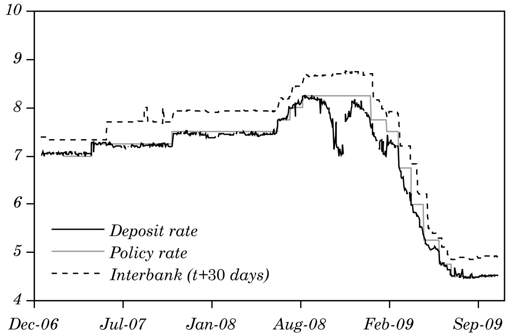
Start	*End*	*Extraordinary action*
8-Oct-08	23-Oct-08	Extraordinary U.S. dollar auction for 11 billion dollars.
9-Oct-08	1-Oct-09	Daily auctions. Initially for 400 million U.S. dollars with a minimum price.
		From March onwards, with no minimum price and in reduced amounts.
27-Oct-08	31-Dec-08	Reduction of the auction program for public bonds for 2008 Q4: replacement with short-term government treasuries (CETES) and later repurchase of bonds.
27-Oct-08	4-Nov-08	Reduction of the auction program for savings protection bonds by the Institute for the Protection of Banking Savings (IPAB): around 140 million U.S. dollars for 2008 Q4; later, announcement to repurchase savings protection bonds worth 10.7 billion U.S. dollars.
8-Oct-08	18-Dec-08	Broadening of admissible collateral for liquidity provision for open market operations.
14-Nov-08	28-Nov-08	Domestic interest rate swap lines of up to 50 billion pesos (around 3.5 billion U.S. dollars).
29-Oct-08	1-Feb-10	Swap lines with foreign central banks extended in May and June.
21-Apr-09		Auction of swap line funds for 4 billion U.S. dollars.
1-Apr-09	1-Apr-10	IMF flexible contingent credit line of 47 billion U.S. dollars.

Source: Authors' compilation from Bank of Mexico reports.

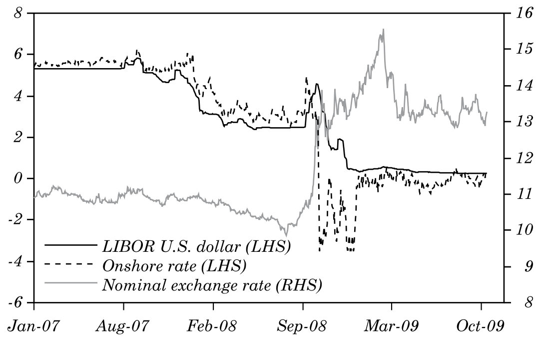
The Bank of Mexico also introduced an interest rate swap facility in mid-November. This facility aimed to reduce bank exposure to high volatility in Mexican government bond prices. In addition to this swap, and in an attempt to reduce long-term interest rates on public debt, the Mexican authorities reduced their issuance of long-term bonds during the last quarter of 2008.

Figure 8. Key Money Market Variables in Mexico

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Bank of Mexico.

Table 5b reports estimates of the partial correlation of these policy measures with domestic rates, onshore rates, and the nominal exchange rate. For the Mexican interbank offered rate (MEXIBOR), the policy rate has the expected sign and magnitude. Interestingly, the coefficient on the VIX is negative and significant (however small), unlike other countries that saw short-term rates go up relative to the policy rate after Lehman. The estimated coefficients indicate a negative correlation between domestic liquidity measures and the interbank rate, and a negative correlation between the interbank rate and interest rate swaps. The fact that so many programs were announced on 8 October makes it difficult to interpret the positive coefficient on the announcement dummy.

The onshore rate co-moves with the LIBOR, as expected. However, the correlations with the VIX and LIBOR-OIS spreads are negative, due to the unwinding of corporate derivative positions in the last quarter of 2008. Both the announcement and implementation of the Federal Reserve swap line reduced the onshore dollar rate, as expected.

The Mexican peso depreciated after the Lehman Brothers bankruptcy, and further depreciated in those periods of highest volatility (as measured by the VIX index). We did not find the expected impact of U.S. dollar sales (both programmed and extraordinary), probably due to endogeneity in the timing of these measures.

Table 5b. Estimation Results for Mexico[a]

	Deposit rate	
Interbank rate	0.877 [45.47]***	
Log (VIX_t)	−0.075 [2.07]**	
LIBOR U.S. dollar	−0.029 [3.63]***	
Onshore rate	−0.009 [1.10]	
Non-monetary policy actions	*Implemented*	*Announced*
Direct sales of U.S. dollars	0.166 [2.74]***	
Broadening of admissible collateral	−0.494 [8.79]***	0.303 [2.00]**
Interest rate swaps	−0.086 [1.79]*	0.037 [0.50]
Financial stress		
Lehman Brothers	0.063 [1.44]	
LIBOR-OIS	−0.031 [1.19]	
Constant	1.298 [7.51]***	
Observations	628	
R^2	0.98	

Table 5b. (continued)

	Onshore rate	
Deposit rate	−0.64	
	[7.36]***	
LIBOR U.S. dollar	0.648	
	[23.22]***	
Log (VIX_t)	0.588	
	[3.98]***	
Non-monetary policy actions	*Implemented*	*Announced*
Direct sales of U.S. dollars	−0.081	
	[0.29]	
Broadening of admissible collateral	−4.262	4.281
	[19.50]***	[6.17]***
Interest rate swaps	−1.005	−1.048
	[4.85]***	[3.07]***
Financial stress		
Lehman Brothers	1.078	
	[5.41]***	
LIBOR-OIS	−0.976	
	[8.55]***	
Constant	5.405	
	[6.91]***	
Observations	662	
R^2	0.94	

Table 5b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−0.421	
	[6.93]***	
Log (CRB_t)	−0.142	
	[4.64]***	
Log (VIX_t)	0.067	
	[13.27]***	
Non-monetary policy actions	*Implemented*	*Announced*
Direct sales of U.S. dollars	0.023	
	[2.47]**	
Broadening of admissible collateral	0.115	−0.031
	[14.34]***	[1.34]
Interest rate swaps	−0.001	−0.01
	[0.29]	[0.91]
Financial stress		
Lehman Brothers	0.029	
	[3.98]***	
LIBOR-OIS	−0.038	
	[10.51]***	
Constant	4.988	
	[32.65]***	
Observations	680	
R^2	0.96	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets.

2.2.5 Australia

The financial crisis also affected money markets in Australia. Markets for bank funding became particularly stressed and the Reserve Bank of Australia applied several measures to alleviate the situation and satisfy the increased demand for cash balances. The tenor of repo operations was extended, and the frequency of 6- and 12-month repos was increased to daily in early October. Moreover, to confront the increase in counterparty risk, the range of acceptable collaterals was expanded to include residential mortgage-backed securities (RMBS) and asset-backed commercial paper (ABCP) of related parties, in contrast with constraints normally in place on the eligibility of collateral for repo operations.[8] Also, restrictions on the ability to substitute collateral within an existing repo were removed. The average term of repo operations increased significantly in October thanks to these measures. Regarding the provision of U.S. dollar liquidity, the main measure was a bilateral swap arrangement with the Federal Reserve.

Table 6a. Extraordinary Actions in Australia

Start	*End*	*Extraordinary action*
24-Sep-08		Bilateral swap with Federal Reserve for 10 billion U.S. dollars.
29-Sep-08		Increase of bilateral swap with the Federal Reserve to 30 billion U.S. dollars.
8-Oct-08		Frequency of 6- to 12-month repos increased to daily; acceptance of related parties' RMBS and ABCP as eligible collateral; restrictions removed on substituting collateral within an existing repo; repo operation of 14 to 30 days; and introduction of a term deposit facility with one and two week maturities to absorb liquidity.
12-Oct-08		State guarantee introduced for an unlimited amount for deposits until October 2011 and for debt securities maturing in up to five years.

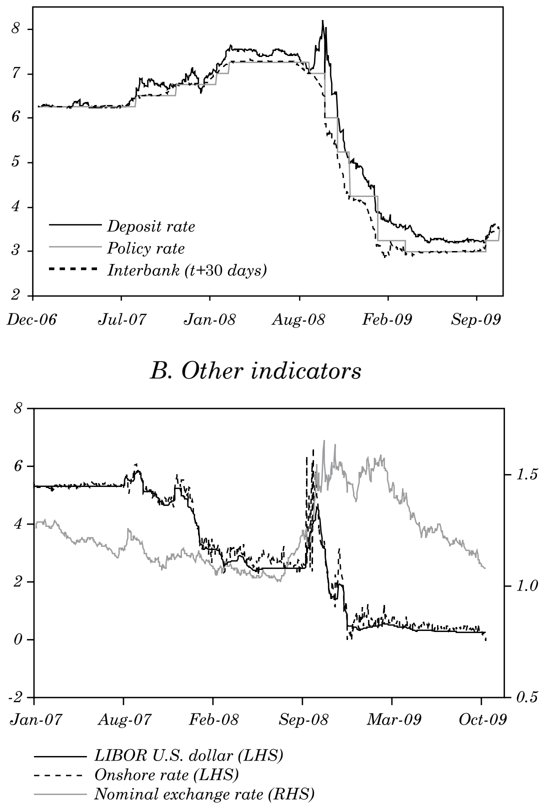
Source: Authors' compilation from Reserve Bank of Australia reports.

8. See Debelle (2008).

Figure 9. Key Money Market Variables in Australia

A. Domestic interest rates

B. Other indicators



Sources: Bloomberg and Reserve Bank of Australia.

What were the effects of these measures according to our empirical specification? We identify two dummy variables, corresponding to the bilateral swap agreement with the Federal Reserve, and the broadening of eligible collateral and term extension for repo operations plus the state guarantees for deposits and other liabilities, respectively. Due to the short time between the latter measures, it is not possible to separately identify the impacts on our selected financial variables. Table 6b presents the results.

Table 6b. Estimation results for Australia[a]

	Deposit rate	
Interbank rate	0.137	
	[4.96]***	
Expected rate (t+20)	0.884	
	[27.67]***	
Log (VIX_t)	0.007	
	[0.34]	
LIBOR U.S. dollar	0.04	
	[2.79]***	
Onshore rate	−0.025	
	[1.69]*	
Non-monetary policy actions	*Implemented*	*Announced*
RBA-TD and Federal Reserve swap line	0.066	−0.179
	[1.12]	[1.65]*
Repo and collateral	0.014	−0.143
	[0.28]	[1.34]
Financial stress		
Lehman Brothers	0.286	
	[6.51]***	
LIBOR-OIS	0.365	
	[17.04]***	
Constant	−0.284	
	[2.25]**	
Observations	644	
R^2	0.99	

Table 6b. (continued)

	Onshore rate	
Deposit rate	−0.096 [2.63]***	
LIBOR U.S. dollar	0.934 [88.66]***	
Log (VIX_t)	0.092 [1.60]	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	−0.656 [4.30]***	0.503 [1.72]*
Repo and reserve requirement	−0.989 [8.02]***	1.44 [5.11]***
Financial stress		
Lehman Brothers	1.045 [9.59]***	
LIBOR-OIS	0.151 [2.32]**	
Constant	0.697 [2.27]**	
Observations	679	
R^2	0.98	

Table 6b. (continued)

	Nominal exchange rate	
Log (U.S. dollar multilateral exchange rate)	−1.51 [30.63]***	
Log (CRB_t)	−0.267 [11.41]***	
Log (VIX_t)	0.044 [11.13]***	
Non-monetary policy actions	*Implemented*	*Announced*
Intense reserve accumulation program	−0.044 [4.44]***	0.018 [0.90]
Repo and reserve requirement	0.004 [0.56]	0.043 [2.18]**
Financial stress		
Lehman Brothers	0.016 [2.11]**	
LIBOR-OIS	0.038 [16.64]***	
Constant	8.546 [74.08]***	
Observations	680	
R^2	0.97	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets.

The bilateral swap with the Federal Reserve and the extensions of repo operations plus the implementation of deposit and other guarantees caused significant currency appreciation, and reduced the onshore rate significantly (from 60 to 100 basis points) and persistently over the period. Interestingly, for local liquidity conditions things were slightly different. The effects were most marked after the announcement, but did not seem to persist, even when we control for other variables. The effects also seem to have been more muted, limited to between 15 and 20 basis points.

2.2.6 New Zealand

In contrast to other economies, the financial and banking system in New Zealand was undergoing a downward credit cycle prior to the October 2008 financial turmoil. Hence, already by June, some precautionary measures had been adopted to expand collateral and assist domestic liquidity. When the crisis hit New Zealand, some finance companies were already under pressure.[9] These measures were further complemented in early October, when RMBS were also allowed as eligible collateral as funding became harder to obtain. By November, further liquidity facilities were implemented through term lending and by December more securities were accepted for domestic liquidity operations, including highly rated corporate bonds.

Table 7b presents the effects of these policy interventions. All three sets of measures (and their announcements) coincided with significantly lower domestic interest rates. Effects of the policy dummies on the onshore rates were mixed. The announcements of all measures coincided with currency appreciations, whereas the measures themselves coincided with a depreciated currency.

9. See Bollard and Ng (2009) and Nield (2008).

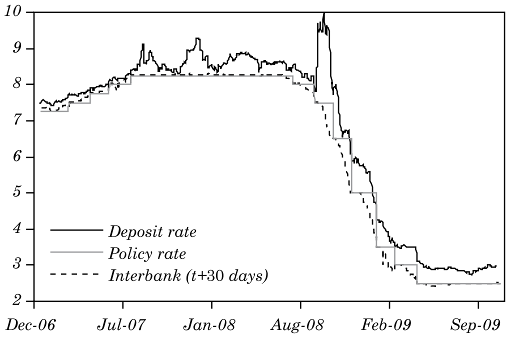
Table 7a. Extraordinary Actions in New Zealand

Start	*End*	*Extraordinary action*
3-Jun-08		Broadening of collateral eligible for acceptance in the Reserve Bank of New Zealand's (RBNZ) domestic liquidity operations: domestically-registered New Zealand dollar AAA-rated securities, including residential mortgage-backed securities, and AA-rated New Zealand government sector debt (including government agencies, state owned enterprises and local authorities). The discount margin applied in the RBNZ's overnight reverse repo facility will be 50 basis points for all eligible securities. Extension of overnight reverse repo facility from one to thirty days.
9-Oct-08		Broaden securities program to residential mortgage backed securities (RMBS).
29-Oct-08	30-Apr-09	RBNZ and Federal Reserve announce U.S. dollar facility of up to 15 billion dollars.
12-Nov-08	26-Oct-09	Term auction facility (TAF) offer raised to 2 billion New Zealand dollars and with three, six, and twelve month maturities.
12-Nov-08	26-Oct-09	RBNZ bill tenders to withdraw liquidity injected via TAF.
17-Dec-08		Extension of the range of securities acceptable in the RBNZ's domestic liquidity operations to include: securities guaranteed by the government, highly rated New Zealand corporate securities, and New Zealand dollar denominated asset-backed securities.
30-Jun-09		Prudential liquidity policy.
22-Oct-09		Prudential liquidity policy deadline implementation is relaxed.

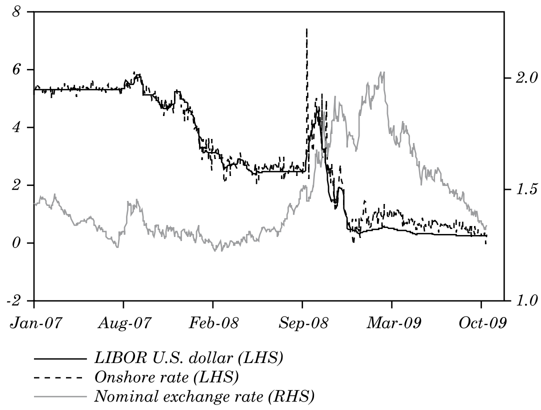
Source: Authors' compilation from Reserve Bank of New Zealand reports.

Figure 10. Key Money Market Variables in New Zealand

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Reserve Bank of New Zealand.

Table 7b. Estimation Results for New Zealand[a]

	Deposit rate	
Interbank rate	0.26	
	[6.82]***	
Expected rate (t+20)	0.802	
	[18.93]***	
Log (VIX_t)	−0.207	
	[5.13]***	
LIBOR U.S. dollar	0.136	
	[5.55]***	
Onshore rate	−0.13	
	[5.49]***	
Non-monetary policy actions	*Implemented*	*Announced*
Broadening eligible collateral	−0.059	−0.064
	[2.03]**	[0.36]
Swap lines with Federal Reserve	−0.196	−0.616
	[6.95]***	[3.42]***
TAF and extension of acceptable collateral	−0.113	−0.346
	[1.71]*	[1.93]*
Financial stress		
Lehman Brothers	0.884	
	[14.02]***	
LIBOR-OIS	0.499	
	[16.70]***	
Constant	0.171	
	[1.14]	
Observations	677	
R^2	0.99	

Table 7b. (continued)

	Onshore rate	
Deposit rate	−0.079	
	[3.74]***	
LIBOR U.S. dollar	0.978	
	[70.38]***	
Log (VIX_t)	0.17	
	[2.64]***	
Non-monetary policy actions	*Implemented*	*Announced*
Broadening eligible collateral	0.075	−0.012
	[1.59]	[0.04]
Swap lines with Federal Reserve	0.17	−0.391
	[3.82]***	[1.33]
TAF and extension of acceptable collateral	−0.582	0.985
	[5.84]***	[3.40]***
Financial stress		
Lehman Brothers	0.246	
	[2.76]***	
LIBOR-OIS	−0.142	
	[2.76]***	
Constant	0.33	
	[1.40]	
Observations	679	
R^2	0.98	

Table 7b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	−1.312 [18.02]***	
Log (CRB_t)	−0.077 [2.04]**	
Log (VIX_t)	0.02 [3.32]***	
Non-monetary policy actions	*Implemented*	*Announced*
Broadening eligible collateral	0.077 [19.85]***	−0.046 [1.74]*
Swap lines with Federal Reserve	0.035 [6.37]***	−0.073 [2.72]***
TAF and extension of acceptable collateral	0.072 [9.16]***	−0.042 [1.59]
Financial stress		
Lehman Brothers	−0.041 [5.13]***	
LIBOR-OIS	0.033 [7.90]***	
Constant	6.703 [37.54]***	
Observations	680	
R^2	0.96	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets.

2.2.7 South Korea[10]

The Bank of Korea initially responded to rising international financial volatility by supplying liquidity to banks and securities companies through long-term repo operations, starting in October 2008. To further ease tensions in funding markets, in November and December 2008 the central bank included bank debentures and certain government agency bonds among the securities eligible for use as collateral in open market operations, which originally included only Treasury bonds, government-guaranteed bonds and monetary stabilization bonds. In November, the central bank supported the creation of a bond market stabilization fund, while in December counterparties for repo operations were expanded to include securities companies in addition to banks.

To facilitate lending, the aggregate credit ceiling was raised in November to boost banks' incentives for lending to small and medium enterprises (SMEs). The aggregate credit ceiling was further increased on 23 March 2009. Moreover, in December 2008, the central bank paid banks a one-off remuneration on their required reserve deposits to help them expand their credit supply capacity by raising their Bank for International Settlements (BIS) capital adequacy ratios.

As in other economies, foreign exchange market tensions grew in the wake of the Lehman Brothers collapse. This is evident from the shift in the level and volatility of the onshore U.S. dollar rate in South Korea in the fourth quarter of 2008, which peaked at over 600 basis points above LIBOR. The central bank undertook a number of measures to alleviate further financial market unrest and to prevent the turmoil from evolving into a full-blown currency crisis. On 30 October 2008, the central bank entered into a 30 billion dollar swap arrangement with the Federal Reserve. In addition, on 12 December the central bank not only entered into a swap arrangement with the People's Bank of China, but also expanded the ceiling of an existing currency arrangement with the Bank of Japan.

Furthermore, the Bank of Korea acted directly to ease corporate access to foreign credit through a number of measures. It directly provided U.S. dollars in foreign currency liquidity to financial institutions experiencing difficulties in overseas fund-raising by way

10. This section is based on Bank of Korea (2009).

of a competitive swap facility between 21 October and 16 December 2008. On 17 November 2008, it introduced measures to heighten the attraction to foreign exchange banks of providing trade finance to SMEs. Meanwhile, for firms which had taken out foreign currency loans or purchased financial derivative products and were facing a widening debt service burden and losses on derivative products, the Bank of Korea allowed domestic banks to extend the maturities of their foreign currency loans made for use as working capital and also permitted export firms to take out foreign currency loans for settlement of currency option contracts such as knock-in knock-out (KIKO) arrangements. Table 8a presents these measures.

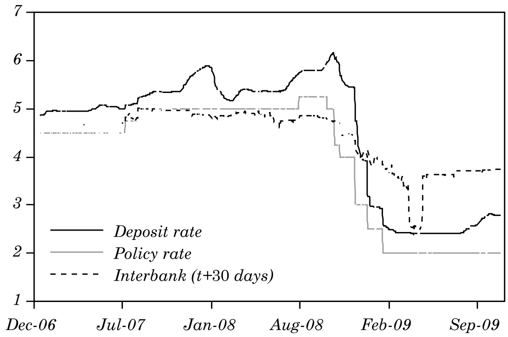
Table 8a. Extraordinary Actions in South Korea

Start	*End*	*Extraordinary action*
30-Apr-08		Specific support to businesses.
1-Oct-08		Specific support to businesses.
17-Oct-08		Foreign exchange swap auctions.
27-Oct-08		Extension of accepted collateral to include bonds issued by banks.
29-Oct-08	30-Oct-09	Swap facility with the Federal Reserve.
1-Dec-08		Specific support to businesses.
3-Dec-08		Interest began to be paid on bank deposits held in the central bank.
9-Dec-08		Extension of accepted collateral to include bonds emitted by public corporations.
11-Dec-08		Twelve more firms made eligible for repo operations.
12-Dec-08	1-Apr-09	Expansion of swap line with the Bank of Japan.
9-Jan-09		91-day repos introduced.

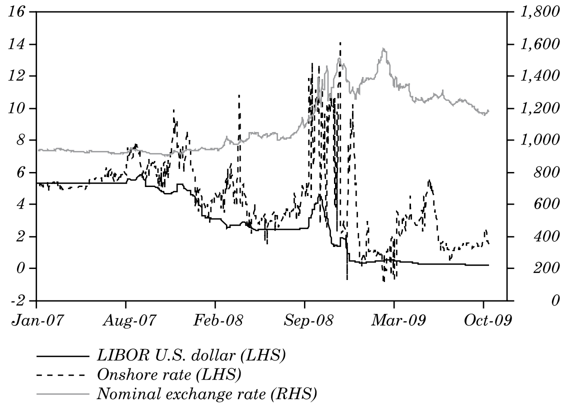
Source: Authors' compilation from Bank of Korea reports.

Figure 11. Key Money Market Variables in South Korea

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Bank of Korea.

Table 8b. Estimation Results for South Korea[a]

	Deposit rate	
Interbank rate	−0.498	
	[10.16]***	
Expected rate (t+20)	1.581	
	[38.49]***	
Log (VIX_t)	−0.045	
	[2.28]**	
LIBOR U.S. dollar	0.038	
	[4.13]***	
Onshore rate	0.003	
	[1.24]	
Non-monetary policy actions	*Implemented*	*Announced*
Support to businesses	0.086	
	[3.39]***	
Won-dollar foreign exchange swaps	0.148	−0.1
	[3.38]***	[1.18]
Collateral relaxation and central bank remuneration on reserves	0.403	0.064
	[7.76]***	[0.79]
Swap facility with Federal Reserve or Bank of Japan	−0.044	0.084
	[3.00]***	[1.09]
Financial stress		
Lehman Brothers	−0.179	
	[6.00]***	
LIBOR-OIS	0.115	
	[7.84]***	
Constant	−0.452	
	[5.63]***	
Observations	559	
R^2	0.99	

Table 8b. (continued)

	Onshore rate	
Deposit rate	1.947	
	[13.38]***	
LIBOR U.S. dollar	0.069	
	[0.42]	
Log (VIX_t)	1.243	
	[3.64]***	
Non-monetary policy actions	*Implemented*	*Announced*
Support to businesses	−2.772	
	[6.01]***	
Won-dollar foreign exchange swaps	−3.319	3.702
	[4.40]***	[2.24]**
Collateral relaxation and central bank remuneration on reserves	4.114	−8.603
	[4.84]***	[5.45]***
Swap facility with Federal Reserve or Bank of Japan	−2.636	1.308
	[9.97]***	[0.85]
Financial stress		
Lehman Brothers	3.726	
	[7.18]***	
LIBOR-OIS	0.025	
	[0.09]	
Constant	−7.955	
	[6.34]***	
Observations	649	
R^2	0.65	

Table 8b. (continued)

	Nominal exchange rate	
Log (U.S. dollar multilateral exchange rate)	−1.403 [16.80]***	
Log (CRB_t)	0.395 [8.74]***	
Log (VIX_t)	−0.01 [1.37]	
Non-monetary policy actions	*Implemented*	*Announced*
Support to businesses	0.104 [21.95]***	−0.063 [2.06]**
Won-dollar foreign exchange swaps	0.072 [4.55]***	−0.036 [1.07]
Collateral relaxation and central bank remuneration on reserves	0.06 [3.71]***	−0.018 [0.58]
Swap facility with Federal Reserve or Bank of Japan	0.052 [8.25]***	−0.07 [2.23]**
Financial stress		
Lehman Brothers	0.082 [8.27]***	
LIBOR-OIS	0.047 [10.04]***	
Constant	10.896 [45.74]***	
Observations	680	
R^2	0.97	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets.

For our purposes, we identify as policy dummies the direct provision of liquidity to businesses, the U.S. dollar-won swap operations by the central bank, collateral extensions and the remuneration of reserves, and the swap arrangement with the Federal Reserve. Table 8b presents the results of the estimation. Two results are the most noteworthy. First, the variable that most reacted to these policy measures was the onshore U.S. dollar interest rate. The liquidity support to businesses, U.S. dollar-won swaps and the swap arrangement with the Federal Reserve reduced this interest rate substantially, by 270, 330, and 260 basis points, respectively. Similarly to other cases, the nominal exchange rate did not seem to react in a significant way to any of these policy measures, in the sense of experiencing an appreciation.

2.2.8 Indonesia

A significant concern in the wake of the global financial crisis in Indonesia was the magnitude of external debt maturing during 2009 as well as the settlement of structured products between a number of banks.[11] Hence, as elsewhere, the implementation of measures to ease short-term funding pressures was key to dealing with the crisis. Most of the measures implemented by the central bank related to the provision of liquidity in foreign currency. By mid-October, the tenor of U.S. dollar-local currency swaps was extended to one month, reserve requirements on U.S. dollar deposits were cut, and limits on foreign borrowing by local banks were abolished. In February 2009, as global financial turmoil continued, Indonesia secured a number of facilities to provide additional foreign liquidity in the form of standby loans from the World Bank, bilateral swap agreements with Japan and China, and an expanded pool of reserves through the Chiang Mai Initiative. In terms of local money markets, also by mid-October, the maximum guarantee for deposits of selected institutions was expanded and longer-tenor repo operations were introduced. In December, the corridor for the overnight rate was narrowed. Table 9a summarizes the timeline of implemented measures.

For our purposes, we identify three policy dummies. First, the introduction of local money market and U.S. dollar facilities in mid-October; second, the narrowing of the interbank rate corridor; and third, the number of credit lines with foreign institutions. Results are

11. See Mulya (2009).

presented in Table 9b, and suggest that several of these measures were indeed effective in easing money market tensions, both in local currency and U.S. dollars. Although the initial implementation of measures in October did not significantly reduce the spread between interbank and policy rates, it did reduce implied onshore U.S. dollar interest rates by close to 300 basis points. The access to a broader set of foreign resources by the first quarter of 2009 significantly affected both local money market interest rates and implied onshore U.S. dollar rates. Interestingly, none of these measures seems to have significantly affected the exchange rate.

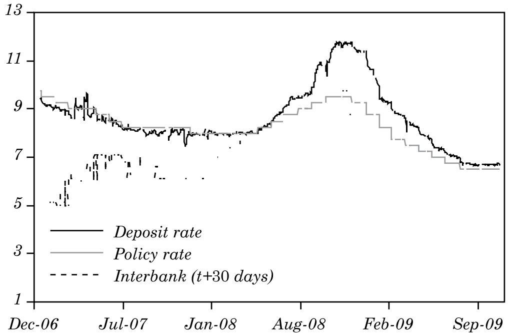
Table 9a. Extraordinary Actions in Indonesia

Start	*End*	*Extraordinary action*
9-Oct-08		Introduction of two week repo operation.
14-Oct-08		Foreign exchange market measures: foreign exchange swap maturities extended from seven days to one month; reserve requirements on foreign currency deposits lowered from three to one percent; and limit on foreign currency borrowing by banks is abolished.
4-Dec-08		Corridor for overnight interest rates narrowed from 200 to 100 basis points.
2-Feb-09		Credit lines with foreign institutions: arrangement of 5.5 billion U.S. dollar standby loans from the World Bank, Asian Development Bank, Australia and Japan; and expansion of bilateral currency swap arrangement with Japan from two to six billion U.S. dollars.
23-Mar-09		Bilateral swap line with China.

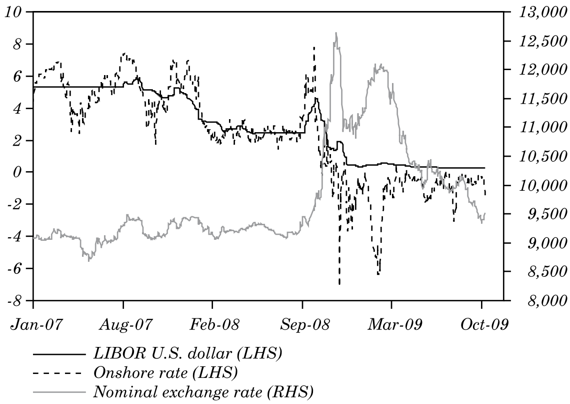
Source: Authors' compilation from Bank Indonesia reports.

Figure 12. Key Money Market Variables in Indonesia

A. Domestic interest rates



B. Other indicators



Sources: Bloomberg and Bank Indonesia.

Table 9b. Estimation Results for Indonesia

	Deposit rate	
Interbank rate	1.344	
	[69.64]***	
Expected rate (t+20)		
Log (VIX_t)	0.417	
	[9.53]***	
LIBOR U.S. dollar	−0.115	
	[10.41]***	
Onshore rate	−0.014	
	[2.01]**	
Non-monetary policy actions	*Implemented*	*Announced*
Repo, swap, or reserve requirement lowered	0.131	−0.969
	[1.93]*	[4.86]***
Narrowing of interbank rate corridor	0.013	0.412
	[0.24]	[2.09]**
Credit lines with foreign banks	−0.645	−0.028
	[12.59]***	[0.15]
Financial stress		
Lehman Brothers	0.849	
	[12.65]***	
LIBOR-OIS	0.01	
	[0.33]	
Constant	-3.641	
	[15.30]***	
Observations	631	
R^2	0.97	

Table 9b. (continued)

	Onshore rate	
Deposit rate	−0.553	
	[7.38]***	
LIBOR U.S. dollar	1.01	
	[21.93]***	
Log (VIX_t)	0.141	
	[0.58]	
Non-monetary policy actions	*Implemented*	*Announced*
Repo, swap, or reserve requirement lowered	−3.726	0.475
	[10.19]***	[0.41]
Narrowing of interbank rate corridor	−0.203	−0.985
	[0.64]	[0.86]
Credit lines with foreign banks	−1.776	1.614
	[5.62]***	[1.42]
Financial stress		
Lehman Brothers	3.69	
	[9.62]***	
LIBOR-OIS	−0.302	
	[1.74]*	
Constant	4.402	
	[4.04]***	
Observations	641	
R^2	0.86	

Table 9b. (continued)

Nominal exchange rate		
Log (U.S. dollar multilateral exchange rate)	0.102 [1.20]	
Log (CRB_t)	−0.372 [9.00]***	
Log (VIX_t)	0.112 [19.19]***	
Non-monetary policy actions	*Implemented*	*Announced*
Repo, swap, or reserve requirement lowered	0.047 [4.94]***	−0.094 [3.20]***
Narrowing of interbank rate corridor	−0.005 [0.58]	0.031 [1.06]
Credit lines with foreign banks	0.03 [4.92]***	0.023 [0.80]
Financial stress		
Lehman Brothers	−0.04 [4.60]***	
LIBOR-OIS	−0.01 [2.26]**	
Constant	10.574 [56.80]***	
Observations	670	
R^2	0.91	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets

2.2.9 Peru

Peruvian authorities did not hesitate to aggressively provide domestic and foreign currency liquidity starting in September 2008. Table 10a summarizes the most relevant actions adopted by the Central Reserve Bank of Peru (CRBP). On domestic liquidity provision, the CRBP reduced reserve requirements for banking institutions gradually but significantly, starting on 26 September 2008, and deepening this incentive into the first quarter of 2009 in six different press releases. On the foreign exchange market, intervention needed to be aggressive since Peru is a highly dollarized economy. The CRBP intervened in the U.S. dollar market by selling almost 7 billion dollars from September 2008 to May 2009, with public announcements by authorities that these interventions were to reduce exchange rate market volatility. From the right panel of figure 13 it is evident that depreciation of the nuevo sol was mild compared to both its own history and other Latin American currencies.

Table 10a. Extraordinary Actions in Peru

Start	*End*	*Extraordinary action*
1-Sep-08	30-Sep-08	Selling auction of 2 billion U.S. dollars to avoid exchange rate volatility.
26-Sep-08		Suspension of reserve requirement for two to seven year obligations (less than twice banks' equity).
		For obligations over seven years, 49 percent of marginal reserve requirement.
10-Oct-08		Establishment of repo operations to provide U.S. dollar liquidity. Accept treasury and Central Reserve Bank of Peru bonds with repurchase agreement.
		Maximum amount previously communicated plus allocation to highest interest rate bids.
20-Oct-08		9 percent unique reserve requirement (national currency) for general liabilities.
21-Oct-08		Reduction of marginal reserve requirement from 49 to 35 percent.
24-Oct-08		New option of currency swaps (soles and U.S. dollars).

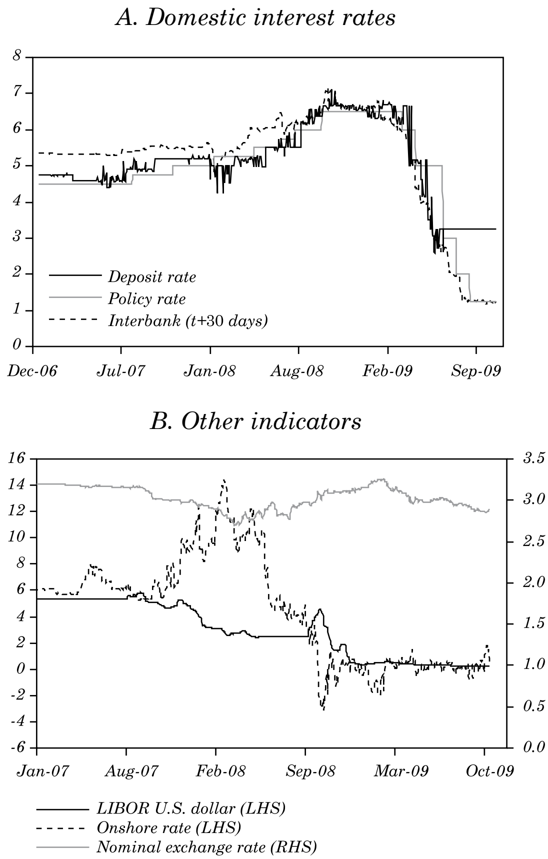
Table 10a. (continued)

1-Oct-08	31-Oct-08	Selling auction of 2.6 billion U.S. dollars to avoid exchange rate volatility.
1-Nov-08	31-Nov-08	Selling auction of 810 million U.S. dollars to avoid exchange rate volatility.
28-Nov-08		Changes to reserve requirements: vindication reserve requirements to 33 percent of liabilities; reduction of reserve requirement for deposits of nonresidents from 120 to 30 percent; reduction of reserve requirement for deposits of nonresidents with investment purposes from 120 to 30 percent; and top mean reserve requirement to short-term foreign loans of 35 percent.
1-Dec-08	31-Dec-08	Selling auction of 289 million U.S. dollars to avoid exchange rate volatility.
30-Dec-08		7.5 percent unique reserve requirement (national currency) for general liabilities.
		Reduction of marginal reserve requirement from 35 to 30 percent.
1-Jan-09	31-Jan-09	Selling auction of 676 million U.S. dollars to avoid exchange rate volatility.
30-Jan-09		6.5 percent unique reserve requirement (national currency) for general liabilities.
1-Feb-09	28-Feb-09	Selling auction of 473 million U.S. dollars to avoid exchange rate volatility.
20-Mar-09		6 percent unique reserve requirement (national currency) for general liabilities.
15-Apr-09		Central bank offers to buy loan portfolios from commercial banks with repurchase agreement.
1-May-09	30-May-09	Selling auction of 77 million U.S. dollars to avoid exchange rate volatility.
24-Jul-09		First currency swap (soles versus U.S. dollars): Central bank sells soles.
14-Aug-09		Currency swap (central bank sells soles).

Source: Authors' compilation from Central Reserve Bank of Peru reports.

The CRBP also implemented repo operations and currency swaps to further ease liquidity in foreign currency. Moreover on 15 April 2009 the CRBP, in a highly unusual policy, offered to buy loan portfolios from commercial banks with a repurchase agreement, thereby moving private sector risk onto the central bank's balance sheet.

Figure 13. Key Money Market Variables in Peru



Sources: Bloomberg and Central Reserve Bank of Peru.

Thus, we identify five dummies for the Peruvian case: (i) liquidity provision through reserve requirement reductions; (ii) direct sales in the foreign exchange spot market; (iii) repo operations in foreign currency; (iv) loan portfolio purchases from commercial banks; and (v) currency swap implementation. Domestic interest rates, as expected, correlated negatively with reserve requirement reductions and the loan portfolio purchase offers, and positively with the VIX index and the policy rate. On the other hand, direct sales of U.S. dollars seem to be positively associated with higher domestic rates, similarly to foreign exchange swaps. Repo operations and currency swaps aimed to enhance foreign currency liquidity tamed foreign exchange interest rates, as expected. Although direct U.S. dollar sales by the central bank do not seem to affect the bilateral exchange rate with the U.S. dollar, the counterfactual scenario would have been one of extensive depreciation of the local currency, as in other economies. Direct interventions specifically aimed to avoid such events. No other policy variable seems to have had a large economic impact on the bilateral exchange rate.

Table 10b. Estimation Results for Peru

	Deposit rate	
Interbank rate	0.719	
	[16.91]***	
Expected rate (t+20)	−0.146	
	[4.23]***	
Log (VIX_t)	0.305	
	[5.75]***	
LIBOR U.S. dollar	−0.082	
	[7.69]***	
Onshore rate	−0.027	
	[5.02]***	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve requirement liquidity	−0.449	0.263
	[3.61]***	[1.02]
Direct sales of U.S. dollars	0.417	0.38
	[8.07]***	[2.14]**
Repo U.S. dollar liquidity	−0.05	−0.317
	[0.51]	[1.25]
Buying offer of loan portfolio	−0.51	1.801
	[5.73]***	[7.20]***
Currency swap	0.488	−0.038
	[5.42]***	[0.15]
Financial stress		
Lehman Brothers	0.16	
	[1.61]	
LIBOR-OIS	0.086	
	[2.19]**	
Constant	1.466	
	[5.45]***	
Observations	680	
R^2	0.93	

Table 10b. (continued)

	Onshore rate	
Deposit rate	−1.837	
	[8.77]***	
LIBOR U.S. dollar	−0.753	
	[10.56]***	
Log (VIX_t)	1.59	
	[4.23]***	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve requirement liquidity	−1.72	0.631
	[1.96]**	[0.34]
Direct sales of U.S. dollars	−0.262	0.152
	[0.69]	[0.12]
Repo U.S. dollar liquidity	−3.277	−0.956
	[4.70]***	[0.52]
Buying offer of loan portfolio	−3.6	4.796
	[6.83]***	[2.58]**
Currency swap	−0.97	0.326
	[1.67]*	[0.18]
Financial stress		
Lehman Brothers	−4.118	
	[6.00]***	
LIBOR-OIS	0.628	
	[2.45]**	
Constant	14.801	
	[9.30]***	
Observations	680	
R^2	0.81	

Table 10b. (continued)

	Nominal exchange rate	
Log (U.S. dollar multilateral exchange rate)	−0.988	
	[22.67]***	
Log (CRB_t)	−0.065	
	[2.91]***	
Log (VIX_t)	0.011	
	[2.90]***	
Non-monetary policy actions	*Implemented*	*Announced*
Reserve requirement liquidity	−0.001	0.011
	[0.12]	[0.59]
Direct sales of U.S. dollars	−0.007	−0.002
	[2.02]**	[0.16]
Repo U.S. dollar liquidity	−0.055	0.034
	[7.94]***	[1.94]*
Buying offer of loan portfolio	−0.01	−0.008
	[2.37]**	[0.49]
Currency swap	0.015	0.008
	[2.59]***	[0.43]
Financial stress		
Lehman Brothers	−0.002	
	[0.35]	
LIBOR-OIS	−0.011	
	[4.48]***	
Constant	6.014	
	[52.50]***	
Observations	680	
R^2	0.86	

Source: Authors' computations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.
a. Period of analysis: January 2007 to October 2009, daily data. Absolute values of *t* statistics in brackets

2.3 Summary of Empirical Results

The previous subsections highlight the diverse experiences in domestic local currency and U.S. dollar markets. In most cases domestic local currency markets experienced some degree of stress in the second half of 2008, with the average spread between 28-day interbank rates and the expected policy rate rising significantly compared to previous levels and becoming considerably more volatile (see table 12a). Notable exceptions to this were Colombia and Mexico. In Mexico, flight from long-term public debt pushed down short-term rates. In Colombia, although there was no evident pressure in money markets, the central bank expanded its mechanisms for domestic liquidity provision, which in turn pushed down short-term interbank rates.

In those countries which experienced rising rates, central banks expanded their offer and the scope of liquidity facilities, seeking to align short-term bank funding rates with policy rates to ensure an effective transmission of monetary policy. Despite the fact that the interbank-swap spread came down in most countries in 2009, the simple regressions presented in the previous section suggest that the statistical effectiveness of these measures was mixed. Table 11 shows a summary of p-values for a joint significance test on the policy dummies (for implementation and announcement alike). In 10 out of 54 country-policy pairs, parameter estimates were statistically different from zero at the 15 percent significance level. However, for 37 out of 54 country-policy pairs the p-value was lower than or equal to 1 percent. This is broadly consistent with the small but growing empirical literature on the effectiveness of unconventional measures for advanced economies. This literature tends to find that domestic liquidity provision programs tend to reduce LIBOR-OIS spreads (see Aït-Sahalia and others, 2009; Artuç and Demiralp, 2010; McAndrews, Sarkar, and Wang, 2008; Deutsche Bank, 2009; and Christensen and others, 2009).

Table 11. P Values for Joint Test on the Efficacy of Non-Monetary Policy Actions

Country		*Deposit rate*	*Onshore rate*	*Exchange rate*
Australia	Implemented	0.47	0.00	0.00
	Announced	0.11	0.00	0.06
Brazil	Implemented	0.72	0.00	0.00
	Announced	0.06	0.00	0.00
Chile	Implemented	0.00	0.00	0.00
	Announced	0.00	0.31	0.24
Colombia	Implemented	0.00	0.00	0.00
	Announced	0.61	0.75	0.12
Indonesia	Implemented	0.00	0.00	0.00
	Announced	0.00	0.40	0.01
Mexico	Implemented	0.00	0.00	0.00
	Announced	0.11	0.00	0.28
New Zealand	Implemented	0.00	0.00	0.00
	Announced	0.00	0.00	0.01
Peru	Implemented	0.00	0.00	0.00
	Announced	0.00	0.00	0.46
South Korea	Implemented	0.00	0.00	0.00
	Announced	0.36	0.00	0.03

Source: Authors' calculations.

Note, however, that with few exceptions, central banks responded to rising market rates by reducing exceptionally high spreads between 28-day and overnight policy rates, but did not abandon the pre-crisis schemes of primarily targeting short-term rates. Indeed, in most cases the liquidity tools traditionally used to target overnight rates were simply enhanced to extend the maturity and eligible collateral of the central bank's operations.[12]

12. For Mexico and Indonesia, we report spreads between the 28-day interbank rate and the overnight policy rate, because data on interest rate swaps are not available.

Table 12a. Swap Spreads in Local Currency and Spread Volatility

	Swap spread in local currency (basis points)						*Spread volatility (std. deviation)*			
	Jan 07– May 07	*Jun 07– Aug 08*	*Sep 08– Dec 08*	*Avg. 2009*	*Max 2008*	*Last Avg.*	*Jan 07– May 07*	*Jun 07– Aug 08*	*Sep 08– Dec 08*	*Avg. 2009*
Australia	2	18	58	30	205	38	19	22	40	33
Brazil	−8	−4	27	−9	110	−15	16	23	60	46
Chile	4	17	22	0	255	22	15	7	21	21
Colombia	−10	−5	−12	−6	5	−3	25	44	26	73
Indonesia	−19	0	180	67	250	19	2	11	26	8
Mexico	3	−3	−39	−19	28	1	6	20	75	17
New Zealand	25	36	93	42	260	47	8	24	19	84
Peru	−65	−49	−8	81	26	201				
South Korea	18	22	61	27	108	40	4	6	37	21

Source: Authors' calculations.

Several central banks in our sample also participated in some form of public debt policy. In the case of Chile, for example, the central bank shifted the maturity of debt issuance to minimize the impact of higher public sector issuance on the yield curve. Implicit in these policies is a belief that the supply of debt could have significant—if transitory—effects on rates, particularly in times of financial distress. The available information indicates that, in most cases, the objective of these measures was to avoid temporary deviations of rates from "fundamentals" that would impact the transmission mechanism rather than complement traditional monetary policy by pushing down long-term rates.

The impact of the crisis on onshore dollar rates is more heterogeneous. Whether rates rose or fell relative to LIBOR depends on both how financial stress affected external financing costs, and events in domestic forward markets. In several cases, including Brazil and Mexico, agents rushed to unwind short U.S. dollar positions, pushing down domestic dollar rates. In others, the risk-adjusted rate rose in line with rising global uncertainty or illiquidity and pushed up onshore rates (see table 12b). In most cases, however, volatility increased over levels observed in the first semester of 2007.

Here, policies aimed to either complement the private supply of dollar credit directly, via swaps or other mechanisms, or to offset the lack of dollar liquidity on the exchange rate. Many of the measures that provided dollar loans seem to have been relatively successful in reducing domestic dollar rates. The effects of direct one-off or programmed sales of U.S. dollars, as discussed in the previous section, were mixed. For instance, direct U.S. dollar sales in the spot market in Peru appreciated the local currency, while in Mexico this same operation was associated with national currency depreciation, possibly due to an intervention that was less aggressive than required. On the other hand, swap lines with foreign central banks do seem to have been widely effective in those countries that implemented them, taming the depreciation of local currencies both during implementation and at the time they were announced.

Table 12b. Swap Spreads in U.S. Dollars and Spread Volatility

	Swap spread in U.S. dollars (basis points)					*Spread volatility (std. deviation)*			
	Jan 07– May 07	*Jun 07– Aug 08*	*Sep 08– Dec 08*	*Avg. 2009*	*Max 2008*	*Jan 07– May 07*	*Jun 07– Aug 08*	*Sep 08– Dec 08*	*Avg. 2009*
Australia	0	14	26	15	318	79	111	444	174
Brazil	101	28	−116	−26	845	11	118	141	149
Chile	−46	81	112	102	458	140	117	128	112
Colombia	−33	−161	62	11	347	119	91	214	134
Indonesia	−22	10	−105	−153	373	21	111	338	129
Mexico	24	51	−249	−49	177	10	19	68	22
New Zealand	2	2	24	32	426	66	321	234	71
Peru	93	381	−171	−24	1154	0	0	0	0
South Korea	−13	125	513	157	1270	8	32	237	45

Source: Authors' calculations based on data from Bloomberg and national central banks (see table A1 for details).

In general, the period after the Lehman Brothers collapse saw a significant increase in onshore U.S. dollar interest rates. This effect occurred over and above the sensitivity to other risk and volatility measures, such as LIBOR-OIS spreads and the VIX index, and the actual movement of the U.S. dollar LIBOR itself. Local interest rates also reacted to global financial turmoil, although the degree of heterogeneity between economies seems to be larger in this case. Worldwide, local exchange rates followed the gyrations of the U.S. dollar and of commodity prices.

3. Conclusions

Events surrounding the financial crisis and the Great Recession of 2008–09 have required significant policy measures by central banks. Has the inflation targeting framework been flexible enough to accommodate these responses? Or has IT restricted their room of maneuver? In this paper we tackle this question by assessing the policy responses to the crisis of a selection of nine central banks that follow inflation-targeting frameworks and that remained financially stable, in the sense of not facing systemic problems in their banking or financial systems. We find that from the second half of 2008 on, monetary policy responses deviated substantially in all cases from the prescriptions of standard simple reaction functions, a finding that we have reconciled in all cases with a drop in the persistence of monetary policy. We show that neither inflation nor output deviations (actual or expected), were plausibly large enough to account for such severe and swift deviations from past policy actions. We have also constructed a timeline history for the nine economies in our sample, documenting non-monetary policy measures and estimated their impact on local money markets—both in local currency and U.S. dollars—and the exchange rate. We find that although there is a significant heterogeneity in the specific characteristics of non-monetary policy measures and their eventual effectiveness, they were broadly successful in limiting and reducing money market and foreign exchange rate market tensions. The heterogeneity of these types of measures across different IT central banks, along with the general preservation of price stability in the selected economies, suggests that IT frameworks have been flexible enough to accommodate unconventional central bank policies.

Appendix

Supplementary Figures and Tables

Table A1. Variable Definitions

Country and variable	*Bloomberg ticker*	*Description*
Australia		
Interbank rate	AU0001M	LIBOR Australian dollar one-month. British Bankers Association fixing for Australia dollar.
Monetary policy rate	RBATCTR	Reserve Bank of Australia cash rate.
Swap rate	ADSOA Curncy	Australian dollar swap OIS one-month.
Nominal exchange rate	AUD Curncy	Spot exchange rate expressed as U.S. dollars per Australian dollar.
Forward contract	AUD1M Curncy**	One-month forward points.
	AUD3M Curncy**	Three-month forward points.
	AUD12M Curncy**	Twelve-month forward points.
Interest rate	ADBB1M Index	Bank bill one-month. Day count: ACT/365.
	ADBB3M Index	Bank bill three-month. Day count: ACT/365.
	ADSWAP1Q Index	Interest rate swap quarterly one-year. Quote: quarterly one to three year use quarterly settlement versus three-month bank bill. Day count: ACT/365.
Brazil		
Swap rate	BCSWAPD Curncy	Real swap Pre-DO one-month. Pre is the fixed rate and DI is the floating rate. Di is the Brazilian interbank deposit average rate.
Interbank rate	BCCDIO Curncy	Brazilian interbank lending rate with no government bonds as collateral.
Deposit rate	BCCDBAE Index	Brazilian retail certificate of deposit quoted as an effective annualized rate (30-day rate).
Monetary policy rate	BZSTSETA Index	Brazilian SELIC target rate.
Nominal exchange rate	BRL Curncy	Spot exchange rate expressed as Brazilian reals per U.S. dollar.
Forward contract	BCN1M Curncy***	One-month NDF points.
	BCN3M Curncy***	Three-month NDF points.
	BCN12M Curncy***	Twelve-month NDF points.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Interest rate	OD1 Comdty	Generic one-day interbank deposit futures contract. Underlying asset: the interest rate of interbank deposits, defined as the capitalized daily average of one-day rates based on the period from the transaction date to the last trade day. Price quotations expressed as a percentage rate per annum compounded daily based on a 252-day year. Day count: DU/252.
	OD2 Comdty	Generic two-day 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD3 Comdty	Generic three-day 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD4 Comdty	Generic 4th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD7 Comdty	Generic 7th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD8 Comdty	Generic 8th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD9 Comdty	Generic 9th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD10 Comdty	Generic 10th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD11 Comdty	Generic 11th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD12 Comdty	Generic 12th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD13 Comdty	Generic 13th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD14 Comdty	Generic 14th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.
	OD15 Comdty	Generic 15th 'OD' future. One-day interbank deposit futures contract. Day count: DU/252.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Chile		
Deposit rate		30/90-day banking system average deposit rate.
Swap rate		Swap average camara.
Monetary policy rate		Overnight interbank rate.
Nominal exchange rate	CLP Curncy	Spot exchange rate expressed in Chilean pesos per U.S. dollar.
Forward contract	CHN1M Curncy***	One-month NDF points.
	CHN3M Curncy***	Three-month NDF points.
	CHN12M Curncy***	Twelve-month NDF points.
Interest rate	CLTN30DS Curncy	Nominal average interbank rate 30 days, provided by *Asociación Nacional de Bancos*, observed amongst the local financial institutions. Nominal rates are ACC/30-days and without considering inflation.
	CHSWPC Index	Interest rate swap peso versus camara three-month. Quote: semi-annual settlement & compounding versus camara. Day count: ACT/360.
	CHSWP1 Index	Interest rate swap peso versus camara one year. Quote: semi-annual settlement & compounding versus camara. Day count: ACT/360.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Colombia		
Interbank rate		90-day interbank rate.
Swap rate	CLSWA Curncy	Colombian peso one-month swap.
Deposit rate	CLDRA Curncy	Colombian peso one-month deposit.
Monetary policy rate	CORRRMIN Index	Colombia minimum repo rate.
Nominal exchange rate	COP Curncy	Spot exchange rate expressed as Colombian pesos per U.S. dollar.
Forward contract	CLN1M Curncy***	One-month NDF points.
	CLN3M Curncy***	Three-month NDF points.
	CLN12M Curncy***	Twelve-month NDF points.
Interest rate	DTF RATE Index	DTF 90-day interest rate. This index is released on a weekly basis. It is a weighted average of all financial institutions' deposit rates, calculated by the central bank. This is an annual effective rate.
	COMM1YR Index	Time deposits of banks yield curve one year. Rates are also known as TBS (*Tasa Básica de la Superintendencia Bancaria*). Refers to a 360 day period.
Indonesia		
Interbank rate	JIIN1M Index	Jakarta interbank one-month rate.
Monetary policy rate	IDBIRATE Index	Official overnight rate.
Swap rate	IHSWOOA Curncy	Indonesian rupiah one-month onshore swap.
Deposit rate	IDRE1MO Index	Indonesian rupiah one-month deposit rate (average of 131 banks).
Nominal exchange rate	IDR Curncy	Spot exchange rate expressed as Indonesian rupiahs per U.S. dollar.
Forward contract	IHO1M Curncy*	One-month onshore forward points.
	IHO3M Curncy*	Three-month onshore forward points.
	IHO12M Curncy*	Twelve-month onshore forward points.
Interest rate	IHDRA Index	Deposit three-month. Day count: ACT/360.
	IHDRC Index	Deposit one-month. Day count: ACT/360.
	IDRE12MO Index	Indonesia deposit rate average twelve month. Day count: ACT/360.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
Mexico		
Monetary policy rate	MXONBR Index	Official overnight rate.
Interbank rate	MPTBA Curncy	Mexico interbank offered rate (MEXIBOR).
Nominal exchange rate	MXN Curncy	Spot exchange rate expressed as Mexican pesos per U.S. dollar.
Forward contract	MXN1M Curncy**	One-month forward points.
	MXN3M Curncy**	Three-month forward points.
	MXN12M Curncy**	Twelve-month forward points.
Interest rate	MXIBTIIE Index	Benchmark interbank deposit rates TIIE 28 day. The TIIE is an interbank interest rate which is decided by the supply and demand of funds. Calculated by bids provided by Mexican banks, this is the rate which is set when supply and demand reach equilibrium.
	MPSWC Index	Mexican peso-denominated interest rate swaps (TIIE) three-month. Day count: 28/360
	MPSW1A Index	Mexican peso-denominated interest rate swaps (TIIE) thirteen-month. Day count: 28/360
New Zealand		
Interbank rate	NZ001M Index	London interbank offered rate – BBA fixing for New Zealand dollar.
Monetary policy rate	NZOCRS Index	Reserve Bank of New Zealand official cash rate.
Swap rate	NDSOA Curncy	New Zealand swap OIS one-month.
Nominal exchange rate	NZD Curncy	Spot exchange rate expressed as U.S. dollars per New Zealand dollar.
Forward contract	NZD1M Curncy**	One-month forward points.
	NZD3M Curncy**	Three-month forward points.
	NZD12M Curncy**	Twelve-month forward points.
Interest rate	NDBB1M Index	Bank bill one month. Day count: ACT/365.
	NDBB3M Index	Bank bill three month. Day count: ACT/365.
	NDBB12M Index	Bank bill twelve month. Day count: ACT/365.

Table A1. (continued)

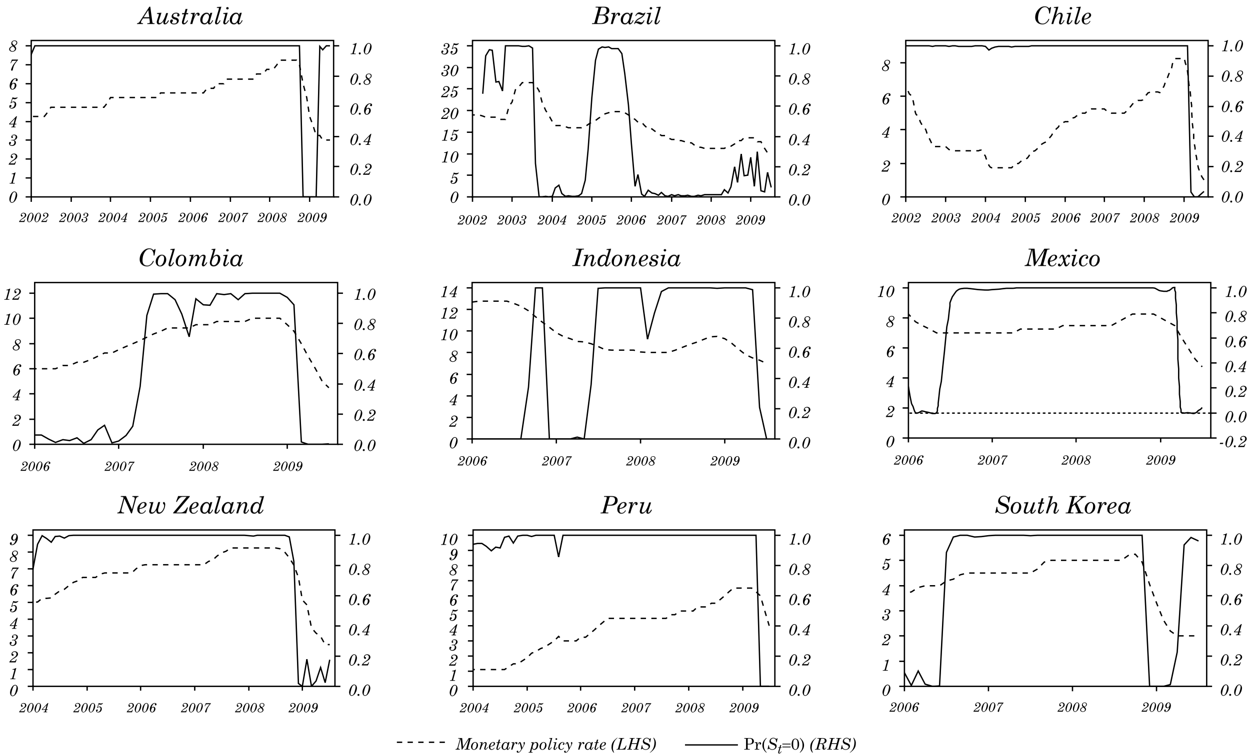
Country and variable	*Bloomberg ticker*	*Description*
Peru		
Deposit rate	PSDRA Curncy	Peruvian one-month deposit.
Interbank rate	PEOPRBI Index	Peru reference interest rate: Lima interbank offered rate (LIMABOR) in local currency.
Monetary policy rate	PRRRONUS Index	Official overnight rate.
Nominal exchange rate	PEN Curncy	Spot exchange rate expressed in nuevos soles per U.S. dollar.
Forward contract	PSN1M Curncy***	One-month NDF points.
	PSN3M Curncy***	Three-month NDF points.
	PSN12M Curncy***	Twelve-month NDF points.
Interest rate	PRBOPRBI Index	Asbanc one-month nominal rate. Reference LIMABOR interest rates in local currency (PES), is the interbank rate to which any bank is available to buy or sell. Day count: ACT/360.
	PRBOPRB3 Index	Asbanc three-month nominal rate. Reference LIMABOR interest rates in local currency (PES), is the interbank rate to which any bank is available to buy or sell. Day count: ACT/360.
	PRBOPRB1 Index	Asbanc one-year nominal rate. Reference LIMABOR interest rates in local currency (PES), is the interbank rate to which any bank is available to buy or sell. Day count: ACT/360.

Table A1. (continued)

Country and variable	*Bloomberg ticker*	*Description*
South Korea		
Deposit rate	KWCDC Curncy	Korean won certificate of deposit (CD) three-month currency.
Interbank rate	KRBO1M Index	South Korea KFB (KORIBOR) KRW one-month index.
Monetary policy rate	KOCRD Index	Official overnight rate.
Nominal exchange rate	KRW Curncy	Spot exchange rate expressed in Korean won per U.S. dollar.
Forward contract	KWO1M Curncy*	One-month onshore forward points.
	KWO3M Curncy*	Three-month onshore forward points.
	KWO12M Curncy*	Twelve-month onshore forward points.
Interest rate	KRBO1M Index	Korea interbank offered rate (KORIBOR) one-month. Is the average of lending interest rates in the interbank market.
	KWCDC Index	CD three-month. Is a debt instrument issued by a bank that will pay principal and interest when it reaches maturity. Settlement for Korean won-denominated CDs is T+0.
	KWSWO1 Index	Interest rate wwap onshore one-year. Quote: quarterly fixed rate versus 91-day Korean won CD. Day count: ACT/365.

Source: Authors' compilation from national central bank reports.

Figure A1. Two-State Markov Switching Estimation of Taylor Rules: High versus Low Persistence



Source: Authors' calculations.

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Fiscal Deficits, Debt, and Monetary Policy in a Liquidity Trap

Michael B. Devereux
University of British Columbia

The dramatic policy response to the 2008–09 global economic crisis from many countries has revived some old debates about the use of fiscal and monetary policy in fighting recessions. The central dilemma for policy-makers in Japan, North America, and Europe has been to try to counter a large recession brought on by an unprecedented fall in private consumption and investment spending, despite being constrained by their inability to lower nominal interest rates below their current near-zero level. The end result was an ad hoc series of fiscal and monetary measures: deficit-financed government spending increases, tax cuts, and unconventional monetary policy measures such as open market purchases on long-dated securities, direct increases in the monetary base, and so on. Coming under the catch-all term of "stimulus-packages," the design of these policies was not based on theoretical frameworks or quantitative macroeconomic models of the kind explored within central banks over the past decade, but rather arose from "back-of-the-envelope" style arguments about the size of fiscal multipliers and the impact of liquidity injections on credit flows.

At the same time, economists have vigorously debated whether fiscal and monetary stimulus are useful at all.[1] One fact that has perhaps been less well recognized is that the central dilemma

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1. See, for instance, Krugman (2009) and the response by Cochrane (2009).

Monetary Policy under Financial Turbulence, edited by Luis Felipe Céspedes, Roberto Chang, and Diego Saravia, Santiago, Chile.

regarding economic policy options in a liquidity trap has been extensively studied within the recent vintage of New Keynesian dynamic stochastic general equilibrium (DSGE) models, in light of Japan's experience in the 1990s. Krugman (1998), Eggertsson and Woodford (2003, 2004), Jung, Teranishi, and Watanabe (2005), Auerbach and Obstfeld (2005), and many other writers explored how to usefully employ monetary and fiscal policy, even when authorities have no further room to reduce short-term nominal interest rates. Recently, a number of authors have revived this literature, given very similar problems now affecting the economies of Western Europe and North America. Papers by Christiano, Eichenbaum, and Rebelo (2009), Eggertsson (2009), and Cogan and others (2010) have explored the possibility of expanding government spending, applying tax cuts, and using monetary policy when the economy is in a liquidity trap.

A key aspect fiscal and monetary policy effects in a liquidity trap that seems to have remained relatively unexplored to date is the role that government deficits and debt issue play, as part of a stimulus package. On the one hand, there has been overwhelming agreement among policy practitioners that to be useful, fiscal stimulus must be financed with debt, rather than compensating tax increases, and also that part of the stimulus could be based on tax cuts rather than spending increases. But in most of the existing classes of New Keynesian DSGE models that examine fiscal and monetary policies in a liquidity trap, the distinction between tax-financed and debt-financed fiscal stimulus is irrelevant (as are tax cuts that leave the present taxation values unchanged), because these models are characterized by Ricardian equivalence, with infinitely lived consumers and infinite planning horizons.

To offer a serious analysis of the role of fiscal stimulus in a liquidity trap, then, it would seem necessary to depart from the benchmark assumption of the infinitely lived Ramsey consumer. This paper takes a first step in this direction. Following several recent papers (such as Annicchiarico, Giammarioli, and Piergallini, 2009), we amend the basic New Keynesian sticky price model of Woodford (2003) and Clarida, Galí, and Gertler (1999), by incorporating finite planning horizons in the manner of Blanchard (1985) and Yaari (1965). This means that debt-financed government spending has different effects than that financed by tax increases; that government debt itself has wealth effects for currently-alive households; that pure lump-sum tax cuts may be expansionary; and moreover, that monetary policy aimed at increasing the outstanding stock of monetary aggregates may have direct real balance effects, independently of its effect (or non-effect) on nominal interest rates.

We explore the impacts of fiscal and monetary policy in this model, contrasting the results with the recent literature on policy in a liquidity trap. We focus on a scenario where a large increase in households' desire to save pushes down the economy's underlying real interest rate and, in an economy with sticky prices, causes a fall in aggregate demand, output, and inflation.

To briefly summarize central results: we find that in an environment where monetary policy rules work "normally"—adjusting interest rates in response to inflation and output gaps—the introduction of finite planning horizons has little to offer in terms of analyzing the impacts of fiscal policy and monetary policy shocks. When the model is calibrated to introduce empirically realistic planning horizons, there is little quantitative impact of the deviation from Ricardian equivalence. In our benchmark model, for instance, the balanced budget government spending multiplier is unity, and the multiplier implied by purely deficit-financed government spending is only slightly larger.

By contrast, when policy is constrained by a liquidity trap, there may be a dramatic difference between the economy's response with an effectively infinite planning horizon and that with a finite horizon. Likewise, the impact of deficit-financing within fiscal policies may be much greater than tax-financed policies. In our benchmark model, the balanced-budget government spending multiplier is also unity, even in a liquidity trap. But the multiplier for a deficit-financed government spending expansion is over 2. Intuitively, the model predicts that in a liquidity trap, government debt issue has substantial wealth effects, which stimulate aggregate demand and private consumption, playing an expansionary macroeconomic role, beyond the direct effects of government spending.

Another perspective is as follows. In an economy with Ricardian equivalence and no capital, a large increase in the desire to save cannot be satisfied in equilibrium. In a flexible price world, we would simply see a fall in real interest rates. In a liquidity trap, where prices are sticky, the adjustment has to take place through a large fall in current output and consumption (see Christiano, Eichenbaum, and Rebelo, 2009 for an explication of this argument). But in a world with finite horizon consumers, government debt issue in effect provides a vehicle for saving, on the part of the private sector. This satisfies part of the increase in their desire to save, and as a result, limits the degree to which aggregate demand and consumption has to fall. Indeed, our results suggest that during a liquidity trap, this macroeconomic role played by government-issued debt can contribute significantly within a fiscal stimulus package.

We also show that the role of government debt issue is essentially equivalent, in our model, to the real balance effect in monetary expansion. As a corollary then, the model implies that this real balance effect may be negligible in normal times, but plays a non-trivial role during a liquidity trap. Again, however, a key requirement for it to work is that Ricardian equivalence fails.

The paper is organized as follows. The next section briefly discusses the nature of fiscal and monetary policy responses to the recent crisis, followed by a section that develops the basic model used throughout this paper. Section 3 discusses the nature of the steady state in the model. Sections 4 and 5 outline the impact of government spending, tax, and debt shocks in the model when the economy is both outside and within a liquidity trap, both qualitatively and quantitatively.

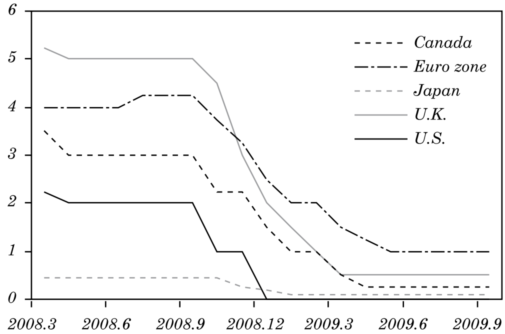
1. Fiscal and Monetary Responses to the Crisis

1.1 The Limits to Monetary Policy

Following the collapse in economic activity across global economies in late 2008, monetary authorities in virtually all countries dramatically reduced interest rates. But by mid-2009, for most central banks, policy rates were close to their minimum feasible levels. Figure 1 describes the path of policy rates from mid-2008 in five major economies. The United States, the United Kingdom, Canada, and the European Central Bank (ECB) all reduced rates in September 2008. By the end of the year, the U.S. Federal Funds rate was near zero. By mid-2009, the other three economies had rates at or below 1 percent. Japan of course, already had a policy rate below 1 percent, but reduced it further in early 2009.

Reaching the limit of monetary policy traction through the interest rate channel, central banks engaged in a range of unconventional monetary policy strategies. The U.S. Federal Reserve for instance, promising to "employ all available tools to promote economic recovery and to preserve price stability," began in late 2008 to widen the range of counterparties it would lend to, and accept a broader range of collateral, based on the assumption that the normal links between interest rates and credit expansion were failing to operate during

Figure 1. Monetary Policy Rates since 2008



Sources: National central banks.

the crisis. Later, the Federal Reserve directly intervened in long-term securities markets, and by mid-2009 had more than doubled the size of its balance sheet (Rudebusch, 2009). Similarly, in March 2009, the Bank of England began a policy of "quantitative easing", involving the purchase of various government and corporate bonds.[2] The ECB has taken a range of similar measures.

There is considerable skepticism about the effectiveness of this unconventional monetary policy, however. Evidence from Japan in the late 1990s provides little support for the idea that increasing available liquidity can stimulate credit flows to consumers and firms and thereby stimulate activity, holding the interest rate constant. Similarly, recent studies in the United States suggest that, to be effective, quantitative easing would have to be much larger than even the recent Federal Reserve balance sheet expansions (Krugman, 2009).

A final channel of monetary policy is communications and the targeting of expectations. Even if interest rates remain at zero for some time, the monetary authority can influence current conditions by announcing its intention to maintain low interest rates even after the recovery is underway. By doing so, the authority influences the private sector's current spending decisions, to the extent that these are based on the projected path of interest rates into the future. Over the past year, this tool has played a key role in central bank communications strategies everywhere.

2. See Céspedes, Chang, and García-Cicco (in this volume) for a discussion of a range of heterodox central bank policies.

1.2 Fiscal Stimulus Policies

Since monetary policy has essentially reached the limit of its effectiveness, virtually all governments, in both advanced and emerging market economies, applied fiscal stimulus packages. Following the G-20 meetings in late 2008, in conjunction with IMF policy recommendations, a rough consensus emerged that fiscal stimulus should equal 2 percent of GDP. There was no direct prescription for distributing this in terms of direct spending and tax cuts, however. Table 1 shows the composition of G-20 economy stimulus packages. Expressed in terms of per capita GDP, after Saudi Arabia, China and the United States provided the largest fiscal stimulus, at 5 and 6 percent of GDP, respectively. But the

Table 1. Stimulus Spending

	2009 stimulus		*Total stimulus*	
Country	*Percent of 2008 GDP*	*Tax cut*	*Percent of 2008 GDP*	*Tax cut*
Argentina	1.3	0	1.3	0
Australia	0.8	47.9	1.8	41.2
Brazil	0.3	100	0.5	100
Canada	1.5	40.4	2.8	45.4
China	2.1	0	4.8	0
France	0.7	6.5	0.7	6.5
Germany	1.5	68	3.4	68
India	0.5	0	0.5	0
Indonesia	1.3	79	2.5	79
Italy	0.2	0	0.3	0
Japan	1.4	30	2.2	30
Mexico	1	0	1	0
Russia	1.7	100	1.7	100
Saudi Arabia	3.3	0	9.4	0
South Africa	1.3	0	2.6	0
South Korea	1.4	17	2.7	17
Spain	1.1	36.7	4.5	36.7
Turkey	0	n.a.	0	n.a.
United Kingdom	1.4	73	1.5	73
United States	1.9	44	5.9	34.8

Source: Prasad and Sorkin (2009).
n.a.: Not available.

composition of these packages varied enormously, with China's stimulus plan having no tax cut component at all, while in the United States about a third of the overall stimulus took the form of tax cuts. Britain's plan consisted mostly of tax cuts, while Russia's and Brazil's contained only tax cuts.

Even without tax cuts, large increases in public sector deficits have financed all stimulus plans. Table 2 illustrates pre-crisis and post-crisis (projected) fiscal balances for G-20 countries. The fiscal positions of many of these advanced economies were already weak in 2007, but over the past year, deficits dramatically increased in most, and are projected to remain well above pre-crisis trends until at least 2014. Emerging economies were generally in a much better fiscal position before the crisis, but most have also seen their fiscal deficits rise significantly.

Table 2. Overall Fiscal Balance as a Percentage of GDP

Country	*2007*	*2009*	*2010*	*2014*
Argentina	−2.1	−3.9	−2.4	−1.7
Australia	1.5	−4.3	−5.3	−1.1
Brazil	−2.8	−3.8	−1.2	−1.0
Canada	1.6	−4.9	−4.1	0.0
China	0.9	−3.9	−3.9	−0.8
France	−2.7	−8.3	−8.6	−5.2
Germany	−0.5	−4.2	−4.2	0.0
India	−1.2	−10.4	−10.0	−0.8
Indonesia	−1.2	−2.6	−2.1	−1.3
Italy	−1.5	−5.6	−5.6	−5.3
Japan	−2.5	−10.5	−10.2	−8.0
Mexico	−1.4	−4.9	−3.7	−3.1
Russia	6.81	−3.6	−3.2	2.2
Saudi Arabia	15.7	5.0	10	14.5
South Africa	1.2	−4.4	−4.7	−2.5
South Korea	3.5	−2.8	−2.7	2.6
Turkey	−2.1	−7.0	−4.3	−4.8
United Kingdom	−2.6	−11.6	−13.2	−6.8
United States	−2.8	−12.5	−10	−6.7

Source: IMF (2009).

While there is significant consensus on the need for fiscal stimulus, the magnitude of this increase in public sector debt, especially among the advanced economies, has raised considerable concerns (IMF, 2009). Table 3 gives the projections for public sector debt for G-20 countries. Higher debt may potentially raise long-term real interest rates, crowding out investment spending and growth, and also potentially raises the prospect of higher inflation rates in the future.

In the analysis below, we only discuss a short-term model, abstracting from the long-run costs of fiscal deficits. The key aim of this paper is to show how deficits may have dramatically different effects in the short run, regardless of whether the economy is in a liquidity trap or not. While we do not dismiss the dangers of increasing public sector debt, at least for the larger economies, these dangers lie more in the future than the present. For now, the path of both long-term interest rates and inflationary expectations in most advanced economies suggest little concern about unsustainable debt levels or high future inflation.

2. The Model of Overlapping Generations

2.1 Demographics and Households

We employ a very standard Blanchard (1985) and Yaari (1965) model of uncertain lifetimes, in an overlapping generation economy. Time is discrete. At any date, a cohort of measure $1 - \gamma$ households is born, where $0 \leq \gamma \leq 1$. An individual household dies with probability $1 - \gamma$ in each period, independent of age, so that γ is the probability of survival from one period to the next. Thus, the total population at any time t is $\Sigma_{s=-\infty}^{t}(1 - \gamma)\gamma^{t-s} = 1$. As in Blanchard's model, we assume a full annuities market, whereby savers get a premium on lending to cover their unintended bequests, and borrowers pay a premium to cover their posthumous debts. Let the utility of a cohort born at date v, evaluated from date 0, be defined as:

$$E_0 \sum_{t=0}^{\infty} (\beta\gamma)^t \left[\log C_{t,v} - v(H_{t,v}) + g(G_t)\right]. \tag{1}$$

Here we define $C_{t,v}$ as the consumption in time t of cohort v, while $H_{t,v}$ is labor supply. Assume that $v'(H_{t,v}) > 0$, $v''(H_{t,v}) \geq 0$. Households supply labor in all periods of life, but real wages decline over an agent's lifetime, as suggested by Blanchard and Fischer (1989). We assume that the composite consumption good represented by $C_{t,v}$ is differentiated across a continuum of individual goods, so that

$$C_{t,v} = \left[\int_{i=0}^{1} C_{t,v}(i)^{1-\frac{1}{\theta}} di \right]^{\frac{1}{1-\frac{1}{\theta}}},$$

where θ is the elasticity of substitution across individual brands. Households also derive utility from aggregate government spending, denoted by G_t. Government spending is taken as given by each household, and utility from government spending is separable from utility of consumption $C_{t,v}$. We assume that $g'(.) > 0$, $g''(.) < 0$.

We focus on a model without capital, to make the comparison with the standard neo-Keynesian DSGE model as clear as possible. Households have only one form of "outside" savings instrument, government bonds. The budget constraint in time t for an agent born in time $v \leq t$ is

$$P_t C_{t,v} + B_{t+1,v} = P_t w_{t,v} H_{t,v} + \Pi_{t,v} - T_{t,v} + \frac{(1+i_t)}{\gamma} B_{t,v}, \tag{2}$$

where $B_{t+1,v}$ represents the nominal bond holdings of cohort v, and $T_{t,v}$ represents their net tax liability to the government.

$$P_t = \left[\int_{i=0}^{1} P_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}$$

is the consumer price index. Real wages in terms of the composite consumption good are denoted $w_{t,v}$, and are cohort specific, as described below. Profits from firms are represented by $\prod_{t,v}$. The presence of full annuity markets implies that rates of return are grossed up to cover the probability of death. To see this, note that in *aggregate*, savers will receive a return of $\gamma \cdot (1+i_t) / \gamma + (1-\gamma) \cdot 0 = (1+i_t)$ on their bond holdings.

Maximizing utility subject to these two constraints gives the conditions:

$$\frac{1}{C_{t,v}} = E_t \frac{\beta\gamma}{C_{t+1,v}} \frac{(1+i_{t+1})P_t}{\gamma P_{t+1}}, \tag{3}$$

$$v'(H_{t,v}) = \frac{w_{t,v}}{C_{t,v}}. \tag{4}$$

Conditions (3)−(4) characterize optimal consumption and labor supply. In addition, the household must choose individual brands to minimize expenditure conditional on a given composite consumption. The familiar condition for the optimal brand choice is given by:

$$C_{t,v}(i) = \left[\frac{P_t(i)}{P(i)}\right]^{-\theta} C_{t,v}.$$

The Euler equation, in conjunction with the household budget constraint, can be represented in the certainty equivalent representation:[3]

$$C_{t,v} = (1-\beta\gamma)\left[\frac{(1+r_t)}{\gamma} b_{t,v} + E_t \sum_{i=0}^{\infty} \alpha_i (w_{t+i,v} H_{t+i,v} + \Pi_{t+i,v} + t_{t+i,v})\right], \tag{5}$$

where $1+r_t = \frac{(1+i_t)P_t}{P_{t+1}}$, $t_{t,v} = \frac{T_{t,v}}{P_t}$, $b_{t,v} = \frac{B_{t,v}}{P_{t-1}}$, and $\alpha_t = \prod_{s=t}(1+r_s)^{-1}\gamma^{s-t}$.

To re-write equation (5) in the form of a dynamic equation in aggregate consumption, it is necessary to be more specific about the way in which wage income evolves over time. Assume that $w_{t,v} = a_{t,v} w_t$ and $a_{t,v} = \bar{a}\phi a_{t-1,v}$ where w_t is the economy-wide average wage, $\bar{a}$ is a constant normalization, and $0 \leq \phi \leq 1$.[4] Thus, relative to the economy-wide average, the wage of each cohort declines over time. This captures, in a crude way, the declining human capital income profile associated with retirement, while still maintaining the ability to aggregate across cohorts, central to the Blanchard-Yaari model. In the description of technology below, we will tie this wage differential to effective labor productivity differences across time. In addition, to

3. This representation ignores complications due to Jensen's inequality, and it is presented simply to give a heuristic account of the aggregation process. The analysis of the model is done by first-order approximation, however, and the solution of the aggregate model is exact at this order. Thus, the error has no consequences for the results below.

4. $\bar{a}$ is chosen so that when the cohort-specific wage is averaged across all currently alive cohorts, it equals the economy wide average wage. This requires that $\bar{a} = \frac{(1-\gamma\phi)}{1-\gamma}$.

allow for easy aggregation to an economy-wide consumption function, we assume that cohort-specific profits and taxes obey the same properties as wage income.

2.2 Aggregation

To represent economy-wide outcomes, we need to aggregate across cohorts. One immediate aggregation difficulty arises from equation (4). Because (i) households have different consumption levels, and (ii) each cohort has a different value for labor productivity in production of final goods, it will not be possible to aggregate equation (4) across generations in general. To proceed, we then make the following specific functional form assumption:

$$v(H_{t,v}) = \eta H_{t,v}. \tag{6}$$

Thus, we assume that the disutility of work is linear in hours worked. In this case, we can aggregate equation (4) directly across all currently alive cohorts. This restricts the analysis somewhat, but provides a simple prediction for the impacts of monetary and fiscal policy shocks when nominal interest rates are positive, and when full Ricardian equivalence holds. The key question we address is how allowing for both of these features (zero-interest rates and non-Ricardian equivalence) to be relaxed together influences policy effects.

The assumption (6) allows us to write the aggregate labor supply condition as:

$$\eta C_t = w_t. \tag{7}$$

The consumption expression (5) may be aggregated across cohorts to give:

$$C_t = (1-\beta\gamma)\left[(1+r_t)B_t + E_t\sum_{i=0}^{\infty}\tilde{\delta}_i(w_{t+i}H_{t+i} + \Pi_{t+i} - t_{t+i})\right], \tag{8}$$

where now $\tilde{\delta}_i = \prod_{s=t}(1+r_s)^{-1}(\gamma\phi)^{s-t}$.

In aggregate, the budget constraint for all households is:

$$B_{t+1} = (1+r_t)B_t + w_tH_t + \Pi_t - t_t - C_t. \tag{9}$$

Note that in the aggregate there is no γ term in the flow budget constraint, since the risk premium only represents a transfer from one generation to another.

Then, manipulating equations (8) and (9), we can write the aggregate Euler equation as:

$$C_{t+1} = \frac{\beta(1+r_{t+1})}{\phi} C_t - \frac{(1-\gamma\phi)(1+r_{t+1})(1-\beta\gamma)b_{t+1}}{\gamma\phi}. \tag{10}$$

In contrast to the standard Ramsey model, in this model, the growth in aggregate consumption depends on both interest rates and aggregate wealth. When $\phi\gamma < 1$ and aggregate wealth is positive, aggregate consumption growth is lower than in the Ramsey model, because the average household is actually less patient. Equivalently, a rise in the value of government debt generates a wealth effect, which reduces desired aggregate savings.

2.3 Firms

Retail goods firms hire labor and capital to produce their individual brands, using the production function:

$$Y_t(i) = A_t H_t(i)^{1-\alpha}, \tag{11}$$

where $H_t(i) = \int_{j=0}^{1} \sum_{s=t}^{-\infty} a_{t,s} H_t(i,s,j)$ is firm i's composite employment. The expression $H_t(i,s,j)$ represents the employment by firm i of household j in cohort s. Each household in a given cohort s has an identical effective labor productivity $a_{t,s}$, captured by the process described above. The idea is that labor of different vintages has different efficiencies, and since $\phi < 1$, labor income per unit of effort tends to decline over time, for each cohort. This is an important feature of the model, since it gives each generation a downward sloping income profile over their planning horizon. In fact, it allows for a greater desire to save on the part of each cohort, and moves the model closer to the standard overlapping generations (OLG) model, with working and retirement phases of life.

We abstract from capital accumulation, but allow for the presence of a fixed factor of production, so that $0 \leq \alpha \leq 1$. Finally, A_t is a productivity term, common to all firms.

Retail firms are monopolistically competitive, and face an elasticity of demand given by $\theta > 1$ in each period. Firms adjust their prices according to the usual Calvo assumption of a constant probability of price change, $1 - \kappa$, however, the previous price changed long ago. When firms adjust their prices, they maximize discounted expected profits, where per-period profits for each firm i are $\prod_t(i) = P_t(i)Y_t(i) - W_t H_t(i)$. Thus, firm i's expected discounted profit is written as:

$$V_t(i) = E_t \sum_{j=0}^{\infty} \delta_{t+j} \kappa^j \left\{ P_{t+j}(i) Y_{t+j}(i) - W_{t+j}(i) \left[\frac{Y_{t+j}(i)}{A_{t+j}} \right]^{\frac{1}{1-\alpha}} \right\},$$

where $W_t = w_t P_t$ is the aggregate nominal wage, and the firm's demand function is $Y_t(i) = \left[P_t(i) / P_t \right]^{-\theta} C_t$. The profit maximizing price for firm i, setting its price at time t is then

$$\tilde{P}_t(i) = \frac{E_t \sum_{j=0}^{\infty} \frac{\theta}{(\theta - 1)(1 - \alpha)} \delta_{t+j} \kappa^j W_{t+j}(i) \left[\frac{Y_{t+j}(i)}{A_{t+j}} \right]^{\frac{1}{1-\alpha}}}{E_t \sum_{j=0}^{\infty} \delta_{t+j} \kappa^j Y_{t+j}(i)}. \tag{12}$$

Each newly price setting firm sets the same price. Then, using the law of large numbers, the price index becomes

$$P_t = [(1 - \kappa) \tilde{P}_t^{1-\theta} + \kappa P_{t-1}^{1-\theta}]^{\frac{1}{1-\theta}}.$$

2.4 Fiscal Authority

The fiscal authority has expenditure commitments arising from net transfers to households and direct government spending. For now, we do not separately consider nominal money balances in the model, so there is no direct measure of seigniorage revenues. Thus, the fiscal authority obtains revenue simply from net tax receipts T_t and nominal debt issue. The government budget constraint is given by:

$$P_t G_t - T_t = B_{t+1} - (1 + i_t) B_t. \tag{13}$$

We allow for a number of possible configurations of fiscal policy rules. One such rule is to take the path of government spending as exogenously given to the fiscal authority, and adjust the net transfer to achieve a given target for the debt-to-GDP ratio. Alternatively, net transfers could be adjusted to balance the government's budget in every period, maintaining a constant path of (real or nominal) government debt.

2.5 Monetary Policy

Assume that the monetary authority follows an interest rate rule, given by:

$$i_t^R = (1+\rho_t)(1+\hat{\pi})\left(\frac{P_t}{P_{t-1}}\frac{1}{1+\hat{\pi}}\right)^{\sigma_\pi}\left(\frac{Y_t}{\hat{Y}}\right)^{\sigma_y} - 1, \tag{14}$$

where ρ_t represents a desired path for the equilibrium real interest rate, $\hat{\pi}$ represents a desired path for the inflation rate, and $\hat{Y}$ is the target level of aggregate output. We assume that $\sigma_\pi > 1$ and $\sigma_y > 0$. This rule is somewhat unrealistic in that we do not allow for interest rate "smoothing". This is not critical to results, however.

The monetary authority can follow the rule (14) only when $i_t^R > 0$, however. If the rule stipulates a negative nominal interest rate, then the central bank is constrained by the zero lower bound on nominal interest rates. Thus, the path of nominal interest rates in the model must be governed by:

$$i_t = \max(i_t^R, 0). \tag{15}$$

2.6 Equilibrium Conditions

Now, combining equations (9), (11), and (13) the aggregate resource constraint for the final composite good is:

$$A_t H_t^{1-\alpha} = Y_t = G_t + C_t. \tag{16}$$

The zero lower bound condition (15) is usually thought of as a constraint on the short-run behavior of monetary policy. But this is not necessarily the case. For instance, if the monetary authority has a low enough long-term inflation target, this could force the long-run real interest rate down to the level where the zero bound is a binding constraint. Although this has no long-term consequences for output's path, it does place a condition on the required path of real government debt. We explore this issue briefly in the next section.

3. Long-Run Flexible Price Equilibrium

In a flexible price equilibrium, equations (7) and (12) give the solution for equilibrium aggregate output:

$$\frac{\theta\eta}{\theta-1}(Y-G)=(1-\alpha)A^{\frac{1}{(1-\alpha)}}Y^{\frac{-\alpha}{(1-\alpha)}}. \tag{17}$$

From equation (17), the long-run government spending multiplier is given by

$$\frac{dY}{dG}=\frac{1-\alpha}{1-\alpha+(1-g_y)\alpha}, \tag{18}$$

where $g_y \equiv G/Y < 1$. The multiplier is increasing in the steady state ratio of government spending to GDP, but it must be no greater than unity.

Define $b_y = b/Y$ as the long-run government debt-to-GDP ratio. For a given value of g_y, the long-run real interest rate is determined by the steady state version of (10):

$$\left[\frac{\beta(1+r)}{\phi}-1\right]=\Phi(1+r)b_y, \tag{19}$$

where $\Phi \equiv [(1-\gamma\phi)(1-\beta\gamma)]/\gamma\phi(1-g_y)$. The real interest rate is increasing in the steady state government debt-to-GDP ratio. In this model, without capital, government debt does not crowd out real investment, and has no effect on steady state aggregate output or consumption. But a higher b_y increases real interest rates, and tilts the profile of each generation's consumption toward the future.

The steady state nominal interest rate is obtained from equation (14), taking the desired real interest rate ρ as constant.

$$(1 + i) = (1 + r)(1 + \pi), \quad i > 0, \tag{20}$$

$$(1 + \pi) = (1 + r)^{-1}, \qquad i = 0. \tag{21}$$

For a given target real interest rate, inflation, and output, there may be more than one inflation rate satisfying these conditions, where i is defined by equation (15). For instance, one equilibrium is given by $\pi = \hat{\pi}$, $Y = \hat{Y}$ and $i = \rho$. But another equilibrium is given by:

$$i = 0, \ \ \pi = \left[(1+\rho)(1+\hat{\pi})^{1-\sigma_\pi}\right]^{-\frac{1}{\sigma_\pi}} - 1.$$

Benhabib, Schmitt-Grohé, and Uribe (2002) were the first to demonstrate that Taylor rules will generally be associated with multiple equilibrium rates of inflation when nominal interest rates are bounded below by zero. Here we focus only on equilibria with positive inflation rates, where the steady state inflation rate is equal to the target rate $\hat{\pi}$.[5] In this economy, there is only one such equilibrium consistent with equations (19) and (15). Thus, we may re-write equation (20) as

$$(1 + i) = (1 + r)(1 + \hat{\pi}), \quad i > 0, \tag{22}$$

$$(1 + \hat{\pi}) = (1 + r)^{-1}, \qquad i = 0. \tag{23}$$

The two conditions (19) and (22) have separate interpretations, depending upon whether the nominal interest rate is positive or at the zero lower bound. When $i > 0$, the conditions determine i and r separately, for given $\hat{\pi}$ and b_y. The steady state monetary rule (14) determines $\hat{\pi}$, while b_y is determined by steady state fiscal policy, consistent with equation (13), in conjunction with an appropriate transversality condition. Thus, monetary and fiscal policy can be thought of as independent, in a steady state with $i > 0$. Moreover, there is a recursive structure, such that the fiscal stance, summarized by the value of b_y, determines r, while the inflation target determines i.

5. This requires that the authority have a steady-state target real interest rate equal to the real interest rate implied by equation (19), and a steady-state target for output equal to that implied by equation (17).

But equations (19) and (22) may also be associated with an equilibrium where $i = 0$, and the nominal interest rate is at the zero lower bound. From equation (22), this can occur only if $r < 0$—that is, if the economy is dynamically inefficient. From equation (19), dynamic inefficiency can occur, even when $b_y > 0$ and $\phi < 1$. If each cohort has a declining wage profile over time, the economy may be dynamically inefficient, even if government debt-to-GDP is positive.

The behavior of the steady state under the zero lower bound is fundamentally different from that occurring when $i > 0$. Putting equations (19) and (22) together when $i = 0$, we obtain the single relationship:

$$\pi^T = \frac{\beta}{\phi} - \Phi\frac{b_y}{1-g_y} - 1. \tag{24}$$

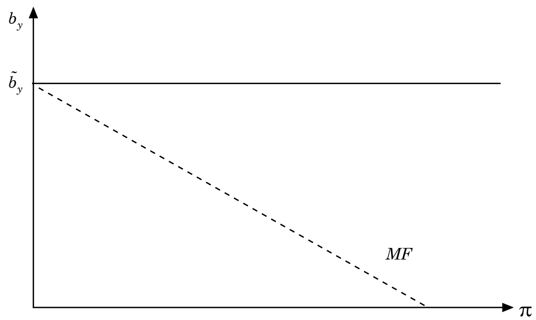
Condition (24) defines the sense in which monetary and fiscal policy are interdependent in an economy at the zero lower bound.[6] If the government debt-to-GDP ratio is such that the equilibrium real interest rate is negative, then the target rate of inflation must be uniquely determined. Conversely, if the target rate of inflation is taken as given, then the debt-to-GDP ratio must be adjusted to achieve the equilibrium real interest implied by this target. Moreover, at the zero lower bound on the nominal interest rate, the steady state is no longer recursive. A higher value of π^T implies a lower (more negative) real interest rate, and must be accompanied by a fall in b_y, holding g_y and all the other variables constant.

Figure 2 illustrates the trade-off implied by condition (24). In the figure, $\tilde{b}_y$ represents the value of the debt ratio for which $r = 0$, implied by (19). For $b_y < \tilde{b}_y$, the real interest rate is negative. Whether the economy is stuck at the zero lower bound depends on the inflation target. The schedule MF illustrates condition (24). For a given $b_y < \tilde{b}_y$, the lower the inflation target, the more likely the economy will be at the zero lower bound. MF describes the required values of b_y for each value of the inflation target, when the economy is stuck at the zero lower bound. Thus, in a steady state, there must be a negative relationship between government debt and the inflation rate, when

6. Leeper (in this volume) provides an alternative view of the interaction between monetary and fiscal policy, even when nominal interest rates are positive, based on the interdependence implied by the public sector budget constraint.

the economy is at the zero lower bound.[7] Intuitively, the condition says that, in the long run, if monetary authorities are committed to low inflation targets, then low real interest rate episodes are likely to push them to the zero bound. If they remain committed by a low inflation target at the zero bound, then this really means that they are preventing the real interest rate from falling any further. This can only be done through giving up control of the outstanding stock of government debt. Equivalently, if the fiscal authority insists on reducing the stock of real debt in an environment where the real interest rate is pushed below zero, then the monetary authorities must accommodate this with a higher rate of inflation. In either case, with a permanent zero nominal interest rate, there must be a negative relationship between government debt and inflation.

Figure 2. The Trade-off Implied by Equation (24)



Sources: Author's drawing.

4. Monetary and Fiscal Policy in the Short Run under a Zero Lower Bound

We now analyze the model in the short run, when prices adjust as per equation (12). Like Christiano, Eichenbaum, and Rebelo (2009),

7. Beaudry, Devereux, and Siu (2009) examine this restriction in a more complete dynamic growth model. Condition (24) abstracts from the possibility of bubble equilibria. When the real interest rate is negative, it is possible that other non-fundamental assets may be valued in equilibrium, so that total wealth would include both the value of government debt and the bubble asset.

Eggertsson and Woodford (2003, 2004), and Eggertsson (2009), we wish to explore the usefulness of monetary and fiscal policy in responding to an environment where the economy has been pushed to a zero lower bound; that is, where the nominal interest rate is stuck at zero for some time. Initially, we will just compare the differential effects of policy in the two environments: the first, when the nominal interest rate operates according to a standard Taylor rule, and the second, when the nominal interest rate is zero. This gives us the basic contrasting results of this section. We later provide a quantitative comparison of the usefulness of monetary and fiscal policy alternatives in response to the zero lower bound constraint.

Under what circumstances should the policymaker face a zero interest rate constraint? As in the previous literature, we may think of this situation as generated by a large increase in the representative agents' discount factor, raising desired savings and pushing down the flexible price equilibrium real interest rate. If the policymaker follows a Taylor rule, as in equation (14), then the nominal interest rate may be pushed down to its lower bound. The increase in desired savings leads to a fall in aggregate demand and a fall in the output gap. In normal times, the optimal response to this shock would be to reduce nominal interest rates to facilitate the required real interest rate adjustment. But when nominal interest rates are zero, they cannot be reduced further. How should policy respond? Two main answers have been offered in the literature. Krugman (1998), Jung, Teranishi, and Watanabe (2005), and Eggertsson and Woodford (2003) discuss a range of alternative monetary policy rules that may be applied, despite the fact that the interest rate remains at or near zero for some time. The common feature of these proposals is that the policymaker should make an announcement about the conduct of monetary policy once the economy has left the zero bound region. If the authority announces that policy will remain loose even after the zero bound no longer binds, it does so to lessen the deflationary impact of the current shock. The obvious difficulty with using monetary policy in this way is that the announcement must be credible for it to have any effect on current output and inflation. The policymaker must follow a history-dependent rule, and continue to pursue monetary easing even after the conditions that warrant such easing have faded. Eggertsson and Woodford (2003) discuss a range of targets for monetary authorities that would replicate the optimal history dependent rule, but may be easier to communicate to the public.

The second main response to a zero lower bound trap is the use of fiscal policy. Fiscal policy may directly influence aggregate demand in the traditional Keynesian manner, even when the monetary authority cannot reduce interest rates any further. Fiscal policy options for the zero lower bound trap are discussed by Christiano, Eichenbaum, and Rebelo (2009), Eggertsson (2009), and Cogan and others (2010).

One common characteristic of previous literature analyzing the role of policy at the zero lower bound is that models display Ricardian equivalence. Hence, the financing of government spending expansion has no role to play, and the real balance effects of monetary policy are not operative. In the recent policy discussion, summarized in section 1, however, the need to run government deficits, generated either by tax cuts or bond-financed government spending increases, is seen as paramount to the stimulus package in all countries. The notion that large fiscal expansion occurring in many countries could just as easily be financed with tax increases as with government deficits seems completely at variance with all policy discussion. It is therefore important to be able to analyze the impact of fiscal deficits when interest rates are stuck at the zero lower bound, and to compare this with the case where interest rates are part of regular monetary policy. The advantage of the current model is that we can analyze the role played by tax cuts and spending increases separately, and distinguish between debt-financed and tax-financed fiscal expansion. Moreover, we can analyze separately the real balance effects of monetary policy, which can operate even at zero interest rates.[8]

4.1 Approximating the Model under a Taylor Rule

In the case where nominal interest rates are positive and adjust according to equation (14), we have a standard New Keynesian model, save for the presence of government debt in the Euler equation (10). Using equations (10) and (16), we may approximate equation (10) as follows:

$$\hat{Y}_{t+1} = \hat{Y}_t + \left[(i_{t+1} - E_t \pi_{t+1}) + \hat{\nu}_{t+1}\right] - \Phi \hat{b}_{t+1} - E_t(\hat{G}_{t+1} - \hat{G}_t), \tag{25}$$

8. Ireland (2005) emphasizes the real balance effect of monetary policy, which can operate even when the nominal interest rate is zero. He does so in a purely flexible price model though, similar to the case described in section 2, above.

where $\hat{Y}_t = \log(\frac{Y_t}{\bar{Y}})$, $\hat{G}_t = \frac{G_t - \bar{G}}{\bar{Y}}$, $\hat{\pi}_t = \log(\frac{P_t}{P_{t-1}})$, $\hat{b}_t = \frac{b_t - \bar{b}}{\bar{Y}}$,

and $\Phi \equiv [(1-\beta\phi)(1-\gamma\phi)]/\gamma\phi(1-g_y)$. The linear approximation is taken around an initial debt-to-GDP ratio equal to zero, so that $\bar{b} = 0$.[9] The government spending shock represents a deviation of government spending from the steady state level, relative to GDP. We are assuming that there is an optimal (flexible price equilibrium) level of government spending given by $\overline{G}$, and movements in government spending here represent deviations from the optimum. The variable $\hat{\nu}_t$ represents a temporary shock to the discount factor, where we assume that the discount factor can be represented as $\beta_t = \exp(\nu_t)$ and the steady state value of ν is set at zero, $\bar{\nu}_t = 0$. The departure from full Ricardian equivalence is governed by the composite coefficient Φ, which depends on the steady state discount rate, the probability of survival, and the time path of labor income within each cohort.

The forward-looking inflation equation follows in standard fashion from the first-order approximation of equation (12) and the definition of the price index.

$$\pi_t = \lambda\left(\frac{\hat{Y}_t - \hat{G}_t}{1-g_y} + \frac{\alpha}{1-\alpha}\hat{Y}_t\right) + \beta E_t \pi_{t+1}, \tag{26}$$

where $\lambda = [(1-\kappa\beta)(1-\kappa)(1-\alpha)]/\kappa\left[(1-\alpha)+\alpha\theta\right]$. The term in brackets represents the deviation of real marginal cost from its steady state level, given the assumptions on the disutility of labor for each generation.

The linear approximation of the interest rate rule is written as:

$$i_t^R = \rho + \bar{\pi} + \sigma_\pi(\pi_t - \bar{\pi}) + \sigma_y \hat{Y}_t. \tag{27}$$

In this section, we assume that $i_t^R > 0$, so that the interest rate always follows equation (27).

9. This facilitates the exposition. Allowing for non-zero debt ratios requires the interest rate to be an additional state variable, which makes the algebra more complicated, but does not substantially change the results so long as b_y is not too large.

Finally, we take a linear approximation of the government budget constraint as follows:

$$\hat{b}_{t+1} = (1+r)\hat{b}_t + \hat{G}_t - \hat{T}_t, \tag{28}$$

where $\hat{T}_t = (T_t - \bar{T})/\bar{Y}$. Since we are approximating around an initial steady state with a zero debt-to-GDP ratio, this approximation does not depend on the first-order dynamics of the real interest rate. On its own, however, equation (28) will involve non-stationary dynamics in the government debt ratio. To avoid this, we assume that the fiscal authority chooses a tax rule so that the dynamics of aggregate government debt to GDP are stationary, for given government spending movements. In particular, we assume that net taxes have a discretionary and an automatic component, such that:

$$\hat{T}_t = \hat{T}_{1t} + t\hat{b}_t, \tag{29}$$

where t is constant, and is chosen such that $\omega = 1 + r - t < 1$. This ensures that following a temporary shock to government spending or the discretionary component of taxes which leaves the long-run real primary deficit unchanged, the debt level will return to its steady state.

4.2 Shocks to the Discount Factor

A natural way to think about policy being constrained by the lower bound on interest rates is that an increase in the desire to save drives down the equilibrium flexible price real interest rate. Under an inflation targeting monetary rule, this requires a fall in the nominal interest rate. The variable $\hat{\nu}_t$, representing a shock to the discount factor, increases the ex-ante savings rate of all generations. Assume that $\hat{\nu}_t$ is governed by the process:

$$\hat{\nu}_{t+1} = \mu\hat{\nu}_t + \varepsilon_{t+1},$$

where $E_t(\varepsilon_{t+1}) = 0$. An increase in the discount factor leads to a persistent fall in the equilibrium real interest rate. Using the interest rate rule (27), the impact of the shock can be obtained from the solution to equations (25)–(29). The increase in the discount factor increases the desire to save, reducing aggregate demand, and causing a fall in both output and inflation. The responses of output and inflation are given by:

$$\hat{Y}_t = -\frac{(1-\alpha)(1-\beta\mu)}{\Delta_\mu}\hat{\nu}_{t+1}, \tag{30}$$

$$\hat{\pi}_t = -\frac{z\kappa}{\Delta_\mu}\hat{\nu}_{t+1}, \tag{31}$$

where $z = (1 - \alpha g_y)/(1 - g_y)$, and $\Delta_\mu = (1 - \alpha)(1 - \beta\mu)(1 - \mu + \sigma_y) + \kappa(\sigma_\pi - \mu)z > 0$.

The impact of a discount factor shock is cushioned by interest rates' endogenous response. The higher the interest rate response to inflation and the output gap, the smaller the effect of the shock. In the optimal monetary policy framework presented in Woodford (2003), an optimal monetary response that goes beyond the interest rate rule can fully accommodate a discount factor shock, reducing nominal interest rates by the extent of the shock itself, and fully stabilizing output and inflation. But this requires that authorities have sufficient leeway to reduce the nominal interest rate. For large enough shocks, the zero bound on the interest rate may apply, and some alternative monetary or fiscal policy must be used to respond to the shock. Before we analyze the economy's response under a zero bound, however, we investigate the impact of fiscal policy shocks when the nominal interest rate is positive, and the economy operates under the monetary rule (27).

4.3 Government Spending, Debt, and Tax Shocks under a Taylor Rule

Previous papers have analyzed the effects of government spending shocks in this type of model. The only difference here from the previous literature is the failure of Ricardian equivalence, and the effects of government debt accumulation. To highlight this difference, we first examine the impact of a one-off shock to government debt. It is easy to solve equations (25)–(29) to show that the effect of an increase in b_t on output and inflation is as follows:

$$\hat{Y}_t = \frac{(1-\alpha)(1-\beta\omega)\omega\Phi}{\Delta_\omega}\hat{b}_t, \tag{32}$$

$$\hat{\pi}_t = \frac{z\kappa\omega\Phi}{\Delta_\omega}\hat{b}_t, \tag{33}$$

where $\Delta_\omega = (1-\alpha)(1-\beta\omega)(1-\omega+\sigma_y) + \kappa(\sigma_\pi - \omega)z > 0$. An increase in government debt is perceived as an increase in wealth for currently alive cohorts. This leads to an increase in consumption and a fall in desired saving. Current aggregate demand rises, pushing up inflation. The rise in inflation increases the real interest rate via the interest rate rule, partly offsetting the impact of the higher debt on current output. The greater the response to inflation or the output gap in the interest rate rule, the greater the increase in the real interest rate, and the smaller the impact on output and inflation. Note also that the impact of a debt shock depends on the persistence in government debt generated by the government budget constraint. If the debt-sensitive tax rule is such that an initial debt shock is very transitory (that is, ω very low), the impact on output or inflation is small.

We can now focus on the effects of government spending and taxes. To provide a benchmark comparison with the Ricardian equivalence case, we focus first on a government spending expansion financed by a tax increase, that is, we calculate the balanced budget multiplier.

Assume that both discretionary taxes and government spending increase by the same amount. In both cases, assume that after the initial increase, both discretionary taxes and spending converge back to their steady state levels at the rate μ. Then, from equations (25)–(29), we may compute that:

$$\hat{Y}_t = \frac{(1-\alpha)\left[(1-\mu)(1-\beta\mu)+\kappa(\sigma_\pi-\mu)/(1-g_y)\right]}{\Delta_\mu}\hat{G}_t, \tag{34}$$

$$\hat{\pi}_t = \frac{\alpha\kappa(1-\mu)-(1-\alpha)\sigma_y/(1-g_y)}{\Delta_\mu}\hat{G}_t. \tag{35}$$

The first thing to note about equation (34) is that it is independent of Φ, the coefficient on government debt in the aggregate Euler equation. The balanced budget multiplier is the same as that of the standard Ricardian equivalence model, because the policy has no consequences for government debt. In addition, the multiplier is clearly less than unity. That is:

$$\mathrm{Sign}\left(\frac{\hat{Y}_t}{\hat{G}_t}-1\right)=-\mathrm{Sign}\left[(1-\beta\mu)(1-\alpha)\sigma_y+\alpha\kappa(\sigma_\pi-\mu)\right]<0.$$

Even though prices are sticky and adjust slowly to changes in aggregate demand, the balanced budget multiplier is actually less than that of the purely flexible price equilibrium multiplier. The key reason is that under the monetary policy rule (27), the real interest rate increases so much in response to a rise in fiscal spending (financed by taxation) that aggregate private consumption falls. Only in the special case of constant returns in production ($\alpha = 0$) and no output gap in the interest rate rule ($\sigma_y = 0$) will the multiplier be exactly unity, that is, equal to that of the flexible price equilibrium.

This suggests that if the nominal interest rate is free to adjust and follows a standard rule (27), government spending is a particularly inefficient way to stimulate the economy. The most that a fiscal expansion can do is to leave aggregate private consumption unchanged, and in general consumption will fall. Equivalently, we can say that government spending expansion increases output, but output actually falls below the level it would attain in a flexible price equilibrium, in the face of the same balanced budget government spending increase.

The impact of a balanced budget government expansion on inflation is given by equation (35). If $\sigma_y = 0$ and $\alpha = 0$, the inflation rate is unchanged, because output responds exactly as in a flexible price equilibrium. With constant returns ($\alpha = 0$) and $\sigma_y > 0$, inflation will *fall*, since output is below the flexible price equilibrium.

We now turn to the analysis of a tax cut in the model with an interest rate rule. A temporary discretionary tax cut will increase the primary government deficit and cause a persistent increase in government debt. How will this affect GDP? From equations (25)–(29) we can establish that:

$$\hat{Y}_t=-\Phi\frac{(1-\alpha)^2(1-\beta\omega)(1-\beta\mu)(1+\sigma_y)-(1-\alpha)\kappa z\left[\beta\omega(\sigma_\pi-\mu)-\sigma_\pi(1-\beta\mu)\right]}{\Delta_\mu\Delta_\omega}\hat{T}_t. \quad (36)$$

Note that with Ricardian equivalence, where $\Phi = 0$, this is negative by definition. For $\Phi > 0$, we would anticipate that the expression on the right hand side of expression (36) is negative (tax increases are contractionary). Interestingly however, this is not necessarily true in this model. Take the case where μ and ω are very close to unity (tax cuts are highly persistent, and the deficit is very slow to fall). Then expression (36) is positive for $\sigma_\pi > 1$, and therefore a cut in taxes will reduce GDP in the economy where the interest rate follows a Taylor rule.

What is the explanation for this? The reason is that, for σ_π greater than unity, and sufficiently large, a tax cut causes a large offsetting increase in interest rates due to its inflationary effects. The impact of a tax cut on current inflation is always positive, and given by:

$$\hat{\pi}_t = -\kappa z \Phi \frac{(1-\alpha)(1+\sigma_y - \beta\omega\mu) + \kappa z \sigma_\pi}{\Delta_\mu \Delta_\omega} \hat{T}_t. \tag{37}$$

A very persistent tax cut signals a persistent increase in future government debt, which causes the forecast of future inflation to rise, increasing current inflation, and pushing current interest rates upward. This secondary effect can be large enough to reduce aggregate demand and lead to a fall in output. Thus, again, we may conclude that during "normal times," when the nominal interest rate follows a conventional rule of the type given by equation (14), tax cuts are unlikely to be an effective stabilization tool.

Note that we have not yet given a quantitative analysis of the effects of tax cuts and government spending policies in this model. In the discussion of the calibrated model below, we show that for both policies, the multiplier effects of government spending and tax cuts (even if the latter are positive) are likely to be quite low.

4.4 Fiscal Policies under a Zero Lower Bound

Now assume that the shock to the discount factor is large enough to push the economy into a liquidity trap: thus, the nominal interest rate is constrained by the zero lower bound.[10] In this case, the economy's dynamics are fundamentally different. The effects of the

10. To ensure that the approximations remain accurate at the zero lower bound, it is necessary to restrict the size of the discount factor shock placing the economy at the bound. See Eggertsson and Woodford (2003).

initial shock and policy measures to counter the shock on inflation and the output gap operate through substantially different channels when the policy interest rate cannot respond.

In section 2 above, we analyzed the properties of a steady state in which the nominal interest rate is at the zero lower bound. By contrast, here we will focus on a situation where the lower bound constraint is temporary, the rise in the discount factor dissipates over time, and the economy's real interest rate returns to its steady state. In a crude way, this captures the impact of an aggregate demand shock coming from an unanticipated temporary rise in the savings rate.[11]

To make the analysis concrete, we follow Eggertsson and Woodford (2003, 2004) and Eggertsson (2009) in assuming that the discount factor shock drives the economy to the zero lower bound for an uncertain number of periods. We assume a one-time shock to the discount factor that continues with probability μ per period. So in each future period, the discount factor reverts to the steady state with probability $1 - \mu$. In the intervening time, the discount factor is at its post-shock level, and is sufficiently high that the policy implied by the original interest rate rule would require a zero interest rate. As in Eggertsson and Woodford (2003, 2004), Eggertsson (2009), and Christiano, Eichenbaum, and Rebelo (2009), we investigate both the impact of the original shock, and the impact of an alternative series of monetary and fiscal policies, when the economy operates at the zero interest rate bound.

Solving the model given by equations (25)–(29) when $i_t^R = 0$, under the assumption that the shock reverts back to steady state with probability $1 - \mu$, we obtain the impact of the discount rate shock on the output gap and inflation as:

$$\hat{Y}_t = -\frac{(1-\alpha)(1-\beta\rho)}{\Delta_{\mu}^{z}}\hat{\nu}_{t+1}, \tag{38}$$

11. In the case of a permanent zero lower bound, the conditions for a unique stable path of adjustment of inflation, output, and government debt are not always met. In particular, in the Ricardian equivalence version of this model (when $\Phi = 0$), the conditions for uniqueness in the zero interest rate case are not met for familiar reasons (for example, Clarida and others, 1999). But with $\Phi > 0$ and allowing for a non-zero initial nominal government debt, there is a real balance effect that may be sufficient to restore uniqueness (Ireland, 2005), even if the nominal interest rate is stuck at zero forever. Nevertheless, because we are primarily concerned with the analysis of short-run stabilization policies, we follow the recent literature and analyze the (somewhat more realistic) case of a temporary liquidity trap.

$$\hat{\pi}_t = -\frac{z\kappa}{\Delta^z_\mu}\hat{\nu}_{t+1}. \tag{39}$$

where $\Delta^z_\mu = (1-\alpha)(1-\beta\mu)(1-\mu) - \kappa\mu z$. A condition for stability is that $\Delta^z_\mu > 0$.[12] Note however that $\Delta_\mu - \Delta^z_\mu = (1-\alpha)(1-\beta\mu)\sigma_y + \sigma_\pi\kappa\mu z > 0$. Hence, in comparing equations (30) and (38), a rise in the discount factor will affect both inflation and the output gap more in an economy constrained by the zero lower bound. This is not surprising, and follows as a converse argument to the logic presented above, regarding the response of inflation and the output gap under an interest rate rule. Since the nominal interest rate cannot respond, the fall in demand reduces output, which reduces inflation and—given the shock's persistence—the fall in anticipated inflation pushes up the real interest rate, pushes demand down further, and reduces output even more. So long as $\Delta^z_\mu > 0$, this process converges, but to a much lower level of output than would occur under a positive interest rate rule.

How do monetary and fiscal policies operate when the interest rate is zero? Again, we focus on the importance of debt- and deficit-related policies, given that the failure of Ricardian equivalence is the key in this analysis. To simplify our analysis and make comparison with the previous section easier, we initially make the special assumption that fiscal policies enacted while the economy is constrained by the zero lower bound are completely eliminated when the constraint is no longer binding, and the economy then reverts immediately to its steady state. This involves the assumption that at the period of the return to positive interest rates, taxes are raised to completely eliminate the accumulated government debt resulting from fiscal policy expansions.

Thus, government debt built up over and above its initial steady state (or zero) is wiped out, and debt reverts to zero after the return to positive interest rates. This allows the economy to return to a steady state. This assumption makes the algebraic comparison with the previous section very simple, but it is not a critical feature of the argument. We explore an alternative case below, where the accumulated debt is eliminated gradually after the return to positive nominal interest rates. We can see that all the points made in this section remain valid. In fact, because the cohorts holding

12. See Eggertsson (2009).

the accumulated debt continue to treat it as net wealth after the return to positive interest rates, this alternative path of convergence reinforces the impact of current fiscal policies.

First, we can analyze the impact of an arbitrary rise in government debt, in a manner similar to equations (32) and (33) above.

$$\hat{Y}_t = \frac{(1-\alpha)(1-\beta\omega\mu)\omega\Phi}{\Delta^z_{\omega\mu}}\hat{b}_t, \tag{40}$$

$$\hat{\pi}_t = \frac{z\kappa\omega\Phi}{\Delta^z_{\omega\mu}}\hat{b}_t, \tag{41}$$

where $\Delta^z_{\omega\mu} = (1-\alpha)(1-\beta\mu\omega)(1-\omega\mu) - \kappa\mu\omega z$. Again, for stability, it is necessary that $\Delta^z_{\omega\mu} > 0$.

As in the case of a positive nominal rate, an increase in government debt leads to a rise in the output gap and the inflation rate, so long as Ricardian equivalence fails ($\Phi > 0$). The quantitative impact may be greater or less than equations (32) and (33). On the one hand, the nominal interest rate does not respond here, leading to a larger impact on both inflation and the output gap. However, in this experiment, the interest rate rule reverts back to equation (14) with probability $1 - \mu$. The quantitative analysis below shows that the effects of increasing government debt may be greater or lesser during a liquidity trap than under a positive interest rate rule.

If a rise in the discount factor affects the output gap more negatively in a liquidity trap, it is reasonable to think that compensating fiscal policies could prove more able to stabilize the economy, since in this environment an expansion in government spending or a tax cut does not elicit automatic interest rate responses that limit fiscal instruments. In this vein, Christiano, Eichenbaum, and Rebelo (2009) and Eggertsson (2009) show that government spending policies may have significantly higher multiplier effects in a liquidity trap than during normal times. But again, their analysis was confined to the situation of full Ricardian equivalence, where a balanced budget expansion in government spending is identical to a debt-financed expansion. We now wish to revisit this question, allowing for debt versus tax-financed spending policies to have different effects. As a corollary, we can investigate the effect of tax cuts compared to government spending expansions, as we did above for the case outside the liquidity trap.

Using equations (25)–(29) we can establish that a *balanced budget* increase in government spending has the following impacts on the output gap and inflation:

$$\hat{Y}_t = \frac{(1-\alpha)\left[(1-\mu)(1-\beta\mu)-\mu\kappa/(1-g_y)\right]}{\Delta_\mu^z}\hat{G}_t, \tag{42}$$

$$\hat{\pi}_t = \frac{\alpha\kappa(1-\mu)}{\Delta_\mu^z}\hat{G}_t, \tag{43}$$

where $\Delta_\mu^z = (1-\alpha)(1-\beta\mu)(1-\mu) - \kappa\mu z$. From equation (42) we see that the multiplier effect on output exceeds unity whenever $\alpha(1-g_y) > 0$. Hence, the balanced budget government spending multiplier is always greater in a liquidity trap than when the nominal interest rate is positive and responds according to a Taylor rule. But the multiplier is not necessarily large. When $\alpha = 0$, the multiplier is exactly unity: a balanced budget expansion has no impact whatsoever on private consumption. Moreover, the inflationary effects of a balanced budget increase in spending also exceed those under the Taylor rule. This is for two reasons: first, because in the absence of endogenous interest rate adjustment to the output gap (that is, $\sigma_y = 0$), the multiplier impacts of shocks are greater in the zero lower bound economy, since$\Delta_\mu^z < \Delta_\mu$. Moreover, when $\sigma_y < 0$, as we saw in expression (34) above, the interest rate response to a government spending increase in the Taylor rule economy will mitigate the impact on inflation, something that does not happen in the zero lower bound economy.

In the economy with the Taylor rule, we saw, paradoxically, that a tax-financed spending increase could be more or less expansionary than the equivalent deficit-financed increase. In the recent rounds of stimulus packages applied in many countries, an important feature of spending policies was that they were financed by debt issue rather than tax increases. In fact, the essential rationale behind this intervention was to combine spending increases with tax cuts, to stimulate overall spending. The perception was that when nominal interest rates cannot be lowered, this becomes the last possible channel for stabilization policy. Again however, in the context of our framework, this only makes sense if Ricardian equivalence fails. To examine this argument, we now focus on the effects of tax cuts in the model constrained by the zero lower bound.

Again, using equations (25)–(29), we can derive the responses of the output gap and inflation as:

$$\hat{Y}_t = \frac{-\Phi(1-\alpha)\left[(1-\alpha)(1-\omega\mu)(1-\beta\omega\mu)+\beta\omega\mu^2 z\right]}{\Delta_\mu^z \Delta_{\omega\mu}^z}\hat{T}_t, \tag{44}$$

$$\hat{\pi}_t = -\kappa\Phi\frac{z(1-\alpha)(1-\beta\omega\mu^2)}{\Delta_\mu^z \Delta_{\omega\mu}^z}\hat{T}_t. \tag{45}$$

The expression in (44) is always negative. Hence, in contrast to the case with positive interest rates, tax cuts are always expansionary at the zero lower bound, so long as Ricardian equivalence fails. Tax cuts increase private sector wealth, leading to a fall in private saving and an increase in aggregate demand and output. Tax cuts also make government debt grow more. At the same time, tax cuts are inflationary, as the output gap increases in response to the increase in aggregate demand, as confirmed by equation (45). Unlike the case where the Taylor rule applies, however, there is no compensating increase in the policy interest rate resulting from the increase in inflation. This raises the possibility that tax cuts may be substantially more expansionary in an economy stuck at the zero lower bound. To assess the validity of the arguments for deficit financing as an important stabilization tool, then, we must turn to a quantitative assessment of the strength of these effects.

4.5 Quantitative Comparison of Policies

How big are the effects of fiscal policy in the economy within a liquidity trap? We take the calibration presented in table 4. The parameter values are quite standard and follow the assumptions made in the recent literature in this area, save for the particular assumptions we have made to allow for aggregation in the OLG model (log utility, and linear disutility of leisure). We look at two versions of each model, one with constant returns to scale and another with decreasing returns to labor, assuming that $\alpha = 0.3$. In the first model, we follow Christiano, Eichenbaum, and Rebelo (2009) in setting the discount factor at 0.99, while the Calvo price adjustment is parameter κ at 0.85, so that $\lambda = 0.028$. In the second version, with $\alpha = 0.3$, the definition of λ is different, so we choose κ at a different value (0.7), and $\theta = 10$, so as to reproduce $\lambda = 0.025$. We initially set the parameters of the interest rate rule at $\sigma_\pi = 1.5$ and $\sigma_y = 0$, but we also look at variations on these settings. In addition we set the steady state government spending ratio equal to 0.15, approximately the relevant value for the U.S. economy.

Table 4. Parameter Values

Parameter	*Value*
β	0.985
Φ	0.011
λ	0.028; 0.025
α	0; 0.3
σ_π	1.5
σ_y	0; 0.25
g_y	0.15
μ	0.8

The parameters governing the cohort time-horizon are very important in assessing the degree to which government deficits have any affect on real allocations. It is well known that if the household planning horizon in the Blanchard-Yaari model is too great, then the results are quantitatively equivalent to a model with an infinite horizon (for example, Evans, 1991). As a result, the quantitative literature on the impacts of deficits using the Blanchard-Yaari model usually interprets the probability of death in a broader manner than that implied by straightforward demographic data. Bayoumi and Sgherri (2008) directly estimate the Blanchard-Yaari parameters from a reduced form consumption function from the model, and find estimates of γ below 0.8 at an annual frequency. This implies a five-year horizon for consumers in their planning decision. We choose γ to match this at the quarterly frequency. On parameter ϕ, governing the rate of earnings decline over the lifetime, we have little direct evidence to match this. We simply make a rough estimate based on the fact that agents spend about two-thirds of their adult lives working and one-third retired, so we set $\phi = 0.6$. In combination with the assumption for β, these assumptions imply that Φ is about 0.011 at the quarterly frequency. We should note that this calibration is not guaranteed to enlarge the impact of government deficits. Even with these assumptions about the planning horizon and wage distribution, we show that the effects of deficits under a Taylor rule are very slight.

The parameter μ, governing the number of periods for which it is anticipated that the zero lower bound on the interest rate will apply, is a critical feature of the dynamics. If this is too large, then the stability condition is not satisfied. We set $\mu = 0.8$, so that nominal interest rates are anticipated to be zero for five quarters.[13] To compare with the economy under the Taylor rule, we assume that all shocks in that case have persistence equal to 0.8.

Table 5 presents quantitative results comparing the effects of policies under the Taylor rule with the economy constrained by the zero lower bound on interest rates. In the baseline calibration, we see that the impact of a discount factor shock in the economy at the zero lower bound is orders of magnitude more than in an economy operating under a Taylor rule. This shock increases the desire to save, reducing current demand, output and inflation. In the economy operating under a Taylor rule, the nominal interest rate will fall, pushing down the real interest rate and reducing the incentive to save. The equilibrium real interest rate falls. In contrast, when the nominal interest rate cannot respond, the way the increased desired savings is satisfied in equilibrium is for current output to fall relative to expected future output. But the fall in current output leads to a fall in current inflation, which raises the real interest rate, increasing the desire to save. When $\mu < 1$, and the stability conditions on the model under the zero lower bound are satisfied, this process has an eventual equilibrium leading to a very large fall in current output.

The second panel of table 5 illustrates the impact of fiscal policies in both interest rate scenarios, under the baseline calibration with $\alpha = 0$ (constant returns to scale). In both cases, the balanced budget multiplier is unity. Even though the impact of demand shocks is potentially much greater in the zero lower bound economy, in which the real interest rate may respond pathologically, in this case a demand shock requires no real interest rate responses at all. When the government spending expansion is financed by current taxation,

13. This is not a necessary feature of the solution. We could allow the zero lower bound to be operative for a finite but known number of periods, after which the economy converges back to steady state. In this case, the duration of the zero interest rate phase could be arbitrarily extended.

Table 5. Simulation Results

Model and variable	$\hat{v}$	$\hat{b}$	$\hat{G}$	$\hat{G}-\hat{T}$	$\hat{T}$
Taylor rule model					
$\hat{Y}$	−3.20	0.04	1.07	1.00	−0.07
$\hat{\pi}$	−0.05	0.01	0.07	0.00	−0.07
$\hat{R}$	−0.36	0.01	0.03	0.00	−0.03
Zero lower bound model					
$\hat{Y}$	−13.8	0.05	2.01	1.00	−1.01
$\hat{\pi}$	−2.68	0.01	0.23	0.00	−0.23
$\hat{R}$	2.15	0.00	−0.19	0.00	0.19

Source: Author's computations.

there is no consequence at all for government debt. Output responds one for one to the expansion in both the current period and all future periods in which expansion continues. Consumption is unaffected. As a result, there is no need for real interest to move. Thus, under this calibration, the zero lower bound has no implications at all for the effects of balanced budget fiscal expansions (although as we see below, this conclusion may be substantially altered under different monetary rules or decreasing returns to scale).

Now, take the same calibration, but assume that the government spending expansion is deficit-financed. Both government spending and government debt increase simultaneously. This rise in government debt leads to a wealth-induced increase in private consumption, and—as in the aggregate—households save less. As a result, the government spending multiplier exceeds unity in the economy with both positive and zero interest rates. But the scale of the responses differs dramatically between the Taylor rule economy and the zero lower bound economy. In the Taylor rule case, growth in aggregate demand pushes up inflation, which in turn leads to a rise in the real interest rate. This substantially reduces the impact of government debt on private consumption. The government spending multiplier rises from unity under a balanced budget expansion to only 1.07 in the economy with deficit financing.

In the economy constrained by the zero lower bound, the inflation generated by the increased government spending leads to a fall in the real interest rate. This substantially increases the government spending multiplier. In the baseline case, the multiplier rises from unity under a balanced budget expansion to approximately 2 under deficit financing of government spending. Thus, while tax-financed government spending has no additional expansionary effects in a liquidity trap, deficit-financed spending is far more expansionary. When the economy is constrained by the zero lower bound, there is a very large difference in the predicted effects of fiscal expansions depending on whether they are financed with debt or with taxes. Deficit spending has a much greater impact on output than tax-financed spending.

An immediate corollary of these results is that the impact of pure tax cuts, holding the path of government spending fixed, is substantially different in the Taylor rule economy to that constrained by the zero lower bound. In the first case, tax cuts generate expansion by increasing private wealth and raising aggregate household saving. Although the economy does not exhibit Ricardian equivalence under the Taylor rule, the scale of the response to tax cuts is very small. With a tax cut of 1 percent of GDP, output rises just 0.08 percent of GDP. Hence as a first approximation, the economy with a Taylor rule has negligible departures from Ricardian equivalence, and tax reductions have little stimulatory effect.

In contrast, at the zero lower bound, tax cuts have a major effect. A tax cut of 1 percent of GDP increases output by about 1 percent of GDP: the tax multiplier is unity. Although they leave the present discounted value of government tax revenues unchanged, tax cuts increase perceived lifetime wealth for currently alive generations. This increases current demand and output. But this in turn boosts inflation, causing real interest rates to fall, and further increasing present aggregate demand.

One aspect of the model that seems somewhat counterfactual is inflation's response in a zero lower bound. Since inflation is purely forward looking in the model, fiscal policies significantly influence inflation, even in a liquidity trap. In fact, fiscal policies influence inflation more with zero interest rates than under a Taylor rule. We could improve the model's performance in this respect by introducing some backward looking elements into the inflation process.

Table 6 also provides some alternative calibrations. In particular, if the interest rate rule is extended to allow for the output gap, setting $\sigma_y = 0.25$, a value close to empirical estimates, then the multiplier impact of all shocks on the output gap is scaled down in the economy governed by the interest rate rule, but the results under the zero lower bound are completely unaffected. The impact of a discount factor shock on output is smaller, because nominal and real interest rates respond more to the shock. The government spending multiplier is also reduced, because real interest rates rise more in response to the shock. Interestingly, the government spending shock is now deflationary, because the decline in household consumption causes real marginal costs to fall. Moreover, tax cuts become even less expansionary in this case than in the baseline calibration.

Table 6. Simulation Results for the Taylor Rule Model
($\sigma_y = 0.25$)

	$\hat{v}$	$\hat{b}$	$\hat{G}$	$\hat{G}-\hat{T}$	$\hat{T}$
$\hat{Y}$	−1.75	0.02	0.59	0.56	−0.03
$\hat{\pi}$	−0.30	0.01	−0.04	0.00	−0.035
$\hat{R}$	−0.36	0.01	0.035	0.00	−0.035

Source: Author's computations.

Table 7 illustrates the case with decreasing returns to scale, setting $\alpha = 0.3$—approximately the measure of capital income share—with an alternative calibration for κ. Shocks' impact on output changes significantly under both interest rate scenarios. Under a Taylor rule, both discount factor shocks and fiscal shocks affect the output gap less. This is because with decreasing returns to scale, the output gap's influence on inflation is greater. This triggers greater compensating

Table 7. Simulation Results

	$\hat{v}$	$\hat{b}$	$\hat{G}$	$\hat{G}-\hat{T}$	$\hat{T}$
Taylor rule model (α = 0.3)					
$\hat{Y}$	−3.00	0.032	0.94	0.89	−0.05
$\hat{\pi}$	−0.57	0.01	0.10	0.03	−0.07
$\hat{R}$	−0.72	0.01	0.027	0.00	−0.027
Zero lower bound model					
$\hat{Y}$	−21.0	0.06	3.62	1.86	−1.76
$\hat{\pi}$	−4.00	0.01	0.58	0.215	−0.36
$\hat{R}$	4.14	−0.01	−0.60	−0.21	0.39

Source: Author's computations.

responses from nominal and real interest rates, reducing the real effects of shocks. Again, the government deficit spending multiplier is less than unity, and the impact of tax cuts is only half that of the baseline case.

In contrast, introducing decreasing returns dramatically magnifies the effects of government spending policies in the economy with a zero lower bound. The balanced budget multiplier now increases to 1.9. The deficit spending multiplier is 3.6, and the tax cut multiplier is 1.8. In this case, fiscal expansions affect inflation more, as marginal cost is more responsive to output movements. This increases the negative impact on real interest rates, generating a much larger expansion in equilibrium output.

To some extent, the very substantial responses of real variables under the zero lower bound arise from the model's lack of capital. It would be interesting to extend the model to allow for endogenous capital accumulation. The results of Christiano, Eichenbaum, and Rebelo (2009), however, suggest that this would not alter the main message of this paper: that there is likely to be a very big difference between tax-financed spending and debt-financed spending in an economy where the nominal interest rate is stuck at zero.

We have assumed that all the debt accumulated during the zero lower bound phase is immediately retired, following a return to positive interest rates. This makes comparing the two cases of positive and zero interest rates simple to present. What if we make the alternative assumption that debt is retired gradually according to the rule described by equation (29)? In that case, the multiplier effects of debt are larger than under the baseline case above, as shown in table 8. While the balanced budget multiplier is still unity, the deficit financing multiplier is over 3, and the tax cut multiplier is over 2. Because debt is expansionary, even in an economy with positive interest rates, the expectation of higher

Table 8. Simulation Results for Zero Lower Bound Model with Gradual Debt Elimination

	$\hat{\upsilon}$	$\hat{b}$	$\hat{G}$	$\hat{G}-\hat{T}$	$\hat{T}$
$\hat{Y}$	−13.7	0.12	3.72	1.00	−2.72
$\hat{\pi}$	−2.68	0.02	0.635	0.00	−0.635
$\hat{R}$	2.15	0.02	−0.533	0.00	0.533

Source: Author's computations.

debt in the future is even more expansionary. Note, however, that unlike the previous case, where the impacts of fiscal policy under the zero lower bound do not depend on the parameters of the interest rate rule at all, these effects will be influenced by the rule. The more sensitive the interest rate to the inflation rate or the output gap in the future, after the Taylor rule has been restored, the smaller will be the multiplier effects of current debt-financed government spending or tax cuts.

4.6 Monetary Policy Options

In the standard New Keynesian model discussed by Christiano, Eichenbaum, and Rebelo (2009), Eggertsson and Woodford (2003, 2004), and Eggertsson (2009), monetary policy has no direct leverage once the economy is at the zero lower bound, since monetary policy is described completely by the use of an interest rate rule. In this case, the only way monetary policy can be used in a liquidity trap is by the announcement of an expansionary monetary policy to follow after the economy returns to positive nominal interest rates. These policies have been explored extensively by Eggertsson and Woodford (2003) and by Jung, Teranishi, and Watanabe (2005). In the current model however, monetary policy can exercise additional leverage, thanks to a real balance effect.[14] The monetary authority can print currency or increase bank reserves, and thereby increase public sector liabilities. At the zero lower bound, this is equivalent to issuing debt. Since the experiment we examined above involved issuing debt to finance tax cuts (or spending expansion), a condition that is retired once the economy returns to a positive nominal interest rate, it turns out that the impact of a debt-financed tax cut described above is equivalent to increasing the money base to finance fiscal transfers to the private sector, and then having this operation reversed once the economy returns to a positive nominal interest rate. Thus, to the extent that deficit financing of tax cuts is an effective macroeconomic tool in dealing with a zero interest rate environment, this is also true of monetary policy expansion, as described.[15]

14. See Ireland (2005) for an analysis of this lever of monetary policy in an OLG model with flexible prices.

15. Note that this is not equivalent to an "unconventional" monetary policy, whereby the central bank purchases private sector obligations with government debt. Our model does not have enough heterogeneity or the presence of risk premia to allow for a complete analysis of such an operation.

Quantitatively, however, it is immediately obvious that the real balance effect cannot significantly affect real GDP. For instance, take a monetary policy operation which directly increases M1, by augmenting the money base. In the United States, money base has more than doubled in the past two years as a result of the emergency procedures implemented by the Federal Reserve. But the total net wealth effects of this have been negligible since even after recent operations, M1 and money base represent very small fractions of total U.S. private sector net wealth. Thus, the impact of monetary operations via direct real balance effects alone would account for small fractions of the debt multipliers reported in tables 4 through 8. As a result, while in principle the model allows for a real balance effect of monetary policy, practically speaking, even in a liquidity trap, increasing monetary aggregates alone would have very small effects, as measured by the present model.

5. Conclusions

This paper has analyzed the impact of government spending, tax cuts, and government deficits in an economy where monetary policy is constrained by the zero lower bound on policy interest rates. We show that deficit-financed government spending may be far more expansionary than tax-financed, under these conditions, even if the difference between the two is small during "normal" times, when the policy rate is governed by a Taylor rule. From a different perspective, this paper makes the case that tax cuts alone may be highly expansionary in a liquidity trap, even if they have almost no impact on aggregate demand during normal times. The results have some substantial implications for the recent debate about the design of fiscal stimulus programs to respond to the 2008−09 global financial crisis. It has been argued that successful fiscal stimulus requires direct government spending rather than tax cuts. The results here suggest that deficit-financed tax cuts alone can be quite successful in targeting aggregate demand. To the extent that a large part of the downturn in the real economy came from a substantial increase in the savings rate, pushing the equilibrium real interest rate below zero, the increase in government debt provided by tax cuts may provide a direct vehicle for private sector saving. This staunches deflationary forces and prevents the perverse response of real interest rates following the initial shock.

One important issue not analyzed here is the welfare consequences of fiscal policy. There are a number of subtle and difficult features associated with welfare evaluation in the present model. First, the model allows for dynamic inefficiency, which in this context implies that the steady state net real interest rate may be negative. In that case, it is well known that an increase in government debt can be Pareto improving. But this argument is not relevant for the analysis of section 4, since the fall in real interest rates in our experiment is a temporary phenomenon. Secondly, an analysis of welfare in the present model would be limited, because the model does not incorporate capital accumulation. Thus, this analysis does not consider the standard crowding out effect of government debt on the long-run capital stock. As discussed in section 3 above, government debt has no impact on steady state output or consumption, but simply increases the steady state real interest rate, tilting the time profile of spending for each generation. Thus, it is likely that this analysis would also miss any first-order effects of government debt on steady state welfare.

Nevertheless, welfare may still be increased using several fiscal policy instruments, even when the economy is in a liquidity trap. In particular, Christiano, Eichenbaum, and Rebelo (2009) show that in a liquidity trap, an increase in direct government spending above the flexible price optimum value of spending can increase welfare. Pursuing this analysis in our model is more difficult, because we do not have a natural social welfare function with which to compare utilities across generations. Calvo and Obstfeld (1988) demonstrate that if a government in the Blanchard-Yaari economy has access to a full menu of redistributional fiscal instruments, the social welfare function in the economy becomes equivalent to that of the Cass-Koopmans neoclassical growth model. In that case, we can directly apply the results of Christiano, Eichenbaum, and Rebelo (2009) to establish that government spending expansion could increase welfare in our model, when the economy is in a liquidity trap. But in such an environment (that is, using the results of Calvo and Obstfeld, 1988), there is no longer a deviation from Ricardian equivalence, so the main focus of interest in the present paper would be lost. Analysis of the impact of short-run stabilization policy on welfare while incorporating departures from Ricardian equivalence would require both a social welfare function, which takes into account intergenerational heterogeneity, and a means of approximating this function, along the lines of Eggertsson and Woodford (2003). Clearly the full exploration of short-run welfare trade-offs in the present model represents an interesting research question. Nevertheless, we defer such an analysis to future research.

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Anchors Aweigh: How Fiscal Policy Can Undermine "Good" Monetary Policy

Eric M. Leeper
Indiana University

Policymakers have long understood that if fiscal policy runs amuck and monetary policy is forced to raise seigniorage revenues, big inflations result. Latin American policymakers understand this outcome better than most. This message is implicit in Cagan's (1956) initial study of hyperinflation, and the message is explicit in Sargent and Wallace's (1981) theoretical analysis of how monetary policy can lose control of inflation and in Sargent's (1983) interpretation of historical episodes of high inflations. The message is forcefully promulgated by international economic organizations that prescribe policy reforms to troubled economies. Underlying this view is the notion that if central bankers display sufficient resolve and stick to their inflation-fighting guns, fiscal policy will eventually relent and reform. Unfortunately, wishing it were so does not make it so.

Recent research on monetary and fiscal policies has shown that the ways in which policies interact to determine inflation and influence the real economy are far more subtle than the "monetization of debt" perspective implies. For example, Sargent and Wallace (1975) find that if the central bank pegs the nominal interest rate—or, more generally, does not adjust the rate strongly with inflation—then the equilibrium inflation rate is undetermined, but this finding is not robust to alternative assumptions about fiscal behavior: Leeper (1991) and others have shown that if primary surpluses are unresponsive to the state of government debt, then inflation is

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uniquely determined. This is not merely of academic interest. Central banks do go through periods when they adjust interest rates weakly to inflation, and many banks are now, in effect, pegging the nominal rate near the zero lower bound. If such behavior endangered price stability by not pinning down the inflation process, this would be of great practical concern.

Another example that has received much attention is that when a government issues nominal debt denominated in its home currency, fluctuations in current or expected primary surpluses can generate important aggregate demand effects.[1] Policies that set the nominal interest rate independently of inflation and primary surpluses independently of outstanding debt represent the canonical case in which a debt-financed tax cut today, which does not carry with it an expectation of higher taxes in the future, raises household wealth and increases aggregate demand. In the standard models used for policy analysis, higher demand raises both output and inflation; higher inflation then serves to revalue outstanding nominal debt. Debt revaluation can be an important source of fiscal financing by ensuring that this mix of policies is sustainable.

This canonical case also points to circumstances in which monetary policy can no longer control inflation. Some observers dismiss the case as special, preferring to stick to the convention that fiscal policy is Ricardian in the sense that expansions in debt are always backed by higher expected primary surpluses (McCallum, 2001). Unfortunately, demographic, political, and economic realities in many countries may not conform to this conventional view.

Within the class of New Keynesian models now in wide use for monetary policy analysis, something of a consensus has developed around what constitutes "good" monetary policy behavior. In terms of implementable simple rules—as opposed to, say, Ramsey optimal solutions—a necessary condition is that the central bank adjust the nominal interest rate more than one-for-one with inflation; this is called the Taylor principle (Taylor, 1993). This principle seems to produce nearly optimal outcomes in models now in use at central banks.[2]

1. The list of contributors to this literature is long, but some key papers include Leeper (1991, 1993), Woodford (1994, 1995), Sims (1994, 2005), Cochrane (1999, 2001), Leith and Wren-Lewis (2000), Schmitt-Grohé and Uribe (2000), Daniel (2001), and Corsetti and Mackowiak (2006).

2. See, for example, Henderson and McKibbin (1993), Rotemberg and Woodford (1997, 1999), Schmitt-Grohé and Uribe (2007), and Taylor (1999b).

In this paper, I explore how the Taylor principle characterization of "good" monetary policy fares in periods of heightened fiscal stress. Fiscal stress is what Chile, the United States, much of Europe, Japan, and a great many other countries are facing in the coming decades as their populations age and government transfer payments for pensions and health care are anticipated to rise substantially as a share of GDP. It is unlikely that tax revenues alone can finance these promised transfers. Some countries are already at or near the peaks of their Laffer curves, according to some estimates (Trabandt and Uhlig, 2009). In those countries, it may be economically impossible to raise sufficient revenues. Other countries, such as the United States, seem to have little tolerance for high tax rates and may find it politically impossible to raise taxes enough. In either scenario, these countries could easily reach their fiscal limits well before the generational storm—in Kotlikoff and Burns's (2004) memorable phrase—has fully played out. At its fiscal limit, a government can no longer follow the conventional prescription by which fiscal policy takes care of itself (and everything else that affects the value of government debt) by financing government debt entirely through future surpluses. By extension, the fiscal limit makes it infeasible for monetary policy to always obey the Taylor principle, for doing so results in unsustainable policies.

At the fiscal limit, macroeconomic policies enter a new realm that economists have only begun to study systematically. Once taxes can no longer adjust and government purchases have achieved their socially acceptable lower bound, only two sources of fiscal financing remain: incomplete honoring of promised transfers and surprise revaluations of outstanding nominal government bonds (or some combination of the two).[3] The first option would permit monetary policy to continue to follow a Taylor principle because, in effect, actual transfers are adjusting to finance government debt. However, the same demographics that are behind the growing transfer payments also create powerful political pressures for democratic governments to honor their earlier promises. The second option allows the government to fully honor its financial commitments, but requires the

3. I take off the table two other options: sovereign debt default and pure inflation taxes. It is difficult to imagine an equilibrium in which many large countries default simultaneously, though this possibility deserves further research. Pure inflation taxes are removed on the grounds that historical experience with hyperinflations has found them to be an extraordinarily costly means of fiscal financing. Moreover, like income taxes, inflation taxes are also subject to a Laffer curve and, therefore, a fiscal limit.

central bank to give up control of inflation. A more likely outcome is some mix of the two options, possibly with policy fluctuating between the two distinct monetary-fiscal regimes. With the mixed outcome, monetary policy would still lose control of inflation, as Davig and Leeper (2006b, 2009), Chung, Davig, and Leeper (2007), and Davig, Leeper, and Walker (forthcoming) show.

No government has made it completely clear to its populace how the coming fiscal storm will be weathered. Existing rules governing fiscal behavior, where they exist, are not obviously robust to an environment in which government transfers constitute a growing fraction of GDP. And how such fiscal rules interact with, say, an inflation-targeting monetary policy is not well understood. Some large countries, like Germany, the United Kingdom, and the United States, seem to have made no provisions whatsoever for dealing with future fiscal stresses. In those countries, the public has no choice but to speculate about how future policies will adjust. Can expectations of inflation and interest rates be anchored by monetary policy in this new policy realm? What will determine such expectations, if not monetary policy? How does the public's speculation about future policy adjustments affect the equilibrium today?

There is much ballyhoo about how a major benefit of having central banks adopt an explicit inflation target is that it contributes in important ways to anchoring private expectations of inflation. There are as many definitions of anchoring expectations as there are people repeating the mantra. Faust and Henderson (2004) grapple with the definition in their thoughtful piece about best-practice monetary policy. Many of their concerns spring from the fact that central banks—even inflation targeters—have multiple objectives and face trade-offs among those objectives. For the purposes of this paper, I simplify the problem by positing that the central bank targets only inflation at π^* and the tax authority targets only government debt at b^*. Faust and Henderson correctly observe that if the primary objective of inflation targeting is to anchor long-run expectations of inflation, then formally this amounts to ensuring that $\lim_{j \to \infty} E_t \pi_{t+j} = \pi^*$. But by this definition of anchoring, as Faust and Henderson point out, best-practice monetary policy permits $\left| E_t \pi_{t+j} - \pi^* \right| > \varepsilon > 0$ for all $j \geq 0$: at times, expected inflation over any forecast horizon will be very far from target.

No inflation-targeting central bank embraces such a liberal definition of anchoring expectations. The Central Bank of Chile aims "to keep annual CPI inflation around 3 percent most of the time"

(Central Bank of Chile, 2007). Sveriges Riksbank targets 2 percent in Sweden (Sveriges Riksbank, 2008). Both Chile and Sweden have a tolerance range of plus or minus 1 percentage point. In New Zealand, the Reserve Bank targets CPI inflation between 1 and 3 percent (Reserve Bank of New Zealand, 2008). It is not apparent from their web pages, but I imagine that all inflation-targeting central banks would interpret "long run" to be something shy of infinity. I also imagine that if in those economies expected inflation could drift arbitrarily far from target for arbitrarily long periods, the central banks would not feel that they have successfully anchored long-run inflation expectations (even if one could prove that the Faust-Henderson limiting condition for expected inflation held). Analogous ranges tend to be applied in ministries of finance and treasuries that have an explicit target for government debt (see, for example, New Zealand Treasury, 2009; Swedish Ministry of Finance, 2008).

In this paper I adopt the more pragmatic notion of anchored expectations that policy authorities seem to apply. If in an equilibrium, expectations of a policy target variable can deviate widely from target for an extended period, then expectations are not well anchored on the announced targets.

Formal theory helps to understand how monetary and fiscal policies interact to determine inflation. I lay out three very simple theoretical models to make concrete the issues that arise in an environment where taxes have reached their limit, but government transfers grow relentlessly. The theory suggests that even if economic agents know how policies will adjust once the economy hits the fiscal limit, it may no longer be possible for monetary policy to achieve its inflation target.[4] Monetary policy's loss of control of inflation begins well before the fiscal limit is hit. Because agents know such a limit exists, monetary policy cannot control inflation even in the period leading up to the limit, when monetary policy dutifully follows the Taylor principle and fiscal policy systematically raises taxes to stabilize debt.

The central bank's problems controlling inflation become more profound in the arguably more plausible environment where agents are uncertain about how monetary and fiscal policies will adjust

4. Sims (2005) makes closely related points in the context of inflation targeting. Sims (2009) explains that as an application of Wallace's (1981) Modigliani-Miller theorem for open market operations, many of the extraordinary measures that central banks have taken over the past year or so run the risk of being insufficiently backed by fiscal policy and, therefore, may make it difficult for monetary policy alone to anchor inflation.

in the future once the fiscal limit is reached. In such a setting it is easy to see how expectations can become unanchored, particularly if monetary and fiscal authorities do little to help resolve uncertainty about future policies.

Policy uncertainty almost certainly reduces welfare. Existing work tends to model the uncertainty in rather stylized forms—a stochastic capital tax, for example—but nonetheless finds that greater uncertainty reduces growth and welfare (Hopenhayn, 1996; Aizenman and Marion, 1993). Uncertainty can also generate an option value for waiting to invest, which slows growth (Bernanke, 1983; Dixit, 1989; Pindyck, 1988). Indeed, one argument for having central banks announce their intended interest rate paths is to reduce uncertainty about monetary policy, which better anchors expectations and improves the effectiveness of monetary policy (Faust and Leeper, 2005; Rudebusch and Williams, 2006; Svensson, 2006). While the implications of uncertainty for welfare are important, I do not pursue them in the positive analysis that follows.

One interpretation of policy uncertainty is in the context of imperfectly credible macroeconomic policies, an application that has been used extensively to analyze policy reforms in developing countries (see, for example, Calvo and Végh, 1993, 1999; Buffie and Atolia, 2007; Calvo, 2007). In that literature, policy uncertainty takes the form of temporary stabilizations, which are implemented, but whose duration is uncertain and, therefore, not credible. Lack of credibility has similar consequences to the presence of a fiscal limit, in that it can undermine the efficacy even of "good" policies.

In light of the profound policy uncertainty that many countries will soon face, I find myself in sympathy with North (1990, p. 83): "The major role of institutions in a society is to reduce uncertainty by establishing a stable (but not necessarily efficient) structure to human interaction. The overall stability of an institutional framework makes complex exchange possible across both time and space." Only the policy institutions themselves— via the desires of the electorate—can help to resolve the uncertainty, and only by reducing uncertainty can policy institutions hope to anchor expectations reliably.

After deriving theoretical results, the paper compares the monetary-fiscal policy frameworks in Chile and the United States. These countries provide interesting contrasts: whereas Chile has adopted specific objectives and even rules for the conduct of monetary and fiscal policy, the United States has consistently eschewed rules-based policies. Chile's policies contribute toward keeping the economy well away from the fiscal limit, permitting the Central Bank of Chile to target inflation and anchor inflation expectations. Chile's policy reforms have made it a leader among emerging economies. In the United States, agents have good reason to be concerned that taxes may reach the fiscal limit, undermining the Federal Reserve's ability to control inflation now and in the future. Perhaps policymakers in the United States and other major economies can learn from the macroeconomic policy reforms adopted by emerging economies.

1. Three Simple Models

I present three models of price-level and inflation determination that increase in the subtlety of the interactions between monetary and fiscal policies. Throughout the analysis I restrict attention to rational expectations equilibria, so the results I present can be readily contrasted to prevailing views, which also are based on rational expectations. The first model draws from Leeper (1991), Sims (1994), and Woodford (2001) to lay the groundwork for how monetary and fiscal policies jointly determine equilibrium. These results are well known, but the broader implications of thinking about macroeconomic policies jointly are not fully appreciated. A second model adds one layer of subtlety by positing that at some known date in the future, call it T, the economy will reach its fiscal limit, at which point it is not possible to raise further revenues. At that limit, the policy regime—the mix of monetary and fiscal rules—changes in some known way. This model illustrates how expectations of future policies can feed back to affect the current equilibrium. The final model adds one more layer of subtlety: although agents know the regime will change at date T, they are uncertain what mix of monetary and fiscal policies will be realized. In this model, agents' expectations of inflation depend on the subjective probabilities they attach to possible future policies. The last two models draw on work in Davig, Leeper, and Walker (forthcoming). The models illustrate how interactions between monetary and fiscal policies, the possibility of regime changes, and uncertainty about future regimes create difficulties for policy authorities who aim to anchor private expectations on the targets of policy.

Each model has a common specification of the behavior of the private sector. An infinitely lived representative household is endowed each period with a constant quantity of nonstorable goods, y.

To keep the focus away from seigniorage considerations, I examine a cashless economy, which can be obtained by making the role of fiat currency infinitesimally small. Government issues nominal one-period bonds, so the price level, P, can be defined as the rate at which bonds exchange for goods.

The household chooses sequences of consumption and bonds, $\{c_t, B_t\}$, to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \tag{1}$$

where $0<\beta<1$, subject to the budget constraint

$$c_t + \frac{B_t}{P_t} + \tau_t = y + z_t + \frac{R_{t-1}B_{t-1}}{P_t}, \tag{2}$$

taking prices and the initial principal and interest payments on debt, $R_{-1}B_{-1} > 0$, as given. The household pays taxes, τ_t, and receives transfers, z_t, each period, both of which are lump sum.

Government spending is zero each period, so the government chooses sequences of taxes, transfers, and debt to satisfy its flow constraint,

$$\frac{B_t}{P_t} + \tau_t = z_t + \frac{R_{t-1}B_{t-1}}{P_t}, \tag{3}$$

given $R_{-1}B_{-1} > 0$, while the monetary authority chooses a sequence for the nominal interest rate.

After imposing goods market clearing, $c_t = y$ for $t \geq 0$, the household's consumption Euler equation reduces to the simple Fisher relation

$$\frac{1}{R_t} = \beta E_t \left(\frac{P_t}{P_{t+1}} \right). \tag{4}$$

The exogenous (fixed) gross real interest rate, $1/\beta$, makes the analysis easier, but it is not without some loss of generality, as Davig, Leeper, and Walker (forthcoming) show in the context of fiscal financing in a model with nominal rigidities. This is less the case in a small open economy, so one interpretation of this model is that it is a small open economy in which government debt is denominated in terms of the home nominal bonds ("currency"), and all debt is held by domestic agents.

1.1 Model 1

I begin with simple fixed policy regimes in order to solidify the understanding of how monetary and fiscal policies jointly determine the equilibrium price level and inflation rate. The focus on price-level determination is entirely for analytical convenience; it is not a statement that inflation is the only thing that macroeconomic policy authorities do or should care about. Because price-level determination is the first step toward understanding how macroeconomic policies affect the aggregate economies, the key insights I derive from this model extend to more complex environments.

1.1.1 Active monetary/passive tax policy

This model reiterates well-known results about how inflation is determined in the canonical model of monetary policy, as presented in textbooks by Galí (2008) and Woodford (2003), for example. This regime—denoted active monetary and passive fiscal policy—combines an interest rate rule in which the central bank aggressively adjusts the nominal rate in response to current inflation with a tax rule in which the tax authority adjusts taxes in response to government debt sufficiently to stabilize debt.[5] In this textbook, best-of-all-possible worlds, monetary policy can consistently hit its inflation target, and fiscal policy can achieve its target for the real value of debt.

To derive the equilibrium price level for the model laid out above, we need to specify rules for monetary, tax, and transfer policies. Monetary policy follows a conventional interest rate rule, which, for analytical convenience, is written somewhat unconventionally in terms of the inverse of the nominal interest and inflation rates:

5. Applying Leeper's (1991) definitions, active monetary policy targets inflation, while passive monetary policy weakly adjusts the nominal interest rate in response to inflation; active tax policy sets the tax rate independently of government debt, and passive tax policy changes rates strongly enough when debt rises to stabilize the debt-GDP ratio; active transfer policy makes realized transfers equal promised transfers, while passive transfer policy allows realized transfers to be less than promised.

$$R_t^{-1} = R^{*-1} + \alpha\left(\frac{P_{t-1}}{P_t} - \frac{1}{\pi^*}\right), \tag{5}$$

where $\alpha > 1/\beta$, π^* is the inflation target, and $R^* = \pi^*/\beta$ is the steady-state nominal interest rate. The condition on the policy parameter α ensures that monetary policy is sufficiently hawkish in response to fluctuations in inflation that it can stabilize inflation around π^*. Fiscal policy adjusts taxes in response to the state of government debt:

$$\tau_t = \tau^* + \gamma\left(\frac{B_{t-1}}{P_{t-1}} - b^*\right), \tag{6}$$

where $\gamma > r = 1/\beta - 1$, b^* is the debt target, τ^* is the steady state level of taxes, and $r = 1/\beta - 1$ is the net real interest rate. Imposing the condition that γ exceeds the net real interest rate guarantees that any increase in government debt creates an expectation that future taxes will rise by enough to both service the higher debt and retire it back to b^*.

For now, I assume that government transfers evolve exogenously according to the following stochastic process:

$$z_t = (1 - \rho)z^* + \rho z_{t-1} + \varepsilon_t, \tag{7}$$

where $0 < \rho < 1$, z^* is steady-state transfers, and ε_t is a serially uncorrelated shock with $E_t\varepsilon_{t+1} = 0$.

Equilibrium inflation is obtained by combining equations (4) and (5) to yield the difference equation:

$$\frac{\beta}{\alpha} E_t\left(\frac{P_t}{P_{t+1}} - \frac{1}{\pi^*}\right) = \frac{P_{t-1}}{P_t} - \frac{1}{\pi^*}. \tag{8}$$

Aggressive reactions of monetary policy to inflation imply that $\beta/\alpha < 1$, and the unique bounded solution for inflation is

$$\pi_t = \pi^*. \tag{9}$$

Equilibrium inflation is therefore always on target, as is expected inflation.[6]

If monetary policy determines inflation—and the path of the price level, $\{P_t\}$—how must fiscal policy respond to disturbances in transfers to ensure that policy is sustainable? This is where passive tax adjustments step in. Substituting the tax rule (equation 6) into the government's budget constraint (equation 3), taking expectations conditional on information at $t - 1$, and employing the Fisher relation (equation 4) yields the expected evolution of real debt:

$$E_{t-1}\left(\frac{B_t}{P_t} - b^*\right) = E_{t-1}(z_t - z^*) + (\beta^{-1} - \gamma)\left(\frac{B_{t-1}}{P_{t-1}} - b^*\right). \tag{10}$$

Because $\beta^{-1} - \gamma < 1$, higher debt brings forth the expectation of higher taxes, so equation (10) describes how debt is expected to return to steady state following a shock to z_t. In a steady state in which $\varepsilon_t \equiv 0$, debt is $b^* = (\tau^* - z^*)/(\beta^{-1} - 1)$, equal to the present value of primary surpluses.

Another perspective on the fiscal financing requirements when monetary policy is targeting inflation emerges from a ubiquitous equilibrium condition. In any dynamic model with rational agents, government debt derives its value from its anticipated backing. In this model, that anticipated backing comes from tax revenues net of transfer payments, $\tau_t - z_t$. The value of government debt can be obtained by imposing equilibrium on the government's flow constraint, taking conditional expectations, and solving forward to arrive at

$$\frac{B_t}{P_t} = E_t \sum_{j=1}^{\infty} \beta^j (\tau_{t+j} - z_{t+j}). \tag{IEC}$$

6. As Cochrane (2007) emphasizes, echoing Obstfeld and Rogoff (1983), there is actually a continuum of explosive solutions to equation (8), each one associated with the central bank threatening to drive inflation to positive or negative infinity if the private sector's expectations are not anchored on π^*. Cochrane uses this logic to argue that fundamentally only fiscal policy can uniquely determine inflation. Pure theory cannot guide us to the unique solution in equation (9), but common sense can. Suppose that equation (5) is not a complete description of policy behavior in all states of the world and that there is a component to policy that says if the economy goes off on an explosive path, monetary policy will change its behavior appropriately to push the economy back to π^*. If that extra component of policy is credible, agents will know that long-run expectations of inflation other than π^* are inconsistent with equilibrium and, therefore, cannot be rational expectations. In this paper, I sidestep this dispute and simply accept the conventional assertion that we are interested in the unique bounded solution in equation (9).

This intertemporal equilibrium condition (IEC) provides a new perspective on the crux of passive tax policy. Because P_t is nailed down by monetary policy and $\{z_{t+j}\}_{j=1}^{\infty}$ is being set independently of both monetary and tax policies, any increase in transfers at t that is financed by new sales of B_t must generate an expectation that taxes will rise in the future by exactly enough to support the higher value of B_t/P_t.

In this model, the only potential source of an expansion in debt is disturbances to transfers. But passive tax policy implies that this pattern of fiscal adjustment must occur regardless of the reason that B_t increases, whether it be economic downturns that automatically reduce taxes and raise transfers, changes in household portfolio behavior, changes in government spending, or central bank open market operations. To expand on the last example, we could modify this model to include money to allow us to imagine that the central bank decides to tighten monetary policy exogenously at t by conducting an open market sale of bonds. If monetary policy is active, then the monetary contraction both raises B_t—bonds held by households— and lowers P_t; real debt rises from both effects. This can be an equilibrium *only if* fiscal policy is expected to support it by passively raising future tax revenues. That is, given active monetary policy, IEC imposes restrictions on the class of tax policies that is consistent with equilibrium; those policies are labeled passive because the tax authority has limited discretion in choosing policy. Refusal by tax policy to adjust appropriately undermines the ability of open market operations to affect inflation in the conventional manner.[7]

A policy regime in which monetary policy is active and tax policy is passive produces the conventional outcome that inflation is always and everywhere a monetary phenomenon, and a hawkish central bank can successfully anchor actual and expected inflation at the inflation target. Tax policy must support the active monetary behavior by passively adjusting taxes to finance disturbances to government debt—from whatever source, including monetary policy—and ensure that policy is sustainable.

7. This is an application of the general insight contained in Wallace (1981). Sargent and Wallace's "unpleasant monetarist arithmetic" (1981) outcome emerges because the tax authority refuses to respond "appropriately," forcing monetary policy in the future to abandon its inflation target. Tobin (1980) emphasizes the distinct consequences for households' portfolios of "normal" central bank operations, such as open market operations, and helicopter drops of money. Section 1.2 picks up this theme.

Although conventional, this regime is not the only mechanism by which monetary and fiscal policy can jointly deliver a unique bounded equilibrium. I now turn to the other polar case.

1.1.2 Passive monetary/active tax policy

Passive tax behavior is a stringent requirement: the tax authority must be willing and able to raise taxes in the face of rising government debt. For a variety of reasons, this does not always happen, and it certainly does not happen in the automated way prescribed by the tax rule in equation (6). Sometimes political factors—such as the desire to seek reelection—prevent taxes from rising as needed to stabilize debt.[8] Some countries simply do not have the fiscal infrastructure in place to generate the necessary tax revenues. Others might be at or near the peak of their Laffer curves, suggesting they are close to the fiscal limit.[9] In this case, tax policy is active and $0 \leq \alpha < 1/\beta - 1$.

Analogously, there are also periods when the concerns of monetary policy move away from inflation stabilization and toward other matters, such as output stabilization or financial crises. These are periods in which monetary policy is no longer active, instead adjusting the nominal interest rate only weakly in response to inflation. The global recession and financial crisis of 2007−09 is a striking case in which central banks' concerns shifted away from inflation. Then monetary policy is passive and, in terms of policy rule (5), $0 \leq \alpha < 1/\beta$.[10]

I focus on a particular policy mix that yields clean economic interpretations: the nominal interest rate is set independently of inflation, $\alpha = 0$ and $R_t^{-1} = R^{*-1} \geq 1$, and taxes are set independently of debt, $\gamma = 0$ and $\tau_t = \tau^* > 0$. These policy specifications might seem extreme and special, but the qualitative points that emerge generalize to other specifications of passive monetary/active tax policies.

8. Davig and Leeper (2006b, 2009) generalize equation (6) to estimate Markov switching rules for the United States and find that tax policy has switched between periods when taxes rise with debt and periods when they do not.

9. Trabandt and Uhlig (2009) characterize Laffer curves for capital and labor taxes in fourteen European Union countries and the United States. They find that some countries (namely, Denmark and Sweden) are on the wrong side of the curve, suggesting that those countries must lower tax rates to raise revenues.

10. Davig and Leeper (2006b, 2009) provide evidence of this for the United States, and Davig and Leeper (2007) study the nature of equilibria when monetary policy regularly switches between being active and being passive.

One result pops out immediately. When the pegged nominal interest rate policy is applied to the Fisher relation, equation (4) yields

$$E_t\left(\frac{P_t}{P_{t+1}}\right)=\frac{1}{\beta R^*}=\frac{1}{\pi^*}, \tag{11}$$

so expected inflation is anchored on the inflation target, an outcome that is perfectly consistent with one aim of inflation-targeting central banks. It turns out, however, that another aim of inflation targeters—the stabilization of actual inflation—that can be achieved by active monetary/passive fiscal policy, is no longer attainable.

Impose the active tax rule on the intertemporal equilibrium condition (IEC),

$$\frac{B_t}{P_t}=\left(\frac{\beta}{1-\beta}\right)\tau^*-E_t\sum_{j=1}^{\infty}\beta^j z_{t+j}, \tag{12}$$

and use the government's flow constraint (equation 3) to solve for the price level:

$$P_t=\frac{R^*B_{t-1}}{\left(\frac{1}{1-\beta}\right)\tau^*-E_t\sum_{j=0}^{\infty}\beta^j z_{t+j}}. \tag{13}$$

At time t, the numerator of this expression is predetermined, representing the nominal value of household wealth carried into period t. The denominator is the expected present value of primary fiscal surpluses from date t on, which is exogenous. So long as $R^*B_{t-1}>0$ and the present value of revenues exceeds the present value of transfers (a condition that must hold if government debt has positive value), expression (13) delivers a unique $P_t>0$.

I have done nothing mystical here, despite what some critics claim (for example, Buiter, 2002; McCallum, 2001). In particular, the government is not assumed to behave in a manner that violates its budget constraint. Unlike competitive households, the government is not required to choose sequences of control variables that are consistent with its budget constraint for all possible price sequences. Indeed, for a central bank to target inflation, it cannot be choosing its policy instrument to be consistent with any sequence of the price level; doing so would produce an indeterminate equilibrium. Identical reasoning applies to the fiscal authority: the value of a dollar of debt—$1/P_t$—depends on expectations about fiscal decisions in the future; expectations, in turn, are determined by the tax rule the fiscal authority announces. The fiscal authority credibly commits to its tax rule, and, given the process for transfers, this determines the backing of government debt and thus its market value.[11]

As remarkable as it may seem, given the solution for the price level in equation (13) to compute expected inflation, it is straightforward to show that $\beta E_t(P_t/P_{t+1}) = 1/R^*$, as required by the Fisher relation and monetary policy behavior.[12] This observation leads to a sharp dichotomy between the roles of monetary and fiscal policy in price-level determination: monetary policy alone appears to determine *expected* inflation by choosing the level at which to peg the nominal interest rate, R^{*-1}, while conditional on that choice, fiscal variables appear to determine *realized* inflation.

To explain the nature of this equilibrium, I need to delve into the underlying economic behavior. This is an environment in which changes in debt do not elicit any changes in expected taxes, unlike in the previous section. First consider a one-off increase in current transfer payments, z_t, financed by new debt issuance, B_t. With no offsetting increase in current or expected tax obligations, households feel wealthier and try to shift up their consumption paths. Higher demand for goods drives up the price level, until the wealth effect dissipates and households are content with their initial consumption plan. This is why in expression (12) the value of debt at t changes with expected, but not current, transfers. Now imagine that at time t households receive news of higher transfers in the future. There is no change in nominal debt at t, but there is still an increase in

11. Cochrane (2001) refers to the intertemporal equilibrium condition (IEC), or equation (12), as a debt valuation equation and reasons that government debt gets valued analogously to equities.

12. To see this, compute

$$E_{t-1}\frac{1}{P_t} = \frac{\left(\frac{1}{1-\beta}\right)\tau^* - E_{t-1}\sum_{j=0}^{\infty}\beta^j z_{t+j}}{R^* B_{t-1}}.$$

To find expected inflation, simply use the date $t-1$ version of equation (13) for P_{t-1} and simplify to obtain

$$\beta E_t(P_t/P_{t+1}) = 1/R_{t-1} = 1/R^*.$$

household wealth. Through the same mechanism, P_t must rise to revalue current debt to be consistent with the new expected path of transfers: the value of debt falls in line with the lower expected present value of surpluses.

Cochrane (2009, p. 5) offers another interpretation of the equilibrium in which "'aggregate demand' is really just the mirror image of demand for government debt." An expectation that transfers will rise in the future reduces the household's assessment of the value of government debt. Households can shed debt only by converting it into demand for consumption goods, hence the increase in aggregate demand that translates into a higher price level.

Expression (13) highlights that in this policy regime, the impacts of monetary policy change dramatically. When the central bank chooses a higher rate at which to peg the nominal interest rate, the effect is to *raise* the price level next period. This echoes Sargent and Wallace (1981), but the economic mechanism is different. In the current policy mix, a higher nominal interest rate raises the interest payments the household receives on the government bonds it holds. Higher R^*B_{t-1}, with no higher anticipated taxes, raises household wealth, triggering the same adjustments as above. In this sense, as in Sargent and Wallace, monetary policy has lost control of inflation.

This section has reviewed existing results on price-level determination under alternative monetary-fiscal policy regimes. In each regime the price level is uniquely determined, but the impacts of changes in policy differ markedly across the two regimes. We now apply the notion that there is a fiscal limit to create a natural setting that blends the two regimes just considered.

1.2 Model 2

The second model adds a layer of subtlety to the analysis in sections 1.1.1 and 1.1.2. The limit to the degree of taxation a society will tolerate is modeled by imposing the condition that at some known date in the future, T, taxes have reached this maximum allowable level, $\tau^{\max}$.[13] Leading up to T, policy is in the active monetary/passive

13. In this model with lump-sum taxes, there is no upper bound for taxes or debt, as long as debt does not grow faster than the real interest rate. In a more plausible production economy, in which taxes distort behavior, there would be a natural fiscal limit. See Davig, Leeper, and Walker (forthcoming) for further discussion and Bi (2009) for an application of an endogenous fiscal limit to the problem of sovereign debt default.

fiscal regime described above, but from date T on, tax policy has no option but to become active, with $\tau_t = \tau^{\max}$ for $t \geq T$. If monetary policy remained active, neither authority would stabilize debt, and debt would explode. Existence of equilibrium requires that monetary policy switch to being passive, which stabilizes debt.[14] Table 1 summarizes the assumptions about policy behavior.

To solve for this equilibrium, I break the intertemporal equilibrium condition into two parts:

$$\frac{B_0}{P_0} = E_0 \sum_{j=1}^{T-1} \beta^j s_j + E_0 \sum_{j=T}^{\infty} \beta^j s_j, \tag{14}$$

where the function for the primary surplus, s_t, changes at the fiscal limit,

$$s_t = \begin{cases} \tau^* - \gamma(B_{t-1}/P_{t-1} - b^*) - z_t, & t = 0,1,...,T-1 \\ \tau^{\max} - z_t, & t = T,...,\infty. \end{cases} \tag{15}$$

Table 1. Monetary-Fiscal Policy Regimes Before and After the Fiscal Limit at Date *T*

	Regime 1 $t=0,1,\ldots, T-1$	*Regime 2* $t=T,T+1,\ldots$
Monetary policy	$R_t^{-1} = R^{*-1} + \alpha\left(\frac{P_{t-1}}{P_t} - \frac{1}{\pi^*}\right)$	$R_t^{-1} = R^{*-1}$
Tax policy	$\tau_t = \tau^* + \gamma\left(\frac{B_{t-1}}{P_{t-1}} - b^*\right)$	$\tau_t = \tau^{\max}$

Source: Author's elaborations.

14. Monetary policy is forced to switch because the fiscal limit is assumed to be an absorbing state. Davig and Leeper (2009) display an equilibrium in which active fiscal policy is a recurring state, so that it is feasible for both policies to be active simultaneously, as least temporarily.

Expression (14) decomposes the value of government debt at the initial date into the expected present value of surpluses leading up to the fiscal limit and the expected present value of surpluses after the limit has been hit.

Evaluating the second part of equation (14) and letting $\tau^{max} = \tau^*$, after the limit is hit at T,

$$\begin{aligned} E_0 \sum_{j=T}^{\infty} \beta^j s_j &= E_0 \left(\frac{B_{T-1}}{P_{T-1}} \right) \\ &= \frac{\beta^T}{1-\beta}(\tau^* - z^*) - \frac{(\beta\rho)^T}{1-\beta\rho}(z_0 - z^*). \end{aligned} \tag{16}$$

The first part of equation (14) is a bit messier, as it involves solving for the endogenous taxes that are responding to the state of government debt before the fiscal limit is hit. That part of equation (14) may be written as

$$\begin{aligned} E_0 \sum_{j=1}^{T-1} \beta^j s_j &= \sum_{j=1}^{T-1} \left(\frac{\beta}{1-\gamma\beta} \right)^j \left[(\tau^* - \gamma b^*) - E_0 z_j \right] \\ &= (\tau^* - \gamma b^* - z^*) \sum_{j=1}^{T-1} \left(\frac{\beta}{1-\gamma\beta} \right)^j - (z_0 - z^*) \sum_{j=1}^{T-1} \left(\frac{\beta\rho}{1-\gamma\beta} \right)^j. \end{aligned} \tag{17}$$

Pulling together equations (16) and (17) yields equilibrium real debt at date $t = 0$ as a function of fiscal parameters and the date 0 realization of transfers:

$$\begin{aligned} \frac{B_0}{P_0} = (\tau^* - \gamma b^* - z^*) \sum_{i=1}^{T-1} \left(\frac{\beta}{1-\gamma\beta} \right)^i - (z_0 - z^*) \sum_{i=1}^{T-1} \left(\frac{\beta\rho}{1-\gamma\beta} \right)^i \\ + \left(\frac{\beta}{1-\gamma\beta} \right)^{T-1} \left[\frac{\beta^T}{1-\beta}(\tau^{\max} - z^*) - \frac{(\beta\rho)^T}{1-\beta\rho}(z_0 - z^*) \right]. \end{aligned} \tag{18}$$

This expression determines the equilibrium value of debt. The value of debt at $t = 0$ and, by extension, at each date in the future is uniquely determined by parameters describing preferences and fiscal behavior, and by the exogenous realization of transfers at that date. We arrive at this expression by substituting out the endogenous sequence of taxes before the fiscal limit. Apparently this economy will not exhibit Ricardian equivalence even if tax policy obeys a rule that raises taxes to retire debt back to the steady-state level. This occurs despite the fact that such a tax rule delivers Ricardian equivalence in the absence of a fiscal limit, as it did in section 1.1.1.

Two other implications are immediate. Higher transfers at time 0, z_0, which portend a higher future path of transfers because of their positive serial correlation, reduce the value of debt. This occurs for the reasons laid out in section 1.1.2: higher expected government expenditures reduce the backing and, therefore, the value of government liabilities. A second immediate implication is more surprising. How aggressively tax policy responds to debt before hitting the fiscal limit, as parameterized by γ, matters for the value of debt. Permanent active monetary/passive tax policies, in contrast, produce Ricardian equivalence in this model, so the timing of taxation is irrelevant: how rapidly taxes stabilize debt has no bearing on the value of debt. Both of these unusual implications are manifestations of the breakdown in Ricardian equivalence that occurs when there is the prospect that at some point the economy will hit a fiscal limit, beyond which taxes will no longer adjust to finance debt.[15]

I now turn to how the equilibrium price level is determined. Given B_0/P_0 from equation (18) and calling the right side of equation (18) b_0, use the government's flow budget constraint at $t = 0$ and the fact that $s_0 = \tau_0 - z_0$, with taxes following the rule shown in table 1, to solve for P_0:

$$P_0 = \frac{R_{-1}B_{-1}}{b_0 + \tau_0 - z_0}. \tag{19}$$

Given $R_{-1}B_{-1} > 0$, equation (19) yields a unique $P_0 > 0$. Entire sequences of equilibrium $\{P_t, R_t^{-1}\}_{t=0}^{\infty}$ are solved recursively: having solved for B_0/P_0 and P_0, obtain R_0 from the monetary policy rule in table 1, and derive the nomimal value of debt. Then use equation

15. This is not to suggest that one cannot concoct Ricardian scenarios. For example, because T is known, if the government were to commit to fully financing the change in the present value of transfers that arises from a shock to z_0 before the economy reaches the fiscal limit, one could obtain a Ricardian outcome. But this is driven by the fact that T is known. If T were uncertain, as in Davig, Leeper, and Walker (forthcoming), with some probability of occurring at every date, even this cooked-up scenario would not produce a Ricardian result.

(18) redated at $t = 1$ to obtain equilibrium B_1/P_1 and the government budget constraint at $t = 1$ to solve for P_1 using equation (19) redated at $t = 1$, and so forth.

The equilibrium price level has the same features as it does under the passive monetary/active tax regime in section 1.1.2. Higher current or expected transfers, which are not backed in present-value terms by expected taxes, raise household wealth, increase demand for goods, and drive up the price level (reducing the value of debt). A higher pegged nominal interest rate raises nominal interest payments, raising wealth and the price level next period. Similarities between this equilibrium and that in section 1.1.2 stem from the fact that price-level determination is driven by beliefs about policy in the long run. From T on, this economy is identical to the fixed-regime passive monetary/active fiscal policies economy and it is beliefs about long-run policies that determine the price level. Before the fiscal limit, the two economies are quite different, and the behavior of the price level will also be different.

In this environment where the equilibrium price level is determined entirely by fiscal considerations through its interest rate policy, monetary policy determines the expected inflation rate. Combining equation (4) with equation (5) yields an expression in expected inflation:

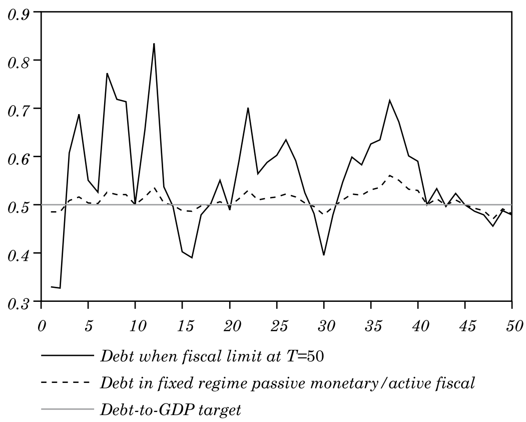
$$E_t\left(\frac{P_t}{P_{t+1}} - \frac{1}{\pi^*}\right) = \frac{\alpha}{\beta}\left(\frac{P_{t-1}}{P_t} - \frac{1}{\pi^*}\right), \tag{20}$$

where monetary policy behaves as table 1 specifies.

As argued above, the equilibrium price level sequence, $\{P_t\}_{t=0}^{\infty}$, is determined by versions of equations (18) and (19) for each date t, so equation (20) describes the evolution of expected inflation. Given equilibrium P_0 from equation (19) and an arbitrary P_{-1} (arbitrary because the economy starts at $t = 0$ and cannot possibly determine P_{-1}, regardless of policy behavior) equation (20) shows that $E_0(P_0/P_1)$ grows relative to the initial inflation rate. In fact, throughout the active monetary policy/passive fiscal policy phase, for $t = 0,1,\ldots,T - 1$, expected inflation grows at the rate $\alpha\beta^{-1} > 1$. In periods $t \geq T$, monetary policy pegs the nominal interest rate at R^*, and expected inflation is constant: $E_t(P_t/P_{t+1}) = (R^*\beta)^{-1} = 1/\pi^*$.

The implications of the equilibrium laid out in equations (18), (19), and (20) for government debt, inflation, and the anchoring of expectations on the target values (b^*, π^*) are most clearly seen in a simulation of the equilibrium. Figure 1 contrasts the paths of the debt-to-GDP ratio from two models: the fixed passive monetary/active tax regime in section 1.1.2 (dashed line) and the present model in which an active monetary/passive tax regime is in place until the economy hits the fiscal limit at date T, when policies switch permanently to a passive monetary/active tax combination (solid line).[16] The fixed regime displays stable fluctuations of real debt around the 50 percent steady-state debt-to-GDP, which the other model also produces once it hits the fiscal limit. Leading up to the fiscal limit, however, it is clear that the active monetary/passive tax policy combination does not keep debt near the target.

Figure 1. Debt-to-GDP Ratios for a Particular Realization of Transfers in Models 1 and 2[a]



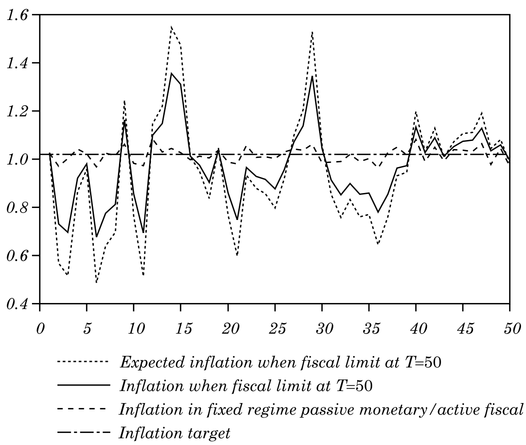
a. Model 1 is the fixed passive monetary/active tax regime described in section 1.1.2 (represented by the dashed line in the figure); in model 2, an active monetary/passive tax regime is in place until the economy hits the fiscal limit at date T, when policy switches permanently to a passive monetary/active tax combination (solid line).

Expected inflation evolves according to equation (20). Since monetary policy is active leading up to the fiscal limit, with $\alpha > 1/\beta$,

16. Figures 1 through 4 use the following calibration. Leading up to the fiscal limit, $\alpha = 1.50$ and $\gamma = 0.15$. At the limit and in the fixed-regime model, $\alpha = \gamma = 0.0$. I assume steady-state values $\tau^* = 0.19$, $z^* = 0.17$, $\pi^* = 1.02$ (gross inflation rate), and $1/\beta = 1.04$, so that $b^* = 0.50$. The transfer process has $\rho = 0.90$ and $\sigma = 0.003$. Identical realizations of transfers were used in all the figures.

there is no tendency for expected inflation to be anchored on the inflation target. Figure 2 plots the inflation rate from the fixed-regime model in section 1.1.2 (dashed line) and from the present model (solid line), along with expected inflation from the present model (dotted dashed line). Inflation in the fixed regime fluctuates around $1/\pi^*$, and expected inflation is anchored on target, given the pegged nominal interest rate. In the period leading up to the fiscal limit, however, the price level is being determined primarily by fluctuations in the real value of debt, which deviates wildly from b^* as shown in figure 1. Expected inflation in that period, though not independent of the inflation target, is certainly not anchored by the target. Instead, under active monetary policy, the deviation of expected inflation from target grows with the deviation of actual inflation from target in the previous period. The figure shows how equation (20) makes expected inflation *follow* actual inflation, with active monetary policy amplifying movements in expected inflation.

Figure 2. Inflation for a Particular Realization of Transfers in Models 1 and 2[a]



a. Model 1 is the fixed passive monetary/active tax regime described in section 1.1.2 (represented by the dashed line in the figure); in model 2, an active monetary/passive tax regime is in place until the economy hits the fiscal limit at date T, when policy switches permanently to a passive monetary/active tax combination (solid line).

The result for periods $t = 0,1,\ldots,T-1$ is reminiscent of Loyo's (1999) analysis of Brazilian monetary-fiscal interactions in the 1980s. Throughout the 1970s, Brazilian tax policy was active and monetary policy was passive. Inflation, interest rates, and primary deficits were stable. In 1980, partly in response to pressure from international organizations, Brazilian monetary policy switched to being active. Doubly active policies is essentially what is going on in the model above, because the knowledge that taxes will hit their limit at time T prevents expected surpluses from that period on from adjusting to satisfy the intertemporal equilibrium condition. In Brazil, when monetary policy switched to being active, with no corresponding switch to a passive fiscal policy, inflation and interest rates began to grow rapidly, even though there was no change in seigniorage revenues. Loyo's analysis reverses the ordering of this model, with passive monetary/active fiscal policy before T, and doubly active policies after.

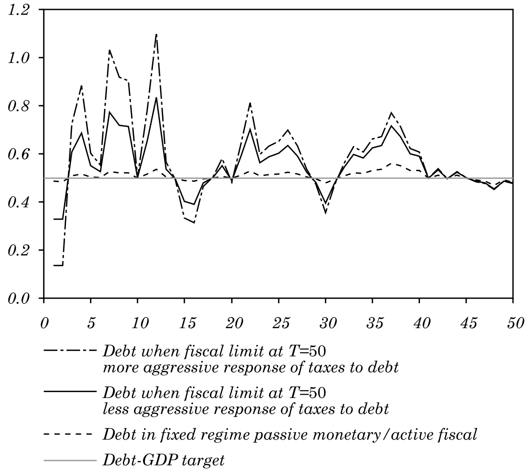
To underscore the extent to which inflation is unhinged from monetary policy, even in the active monetary/passive tax regime before the fiscal limit, suppose that tax policy reacts more aggressively to debt. A higher value of γ in equation (6) can have unexpected consequences. Expression (18) makes clear that raising γ, which in a fixed active monetary/passive tax regime would stabilize debt more quickly, amplifies the effects of transfer shocks on debt. A more volatile value of debt, in turn, translates into more volatile actual and expected inflation.

Figures 3 and 4 show this result by repeating the previous figures, but with a passive tax policy that responds more strongly to debt (γ is raised from 0.10 to 0.15). Figures 3 and 4 also illustrate a general phenomenon: as the economy approaches the fiscal limit at time T, the equilibria under different tax policies converge. As also shown in figures 1 and 2, as time approaches T, the equilibrium also converges to the fixed-regime economy.

An analogous exercise for monetary policy illustrates its impotence when there is a fiscal limit. A more hawkish monetary policy stance, represented by a higher α in equation (5), has no effect whatsoever on the value of debt and inflation: α does not appear in expression (18) for real debt or in expression (19) for the price level. More hawkish monetary policy does, however, amplify the volatility of expected inflation, as the evolution of expected inflation in equation (20) shows.

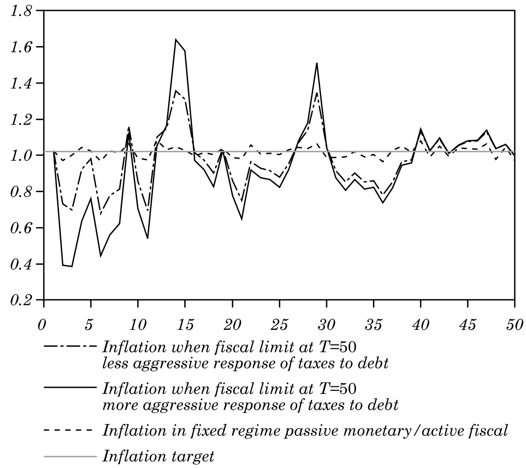
Because monetary policy loses control of inflation after the fiscal limit is reached, forward-looking behavior implies that it also loses control of inflation before the fiscal limit is hit. By extension, changes in fiscal behavior in the period leading up to the limit affects both the equilibrium inflation process and the process for expected inflation.

Figure 3. Debt-to-GDP Ratios for Two Settings of Tax Policy[a]



a. The figure presents the fixed passive monetary/active fiscal regime described in section 1.1.2 (model 1, represented by the dashed line in the figure), plus two settings of tax policy before the economy hits the fiscal limit at date T under an active monetary/passive fiscal regime (model 2): a weaker response of taxes to debt ($\gamma = 0.15$, represented by the solid line) and a stronger response of taxes to debt ($\gamma = 0.17$, represented by the dotted dashed line).

Figure 4. Inflation for Two Settings of Tax Policy[a]



a. The figure presents actual inflation in the fixed passive monetary/active fiscal regime described in section 1.1.2 (model 1, represented by the dashed line in the figure), plus expected inflation under two settings of tax policy before the economy hits the fiscal limit at date T under an active monetary/passive fiscal regime (model 2): a weaker response of taxes to debt ($\gamma = 0.15$, represented by the solid line) and a stronger response of taxes to debt ($\gamma = 0.17$, represented by the dotted dashed line).

1.3 Model 3

The two models presented above contain no uncertainty about future policy regime, making the rather implausible—though extremely common—assumption that agents know exactly what monetary and fiscal policies will be in effect at every date in the future. Although this assumption is maintained in nearly all macroeconomic studies, it is difficult to reconcile the assumption with observed policy behavior. In fact, policies do change, and therefore they can change. In the face of a history of changes in policy regimes, analyses that fail to incorporate the possibility of regime change into expectations formation run the risk of misspecifying expectations and providing misleading policy advice.[17] Given the prominent role ascribed to expectations formation in policy discussions and deliberations, this is a potentially serious misspecification of policy models.

I introduce uncertainty about policy in a stark fashion that allows me to extract some implications of policy uncertainty while retaining analytical tractability. The economy continues to hit the fiscal limit at a known date T, at which point taxes become active, setting $\tau_t = \tau^{\max}$ for all $t \geq T$. Uncertainty arises because at the limit agents place a probability q on a regime that combines passive monetary policy with active transfer policy and a probability $1 - q$ on a regime with active monetary policy and passive transfer policy. In polite company, passive transfer policy is referred to as entitlements reform.[18] To avoid the tangle of euphemisms, I refer to this as reneging on promised transfers. Instead of receiving promised transfers of z_t at time t, agents receive $\lambda_t z_t$, with $\lambda_t \in [0,1]$, so λ_t is the fraction of promised transfers that the government honors. Budget constraints for the household and the government, equations (2) and (3), are modified to replace z_t with $\lambda_t z_t$.

Aging populations in many countries represent a looming fiscal crisis that offers a practical motivation for considering the

17. This is the theme of Cooley, LeRoy, and Raymon (1982, 1984), Sims (1982, 1987), Andolfatto and Gomme (2003), Leeper and Zha (2003), Davig (2004), Davig and Leeper (2006a, 2006b, 2007, 2009), Chung, Davig, and Leeper (2007), and Davig, Leeper, and Walker (forthcoming).

18. To quote the *New York Times*, "Just about everybody agrees that solving the deficit depends on reducing the benefits that current law has promised to retirees, via Medicare and Social Security. That's not how people usually put it, of course. They tend to use the more soothing phrase 'entitlement reform.' But entitlement reform is just another way of saying that we can't pay more in benefits than we collect in taxes" (D. Leonhardt, "A Drop in the Wrong Bucket," *New York Times*, 29 October 2009).

possibility that governments may not honor their promises. Some countries—including Australia, Chile, New Zealand, Norway, and Sweden—are preparing for the demographic shifts through the creation of superannuation funds or the adoption of fiscal rules that aim to have surpluses that can be saved to meet future government obligations. Other countries—such as Germany, the United Kingdom, and the United States—are entering the period of enhanced fiscal stress unprepared. In both sets of countries, there is uncertainty about exactly how the government will finance its obligations, but in the unprepared countries, government reneging on promised transfers is a real possibility. This possibility potentially has important impacts on expectations formation and economic decisions today.

For simplicity I reduce the previous models to just four periods. In the initial two periods ($t = 0,1$), the fiscal limit has not been reached, promised transfers follow the process in equation (7), monetary policy is active, and tax policy is passive. The economy begins with $R_{-1}B_{-1} > 0$ given and some arbitrary P_{-1}. This is equivalent to the time period $t = 0,\ldots,T - 1$ in section 1.2. At the beginning of period two ($t = 2$), the fiscal limit is reached, but agents remain uncertain about which mix of policies will be adopted. This uncertainty is resolved at the end of period 2. In period 3, there is no uncertainty about policy, so period 3 is completely analogous to section 1.2 for $t = T, T + 1,\ldots$

Combining the Fisher relation (equation 4) with the active monetary policy rule (equation 5) for periods 0 and 1 yields

$$E_0\left(\frac{P_1}{P_2}-\frac{1}{\pi^*}\right)=\frac{\alpha^2}{\beta^2}\left(\frac{P_{-1}}{P_0}-\frac{1}{\pi^*}\right), \tag{21}$$

and combining the government budget constraint (equation 3) with the passive tax rule (equation 6) yields

$$E_0\left(\frac{B_1}{P_1}-b^*\right)=E_0(z_1-z^*)+(\beta^{-1}-\gamma)\left(\frac{B_0}{P_0}-b^*\right). \tag{22}$$

Agents know that the fiscal limit will be reached in the next period ($t = 2$) and policy will switch to either a passive monetary/active transfer regime with probability q or an active monetary/passive transfer regime with probability $(1 - q)$. Assume that the reneging rate is fixed and known at $t = 0$, so $\lambda_2 = \lambda_3 = \lambda \in [0,1]$. Then the conditional probability distribution of these policies is given by

$$\begin{cases} q & R_2^{-1} = R^{*-1}, & z_2 = \rho z_1 + \varepsilon_2 \\ (1-q) & R_2^{-1} = R^{*-1} + \alpha\left(\dfrac{P_1}{P_2} - \dfrac{1}{\pi^*}\right), & \lambda z_2 = \lambda\rho z_1 + \lambda\varepsilon_2. \end{cases}$$

The analogs of equations (21) and (22) for period 2 are

$$E_2\left(\frac{P_2}{P_3} - \frac{1}{\pi^*}\right) = (1-q)\frac{\alpha}{\beta}\left(\frac{P_1}{P_2} - \frac{1}{\pi^*}\right) \tag{23}$$

and

$$E_1\left(\frac{B_2}{P_2} - b^*\right) = \left[q + (1-q)\lambda\right]E_1 z_2 - z^* + \beta^{-1}\left(\frac{B_1}{P_1} - b^*\right). \tag{24}$$

In equation (24), to make the relationships transparent, I have imposed that $\tau^{\max} = \tau^*$, the steady-state level of taxes.

In period 3, τ_3 is set to completely retire debt ($B_3 = 0$) no matter which policy regime is realized in period 2. This corresponds to $\tau_3 = \delta z_3 + (R_2 B_2)/P_3$, where $\delta = 1$ if the economy is in the passive monetary/active transfer regime and $\delta = \lambda$ if the active monetary/passive transfer regime is realized. This assumption implies that agents know one period in advance which tax policy will be in place in the final period.

Combining equations (21) and (23) yields a relationship between expected inflation between periods 2 and 3 and actual inflation in the initial period

$$E_0\left(\frac{P_2}{P_3} - \frac{1}{\pi^*}\right) = (1-q)\frac{\alpha^3}{\beta^3}\left(\frac{P_{-1}}{P_0} - \frac{1}{\pi^*}\right). \tag{25}$$

Given the discount rate β, this solution for expected inflation shows that whether expected inflation converges to target or drifts from target depends on the probability of switching to passive monetary/active transfer policies relative to how hawkishly monetary policy targets inflation when it is active. For the deviation of expected inflation from target to be smaller than the deviation of actual inflation from target in period $t = 0$, it is necessary that $q > 1 - (\beta/\alpha)^3$. The longer the period leading up to the fiscal limit, the larger must q be to ensure that equation (25) is stable. It may seem paradoxical, but the more hawkish is policy—the larger is α—the greater must be the probability that monetary policy will be passive (dovish?) in the future in order for the evolution of expected inflation to be stable. Resolution of this paradox comes from recognizing that when $q = 1$, such that monetary policy is known to be passive at the fiscal limit, expected inflation is anchored on π^*, whereas when $q = 0$, such that transfer policy is known to be passive at the limit, then equation (25) yields equilibrium inflation, just as in section 1.1.1.

Since we assume that taxes in period 3 are known, and they are a function of exogenous objects, we can treat τ_3 as fixed. Combining equations (22) and (24) and imposing that $B_3 = 0$, as is the debt target in the last period,

$$\frac{B_0}{P_0} - b^* = \left(\frac{1}{\beta^{-1} - \gamma}\right) E_0\left\{\beta^2\left[(\tau_3 - \tau^*) - (\vartheta z_3 - z^*)\right] - \beta(\vartheta z_2 - z^*) - (z_1 - z^*)\right\}, \tag{26}$$

where $\vartheta = q + (1 - q)\lambda$ determines expected post-reneging transfers.

Equation (26) uniquely determines the value of debt in period 0 as a function of the expected present value of surpluses. We can combine equation (26) with the government's flow constraint at $t = 0$ to obtain a unique expression for P_0 as a function of $R_{-1}B_{-1}$, τ_0, z_0, and the parameters in the expression for equilibrium B_0/P_0.

The solution in equation (26) leads to the following inferences. As q—the probability of switching to the passive monetary/active transfer regime—rises, the value of debt at 0 falls, and P_0 rises. In addition, as λ—the fraction of transfers on which the government reneges in periods 2 and 3—falls, the value of debt at 0 falls, and the price level rises. Both of the consequences for P_0 operate through standard fiscal theory wealth effects. Higher q means that the government is less likely to renege, so expected transfers and, therefore, household wealth rise. Households attempt to convert the higher wealth into consumption goods, driving up the price level until real wealth falls sufficiently that they are content to consume their original consumption place. Lower λ also raises the expected value of transfers, increasing wealth and the price level.

Expectational effects associated with switching policies can be seen explicitly in equations (25) and (26). Equation (26) shows that the value of debt is still determined by the discounted expected value of net surpluses. In contrast to the previous models without uncertainty about future policies, now the actual surplus is conditional on the realized policy regime. Conditional on information at time $t = 0$, the expected transfers process in periods 2 and 3 is unknown. If $q \in (0,1)$ and at the end of period 2 passive monetary policy is realized, agents will be surprised by amount $z_2(1 - q)(1 - \lambda)$ in period 2 and by amount $z_3(1 - q)(1 - \lambda)$ in period 3. With transfers surprisingly high—because the passive transfer regime with reneging was not realized—households feel wealthier and try to convert that wealth into consumption. This drives up the price level in periods 2 and 3, revaluing debt downward. This surprise acts as an innovation to the agent's information set due to policy uncertainty. Naturally, as agents put a high probability on this regime occurring ($q \approx 1$) or assume that the amount of reneging is small ($\lambda_2, \lambda_3 \approx 1$), the surprise is also small, and vice versa.

Comparing equation (25) with (20), expected inflation in period 1 now depends on q, which summarizes beliefs about future policies. But q is a parameter of both monetary and transfer policy. The previous model demonstrated that monetary policy alone cannot determine the price level. With policy uncertainty, monetary policy alone also cannot determine expected inflation. If agents put a high probability on the passive monetary/active transfer regime ($q \approx 1$), then expected inflation at the beginning of period 2 will be primarily pinned down by the nominal peg. It is in this sense that expectational effects about policy uncertainty can dramatically alter equilibrium outcomes.

In this simple setup, these expectational effects are limited in magnitude because agents know precisely when the fiscal limit is reached. The additional level of uncertainty not examined in these simple models, but present in Davig, Leeper, and Walker (forthcoming), is randomness in when tax policy will hit the fiscal limit. In that environment, the conditional probability of switching policies outlined above would contain an additional term specifying the conditional probability of hitting the fiscal limit in that period. This implies that, because there is a positive probability of hitting the fiscal limit in *every* period up to T, these expectational effects will be present from $t = 0,\ldots,T$ and will gradually become more important as the probability of hitting the fiscal limit increases. In effect, the endogenous probability of hitting the fiscal limit makes the probability q time varying.

1.4 Summary

The models presented above severely understate the degree of uncertainty about future policies that private agents face in actual economies. To derive a rational expectations equilibrium, I have taken stands on the stochastic structure of the economy that are difficult to reconcile with observations about any actual policy environment.[19] Remarkably, the models show that even in a setting that drastically understates the actual degree of uncertainty, private expectations of monetary and fiscal objectives are not well anchored on the targets of policy. These models also make clear that in an economy that faces heightened fiscal stress, the monetary policy behavior that most economists regard as "good" cannot control either actual or expected inflation. "Good" monetary policy can actually exaggerate the swings in expected inflation.

2. Policy Institutions and Future Policies

This section examines monetary and fiscal policy arrangements in Chile and the United States to draw some inferences about how the theoretical points derived above might play out in those economies. Chile and the United States offer interesting contrasts. Whereas Chile has adopted specific objectives and even rules for the conduct of monetary and fiscal policy, the United States has eschewed rules-based policies. The Central Bank of Chile is guided by an explicit inflation target; the Federal Reserve operates under a multiple mandate. Chile has adopted a series of fiscal rules, designed in part to provide for its aging population; the United States has done nothing except implement short-run fiscal policies that are projected to double the outstanding debt over the next decade. For the theme of this paper—how macroeconomic policies do or do not anchor expectations—the contrast is particularly relevant.

19. Sargent (2006) acknowledges this and goes so far as to say that U.S. monetary and fiscal policies are marked by "ambiguity or Knightian uncertainty," which precludes the specificity about stochastic structure assumed in the models of section 1.

2.1 The United States

Even in normal times, the multiple objectives that guide Federal Reserve decisions and the absence of *any* mandates to guide federal tax and spending policies conspire to make it very difficult for private agents to form expectations of U.S. monetary and fiscal policies.[20]

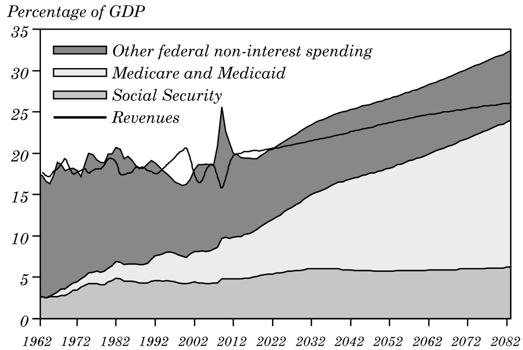
In the United States, the Congressional Budget Office (CBO) regularly publishes projections of the country's long-run fiscal situation. In the wake of the financial crisis and recession of 2007–09, monetary and fiscal policies have not been normal and, in the absence of dramatic policy changes, policies are unlikely to return to normalcy for generations to come, as long-term projections by the CBO make plain. Figure 5 reports actual and projected federal transfers due to Social Security, Medicaid, and Medicare as a percentage of GDP (CBO, 2009). Demographic shifts and rising relative costs of health care combine to grow these transfers from under 10 percent of GDP today to about 25 percent in 70 years. One much-discussed consequence of this growth is shown in figure 6, which plots actual and projected federal government debt as a share of GDP from 1790 to 2083. Relative to the future, the debt run-ups associated with the Civil War, World War I, World War II, the Reagan deficits, and the current fiscal stimulus are mere hiccups.

These debt projections highlight two points. First, under the maintained assumptions, debt will grow exponentially in these countries. Second, the maintained assumptions—which produced the exploding debt paths—cannot possibly hold. We learn the second point from the intertemporal equilibrium condition. Figure 6 implies that within our children's lifetimes, U.S. debt will exceed the fiscal limit, violating the intertemporal equilibrium condition.[21] These projections are public information and well understood by investors who continue to buy these government bonds without demanding a risk premium. Why do they continue to buy bonds? Because their expectations of future policy adjustments are at odds with the projections' maintained assumptions. In sum, figures of exploding debt paths, which fiscal authorities around the world routinely

20. This section draws heavily on Leeper (2009) and Davig, Leeper, and Walker (forthcoming).

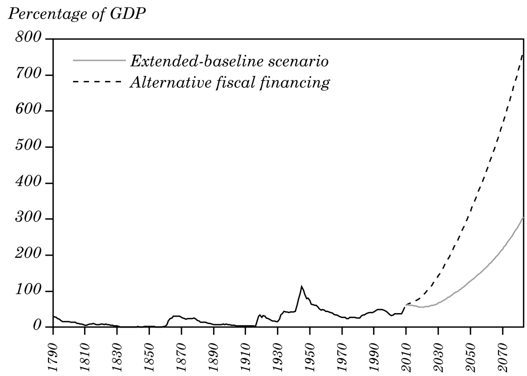
21. The U.S. fiscal limit is unknown, but I imagine it implies something less than a 300 percent debt-to-GDP ratio.

Figure 5. Projected and Actual Federal Expenditures Decomposed into Medicare, Medicaid, and Social Security Spending and Other Noninterest Spending[a]



Source: CBO (2009).
a. The solid line represents actual and projected revenues under the extended-baseline scenario, which assumes current law does not change.

Figure 6. CBO's Projections of Debt-to-GDP Ratio under Extended-Baseline and Alternative Fiscal Financing Scenarios



Source: CBO (2009).
a. The extended-baseline scenario assumes that current law does not change, while the alternative fiscal financing scenario allows for "policy changes that are widely expected to occur and that policymakers have regularly made in the past," according to the CBO.

publish, arise from economic behavior that is not happening and which flies in the face of basic economic logic. Projections of things that cannot happen cannot help to anchor expectations.

Having the future inherit larger government debt is problematic for several reasons. First, higher debt entails higher debt service, and more government expenditures must be devoted to paying interest on outstanding debt. Historically, countries have found that higher debt service crowds out other forms of government expenditures. Second, as the intertemporal equilibrium condition implies, higher debt requires higher present-value surpluses. That present value is bounded, however: as a share of GDP, tax revenues have some maximum level and spending has some minimum level. At those levels, the natural fiscal limit is reached and the economy cannot support a value of debt higher than that limit. By pushing more debt into the future, current policies move debt closer to the fiscal limit, which places restrictions on fiscal flexibility in the future. But the future is when the fiscal consequences of aging populations come home to roost; it is precisely when fiscal flexibility is most needed.

Additional reasons that higher debt is problematic tie back to anchoring expectations. Higher levels of interest payments require larger future fiscal adjustments. If the public is uncertain about the hows and whys of those adjustments, the macroeconomic consequences of the move to higher debt will be difficult to predict. But there is another more fundamental issue. In countries without guidelines governing debt levels, large debt run-ups leave unanswered a question that is critical to the public's formation of expectations: will the economy settle in at the new, higher level of debt, or will policy endeavor to retire debt back to its previous level or some other level? The answer to this question is central to the public's ability to form reasonable fiscal expectations.

And what of Federal Reserve policy? Many observers believe that U.S. monetary policy performance improved dramatically with the appointment of Chairman Paul Volcker in 1979 and continued to be good at least until the most recent period (Taylor, 1999a; Clarida, Galí, and Gertler, 1999). The appointment of a sequence of good Federal Reserve chairmen, however, has been largely a matter of luck, rather than a reflection of institutional reform. This institutional reality is underscored by the fact that the particular Fed chairman plays such a large role in the outcome of Fed policies. Expectations formation is all the more challenging in this kind of unstructured environment.

2.2 Chile

Two linchpins in Chilean macroeconomic policies are the mandate for the Central Bank of Chile to target a three percent inflation rate (plus or minus a percentage point) and the Fiscal Responsibility Law.[22] The Basic Constitutional Act of the Central Bank of Chile, passed in 1989, granted the central bank full independence and prescribed price stability and smooth functioning of the payments systems as its objectives. A formal inflation target was adopted in 2007, with the aim of hitting three percent inflation "in a medium-term horizon of two years." As with many inflation-targeting central banks, along with the explicit target came enhanced transparency and an emphasis on communication with the public.

Although many countries adopted inflation targeting without also implementing a compatible fiscal framework, Chile has been at the vanguard of countries that have reformed their monetary and fiscal policy institutions jointly. Chilean fiscal policy has been guided by a structural surplus rule since 2000, and the rule was given some legal teeth by the passage of the Fiscal Responsibility Law in August 2006. In the beginning, the rule aimed for a structural surplus of 1 percent of GDP. But the target itself is state dependent: it was changed to 0.5 percent in 2008 and again in January 2009, explicitly temporarily, with the aim of balancing the budget.

Like many Latin American countries, Chilean fiscal policy was strongly procyclical, which exacerbated cyclical fluctuations.[23] The structural balance methodology and the associated surplus rule were designed to counter the procyclicality, among several other key goals. To arrive at the structural surplus, the government estimates what revenues it would receive if the economy were growing at trend and if the prices of copper and molybdenum were at their long-run levels.[24] For the first six years, the aim of the surplus was to accumulate assets that could be used to meet future government obligations, particularly guaranteed minimum pensions and old-age transfer payments.

22. This section draws on several sources, including Perry, Servén, and Suescún (2008), Singh and others (2005), Rodríguez, Tokman, and Vega (2007), Marshall (2003), Central Bank of Chile (2007), Velasco (2008), and IMF (2009).

23. Procyclicality and its consequences are documented in Gavin and Perotti (1997) and Kaminsky, Reinhart, and Végh (2004).

24. Batini, Levine, and Pearlman (2009) and Kumhof and Laxton (2009) assess the performance of such a rule in dynamic stochastic general equilibrium models.

The benefits from the adoption of the structural surplus rule have been remarkable. Some key benefits include the following:

—Chilean fiscal policy has been freed to behave countercyclically;

—Government debt and interest payments on debt fell throughout the 2000s, with gross central debt down to 5 percent of GDP in 2008;

—A Pension Reserve Fund was established, in which assets are invested, just as in private pension funds, and accumulated to meet future obligations;[25]

—Sovereign debt interest-rate spreads for Chile are now well below those of other emerging economies and did not rise after 9/11 or the Argentine crisis of 2002, when other countries' spread rose sharply; the decline in Chilean spreads began with the adoption of the structural balance policy; and

—Declining sovereign debt risk spreads speak directly to the improved prospects for sustainability of Chile's fiscal policies.

The last two points are pertinent to the paper's theme of anchoring expectations and therefore deserve elaboration.[26] Small open economies are susceptible to large external shocks that make the economies highly volatile. This tendency is still more pronounced in economies, like Chile, that are strongly affected by fluctuations in commodity prices. Bi (2009) shows theoretically that default risk premiums emerge from the market's expectations about a country's ability and willingness to service its debt. Ability arises endogenously from the country's stochastic fiscal limit, which is tied to the peak of the country's Laffer curve. The probability distribution of the fiscal limit depends on the persistence and volatility of technology shocks, the size of the government, the degree of countercyclicality of fiscal policies, and the impatience of political decisionmakers. Volatile economies tend to have highly dispersed distributions for the fiscal limit, which increase the probability of default at any given debt-to-GDP ratio; countries with large government transfer programs have fiscal limits with lower means; impatient political leaders reduce the mean of the limit.

25. Several countries have similar funds. Norway has created a large sovereign wealth fund from oil revenues; Australia and New Zealand have superannuation funds.

26. This discussion is based on the insightful study of fiscal limits and sovereign debt risk premiums by Bi (2009).

A country's willingness to service debt is driven by the flexibility of its fiscal policy. Flexible policy implies a willingness to raise taxes or lower government expenditures in the face of debt run-ups. A country that is operating well below its fiscal limit and is willing to adjust surpluses to stabilize debt can successfully steer its way through economic downturns without incurring the wrath of financial markets in the form of risk premiums.

Viewed in the context of fiscal limits, Chile's structural balance rule and related innovations stemming from the Fiscal Responsibility Law serve to move Chile's government debt position farther from the fiscal limit. Greater distance from the limit arises from the both reducing government debt today and effectively shifting the distribution of the limit up to higher debt-to-GDP levels. Shifts in the distribution of the fiscal limit come from forcing a longer-term perspective on fiscal decisions and creating reserves that can be tapped in the future to finance benefits to the aging population. In this sense, the structural balance rule contributes in important ways to anchoring expectations on sustainable policies that are well cushioned away from Chile's fiscal limit.

As the theory in this paper implies, so long as the probability of hitting the fiscal limit in Chile is remote, there is every reason to believe that the Central Bank of Chile's efforts at inflation targeting will continue to be successful.

3. Concluding Remarks

Many countries are entering an extended period of relentless growth in transfer payments promised to their aging populations. Some, but not all, of these countries ultimately are relying on a pay-as-you-go scheme for financing these expenditures. If there is a level of taxation that, for economic or political reasons, those economies cannot exceed, then the pay-as-you-go scheme is unsustainable.

As Herb Stein famously said, "If something cannot go on forever, it will stop." Stein also pointed out that although economists are good at pointing out when something cannot persist indefinitely, they are less adept at predicting when it will stop. This is true enough in the present context, but we can say something constructive. Economic agents' beliefs about when the economy will reach its fiscal limit and how policies will adjust after the limit will feed back to affect the equilibrium we observe today, before the limit is reached. Predicting when an economy will hit its fiscal limit is less important for policymaking than is the systematic analysis of the possible existence of such a limit and all that that implies about expectations and macroeconomic policy effects.

For policymakers, the feedback from beliefs about the limit to the current equilibrium should be disturbing. Because pre-limit economic decisions depend, in part, on beliefs about post-limit policy behavior, accurate predictions of the impacts of policy changes today rely on understanding to what those beliefs are anchored. Coherent monetary-fiscal frameworks can help to anchor those beliefs. Incoherent frameworks can actually make beliefs even more untethered.

Countries can guard against this eventuality by implementing monetary-fiscal frameworks that keep their debt-to-GDP ratios well away from their fiscal limits.[27] However, fiscal limits are country specific and depend on myriad things that characterize a country's political-economic environment. No one-size-fits-all policy framework will work across a highly diverse set of countries.

Chile has instituted a monetary-fiscal framework that, at least for now, appears to be moving the country farther from its fiscal limit. With sufficient distance from that limit, there is reason to believe that the Central Bank of Chile's pursuit of inflation targeting can successfully anchor actual and expected inflation. Progress has been far slower—or even nonexistent—in many larger countries, and even responsible countries may bear some of the costs created by those large countries.

27. Of course, there is a delicate balancing act here, since high tax rates and low government infrastructure spending, which could keep debt low, are also socially costly.

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Competition and Stability in Banking

Xavier Vives
IESE Business School

Banking went from being one of the most regulated sectors in the economy after the crisis in the 1930s, to a more lightly regulated sector with the liberalization process that started in the 1970s in the United States. The previous period was marked by few crises, with much more instability in the second, culminating in the 2007 subprime crisis. In the first period, competition was considered detrimental to stability and in many countries competition policy was not applied fully to this sector until recently, despite its importance within the economy and the costs and inefficiencies induced by financial repression. Indeed, central banks and regulators were often complacent about collusion among banks, preferring to deal with a concentrated sector characterized by soft rivalry.

This changed with deregulation and the idea that competition enhances efficiency, be it productive, allocative, or dynamic (innovation). Competition policy is now taken seriously in the banking sector.[1] However, crisis hit in 2007, starting with subprime mortgages and then becoming systemic after the demise of Lehman Brothers in September 2008. Cumulative banking losses are estimated at 1.1 trillion euros (through November 2009) and massive

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1. In the U.S., banking became subject to competition law in the 1960s with the end of its antitrust exemption. In the European Union, the European Commission has intervened since the 1980s against a range of restrictive practices, in mergers and in state aid. See Carletti and Vives (2009).

Monetary Policy under Financial Turbulence, edited by Luis Felipe Céspedes, Roberto Chang, and Diego Saravia, Santiago, Chile.

bailouts (state aid with commitments involving public intervention in the European Union and United States) of up to 30 percent of GDP have overridden competition policy concerns. Indeed, public help programs have distorted competition and created an uneven playing field in terms of the cost of capital and perception of safety and soundness. Market power concerns about mergers have been also overruled. In the United Kingdom, Lloyds TSB took over the troubled HBOS (merger of Halifax and Bank of Scotland) in a merger opposed by the Office of Fair Trading, thereby creating a large entity, while the same Lloyds TSB had not been allowed to take over Abbey in 2001. The investment banking business has been consolidated in the United States, with the forced takeovers of Bear Stearns by J.P. Morgan, and Merrill Lynch by Bank of America. The result is potentially weak competition among the remaining players. Those events have deepened a current trend toward increased consolidation within countries, across countries, and across business lines (for example, forming financial conglomerates).[2]

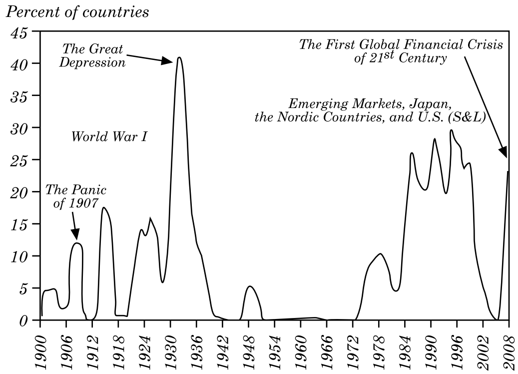
Banking and financial markets display the whole array of classical market failures, due to externalities (fragility due to coordination problems and contagion), asymmetric information (excessive risk taking with agency problems, moral hazard and adverse selection), and potential market power. This has brought in regulation to protect the system, small investors, and market competitiveness. The problem is that the lender of last resort, deposit insurance, and too-big-to-fail policies introduce further distortions and exacerbate excessive risk taking. In fact, the crisis has uncovered massive regulatory failure and potential contradictions between regulatory intervention and competition policy.

This paper takes stock of what we know about the relationship between competition and stability, and suggests how to deal with the interplay of regulation and competition issues in banking in the aftermath of the systemic crisis started in 2007.

Section 1 examines trends in the banking sector and its regulation, taking into account the impact of the crisis. Section 2 explains the uniqueness of banks, why the banking system is fragile, and the role of regulation.[3] Section 3 examines the trade-off between competition and stability in banking from a theoretical perspective, from the perspective of both fragility and the potential for excessive risk taking. Section 4 surveys the empirical evidence available. Section

2. See, for example, Group of Ten (2001).
3. Sections 2 and 3 are partially based on Vives (2001, 2006).

Figure 1. Proportion of Countries with Banking Crises, 1900–2008[a]



Source: Reinhart and Rogoff (2008a, figure 1).
a. Countries are weighted by their share of world income.

5 ponders whether we can regulate away the competition-stability trade-off. Section 6 examines the policy response to the crisis, and concluding remarks close the paper.

1. Trends in the Banking Sector

Two periods can be distinguished in the recent history of the financial sector. The first, from the 1940s up to the 1970s, was characterized by tight regulation, intervention, and stability, while the second was marked by liberalization and greater instability (see figure 1). From the 1940s to the 1970s, competition between financial institutions was severely limited by the regulation of rates, activities, and investments; the separation of commercial banking, insurance, and investment banking (through the Glass-Steagall Act of 1933 in the United States);[4] restrictions on the activity of savings banks; and geographical segregation (in the United States). Universal banking remained in some European countries. Deposit insurance was established, and the central bank acted as lender of last resort to the financial system.

4. The Glass-Steagall Act prohibited any one institution from acting as any combination of an investment bank, a commercial bank, and/or an insurance company.

The stability of this earlier period contrasts with a sizeable increase in the number of failures and crises in the later period, in which the sector was liberalized and competition introduced.[5] International evidence points to liberalization as one of the factors behind banking crises, together with inadequate macro policies, adverse macro shocks, and vulnerability of the foreign sector. That is, liberalization, even controlling for a wide range of factors, increases banking fragility. There are also strong indications that the institutional environment (for example, in terms of the rule of law and contract enforcement) and inappropriate regulation that accompanies liberalization reinforce the development of crises.[6] This is consistent with banking crises in diverse places, among them the United States (the savings and loan crisis), Japan, Scandinavia, and Spain. In all these cases, regulatory failure seems to have played an important role in the crisis.[7] Despite these crisis episodes, financial liberalization has generally contributed to financial development, and therefore output growth.

Liberalization involved the lifting of controls on rates and banking investment activities, of geographical restrictions (for example, the Riegle-Neal Act of 1994 in the United States), of compulsory investment coefficients, and a convergence among the activities of different types of institutions (for example, savings and ordinary banks, commercial banking and investment banking, and, with the final repeal of the Glass-Steagall Act, through the 1999 Financial Services Modernization Act, between banking and insurance, at least to a point).[8] Behind the process of liberalization and deregulation we

5. See Reinhart and Rogoff (2008a, 2008b).

6. See, for example, Demirgüç-Kunt and Detragiache (1998, 2001).

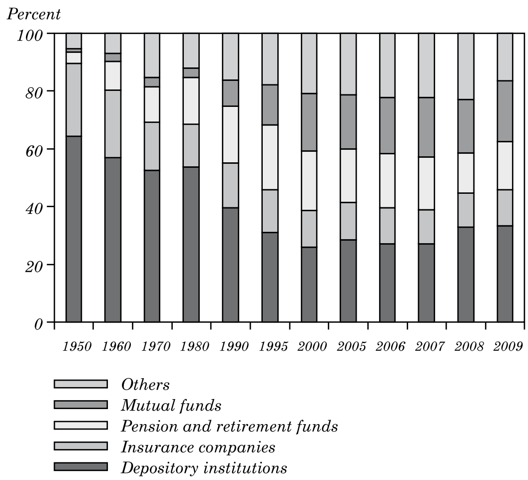
7. See Dewatripont and Tirole (1994) for the U.S. case and Hoshi and Kashyap (2000) for Japan. In both cases increased competitive pressures on financial institutions (for example, competition from non-bank intermediaries allowed by deregulation) leads to overexpansion in risky lines of business (for example, real estate), which are not checked, because of lax supervision and regulatory forbearance combined with implicit protection of entities in trouble. In Scandinavia, the roots of the early 1990s crisis lie in a set of factors following the financial liberalization of the 1980s: lax enforcement of capital requirements, poor supervision, lack of internal risk control methods, together with mistakes in fiscal and monetary policy in the context of an asset price bubble (see, for example, Honkapohja, 2009). In Spain, financial liberalization started in the 1970s and the banking crisis of the first half of the 1980s is explained by the large impact of the economic crisis derived from the oil shocks, the close links of banks with industrial firms, lack of diversification of banks' industrial portfolios, bad management and inadequate supervision (see Caminal, Gual, and Vives, 1990).

8. For example, Citicorp (a commercial bank holding company) merged with Travelers Group (an insurance company) in 1998 to form the conglomerate Citigroup.

find advances in information technology, in transaction processing (automatic teller machines, telephone and electronic banking), computer capacity, management techniques, and risk coverage (for example, the use of derivative instruments and securitization techniques). The liberalization of international capital movements and the general reduction in transport costs and barriers to trade—that is, financial globalization—were an integral part of the process.

Liberalization has resulted in an increase in competition, both within and from outside the banking industry, with banks facing direct competition from financial markets and the development of disintermediation and financial innovation. Market integration in Europe and elsewhere has contributed decisively to steeper competition in wholesale and investment banking. Interestingly, the share of assets held by banks relative to non-bank financial intermediaries is declining in developed economies (for example, in the United States through 2007), although bank assets are not declining relative to total financial assets because the share of non-bank intermediaries grows at the expense of directly held assets (see figure 2).[9]

Figure 2. Distribution of U.S. Financial Assets by Type of Financial Intermediaries

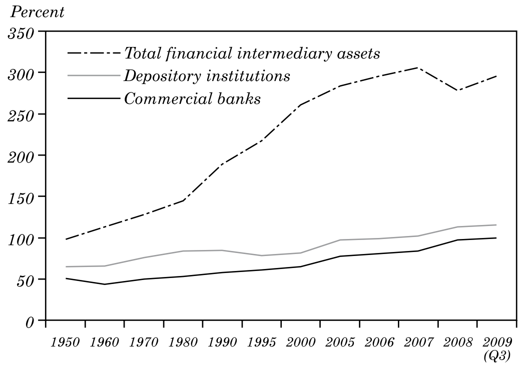


Source: Barth and others (1997), and updated data from *Flow of Fund Accounts*, Board of Governors of the Federal Reserve System.

9. See also Berger, Kashyap, and Scalise (1995) and Allen and Santomero (2001).

The liberalization process has also resulted in a tremendous expansion of financial intermediation, with financial assets of intermediaries increasing sharply, when expressed as a percentage of GDP.[10]

Figure 3. Relative Size of the U.S. Financial Sector and the Banking Industry[a]

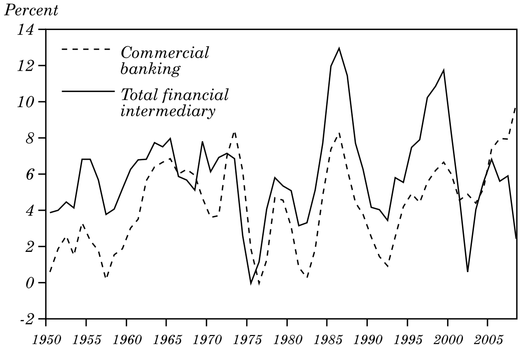


Source: *Flow of Funds Accounts*, Board of Governors of the Federal Reserve System.
a. Size is measured as financial assets over GDP.

This effective expansion of the financial market has implied that even banking, in spite of the advance of disintermediation, has grown in real terms (see figure 4). Before the 2007 crisis, banking was evolving from the traditional business of taking deposits and granting (and monitoring) loans to the provision of services to investors (investment funds/asset management, advice, and insurance) and firms (consulting, insurance, mergers and acquisitions, underwriting of equity and debt issues, securitization, risk management), and proprietary trading. In a financial conglomerate, we can distinguish a retail bank, an investment or corporate bank, asset management, proprietary trading, and insurance. The infamous model of "originate-and-distribute" banking, where banks try to get rid of credit risk by originating mortgage loans and quickly securitizing them, leaving the monitoring of mortgages in a limbo, is a good example of the evolving banking process.

10. In the United States, for example, this has risen from less than 100 percent in 1950 to a peak of more than 300 percent in 2007, with assets in banks rising from 50 percent to 100 percent in the same period. See figure 3 for details.

Figure 4. Growth Rates in U.S. Real Financial Assets[a]



Source: Board of Governors of the Federal Reserve System.
a. Three-year moving average, 1950–2008.

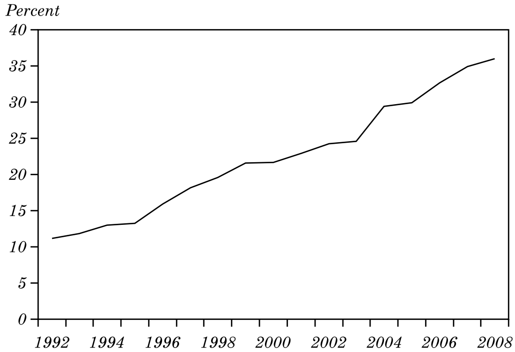
At the same time, even if banks created off-balance-sheet vehicles such as structured investment vehicles and asset-backed commercial paper conduits, in the end they were insuring them with liquidity lines. In any case, the financial margin made way for fee and commission revenue and there was a switch from investment in bricks and mortar (the branches) to investment in communication networks, information technology, and highly specialized human capital. Post-crisis, the financial margin has regained importance (if nothing else, because of the very low or zero interest rate policy of central banks) and the share of banks' assets in financial assets is up from pre-crisis levels (see figure 2). The return to traditional banking is apparent in figure 4, which reveals that recently, commercial banking has grown more than total financial intermediaries, in terms of real assets.

Restructuring is taking the form of consolidation, with the number of banks declining from 1997 to 2007 in both the United States (down 22 percent) and Europe (E.U.-15 down 29 percent). In Europe, domestic and, more recently, cross-border, and in the United States, interstate mergers have prevailed.[11] One result is that despite an increase in national concentration (United States) in the past 20 years (see figure 5

11. For example, Hypobank-Vereinsbank in Germany, UBS-SBC in Switzerland, BNP-Paribas in France, IMI-San Paolo and Crédito Italiano-Unicrédito in Italy, Santander-BCH to form BSCH and BBV-Argentaria to form BBVA in Spain. Exceptions are some cross-border deals in the Benelux and Scandinavia. Some cross-border mergers have failed because of political interference of national authorities. See Danthine and others (1999).

for assets), local concentration (measured by deposits in MSA and non-MSA counties) has, if anything, tended to decline (Berger, Demsetz, and Strahan, 1999; White, 2009, table 7).[12]

Figure 5. U.S. CR5 Ratio[a]



Sources: Federal Deposit Insurance Corporation (FDIC) and Federal Reserve.
a. Share of the five largest depository institutions expressed as a percentage of total assets. The merger of Wells Fargo and Wachovia is accounted for in 2008.

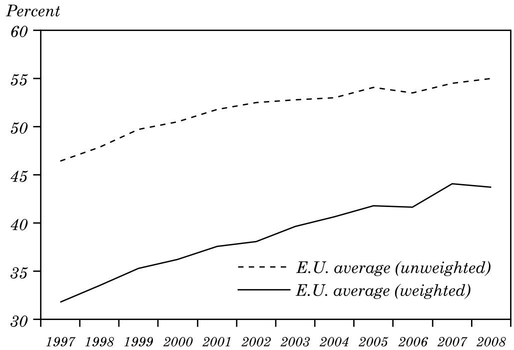
In Europe, the prevalence of domestic mergers tends to increase local concentration (for example, in 19 of 27 E.U. markets, the CR5 ratio for assets was over 50 percent in 2007).[13] Figure 6 presents the CR5 concentration ratio for the E.U.-15.

In the United States, the CR5 ratio for assets rose from 23 percent in 2001 to 36 percent in 2008 (with several post-crisis operations, including J.P. Morgan-Washington Mutual and Wells Fargo-Wachovia).[14] This contrasted with a gentler shift in the E.U.-15, from 52 percent to 54.5 percent (unweighted average) and from 37.6 percent to 44 percent (weighted average) in the same period.[15]

In short, liberalization has come with an increase in competition amongst financial intermediaries, but bank assets over total financial assets have held steady, and the incidence of crises has risen. Meanwhile, banking has shifted significantly towards service

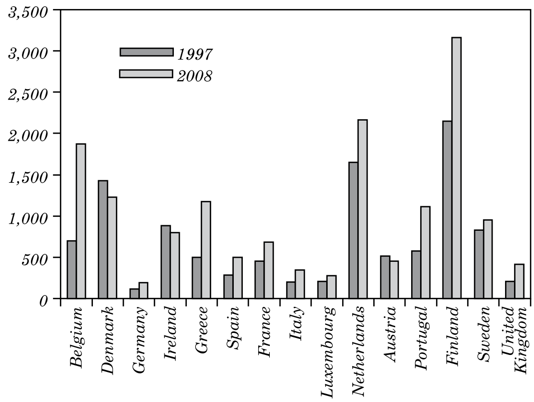
12. Metropolitan Statistical Areas (MSAs) are used as proxies for urban local markets, while non-MSAs are used as proxies for rural local markets.
13. See Schildbach (2009) for the United States.
14. The CR10 ratio for deposits rose from 36 percent in 2000 to almost 51.5 percent in 2008.
15. See Schildbach (2009) for the United States.

Figure 6. Share of CR5 as a Percentage of Total Assets[a]



Source: European Central Bank.

Figure 7. Herfindahl Index Based on Total Assets



Source: European Central Bank.

provision, while restructuring has tended to increase aggregate concentration (although the consequences may have varied in relevant local retail markets in the United States and Europe). The crisis marks a return to traditional banking and tends to exacerbate the consolidation trend.

The introduction of competition in banking has come with checks on risk taking with capital requirements, allowing banks to rely on their own internal models to assess and control risk, and disclosure requirements for financial institutions, to improve transparency and foster market discipline. Flexible views of capital requirements, supervision, and market discipline have become the pillars of the Basel II framework.[16] The rationale behind these reforms was to make capital requirements more risk sensitive. Supervisors would assess how well banks were matching their capital to risks assumed and banks would disclose information on their capital structure, accounting practices, risk exposures, and capital adequacy. In short, capital requirements plus appropriate supervision and market discipline were considered the main ingredients of a sound banking system. All this is under revision because of the crisis.

2. The Role of Banks, Fragility, and Regulation

Banks provide transaction and payment system services, insurance, and risk sharing (transforming illiquid assets into liquid liabilities). A central function of banks is to finance and monitor entrepreneurial projects that are illiquid and opaque due to asymmetric information problems, such as adverse selection and moral hazard. A lender needs relationship-specific skills to collect those loans that are illiquid, because the financed projects are opaque. Indeed, a main function of the banking and financial system is to overcome problems associated with asymmetric information in an economy.

2.1 Fragility and the Uniqueness of Banks

The essence of banks is that they create liquidity, but this leaves them vulnerable to runs. Banks protect entrepreneurs from the liquidity needs of depositors/investors. There are different versions of the story, but this is the cornerstone of modern banking theory (Diamond and Dybvig, 1983; Holmstrom and Tirole, 1997, 1998; Diamond and Rajan, 2001). The demand deposit contract, redeemable at par, creates a coordination problem for investors, which allows bankers to not extort rents on their abilities to collect illiquid loans (Diamond and Rajan, 2001) or disciplines bank managers subject to a moral hazard problem (Calomiris and Kahn, 1991; Gale and Vives, 2002). Because of asymmetric information, firms may get no funding because they do not have enough pledgeable income (fraction of their

16. Allowing banks to choose from a menu of approaches (for example, standardized and internal rating) to measure risk (credit, market, and operational).

return that can be committed to be paid to outsiders). Banks come to the rescue, for example, by creating liquidity-holding collateral and committing to make payments (Holmstrom and Tirole, 1997, 1998). In short, the standard deposit contract and loan provision to opaque entrepreneurial projects are complementary and central to a bank's function.

At the base of the fragility of banking, there is a coordination problem of investors, who may decide to call back their short-term deposits or certificates of deposit and make a sound bank fail. The literature has presented two views of crises: the multiple equilibrium panic view (Bryant, 1980; Diamond and Dybvig, 1983) and the information-based view (Gorton, 1985, 1988; Jacklin and Battacharya, 1988). According to the former, sunspots (events unrelated to fundamentals) trigger runs, while according to the latter, bad news about bank assets triggers runs. Recently, these views have been reconciled with the introduction of asymmetric information and the identification of links between the probability of a run and the strength of fundamentals (Goldstein and Pauzner, 2005; Rochet and Vives, 2004).[17,18] Thus, a solvent bank may be subject to panic, with depositors withdrawing funds invested and the bank forced to liquidate assets quickly, incurring a penalty. The cause of the problem is banks' dependence on short-term debt.

Moreover, systemic risk can arise from contagion by a single entity's failure and this may produce a strong, negative externality, affecting both the financial and real sectors of the economy. For example, through interbank market commitments, the failure of one entity may cause the downfall of others (see Allen and Gale, 2000). Similarly, large shifts in asset prices, such as an abrupt fall in the stock market or the failure of a major intermediary, may generate a domino effect and a systemic crisis, affecting the entire payment system.[19]

Crises, however, may have positive aspects and in some circumstances can be optimal from an *ex ante* point of view, by making payment to depositors contingent on returns and improving risk

17. Postlewaite and Vives (1987) provided an early model with a unique equilibrium, where the probability of a crisis is determined by the realization of the liquidity needs of depositors, which involves private information.

18. In section 3.1, I will examine the impact of competitive pressure on instability in this context.

19. System-wide runs were usual in the United States in the nineteenth and early twentieth centuries. More recently they have occurred in Brazil in 1990, Ecuador in 1999, and Argentina in 2001.

sharing (Alonso, 1996; Allen and Gale, 1998) or by helping control the incentives of the banker (Calomiris and Kahn, 1991; Gale and Vives, 2002). For example, in the presence of moral hazard, incentive efficiency requires that the expected utility of investors/depositors be maximized, subject to the constraint that the bank manager exerts effort. This can be accomplished by liquidating the project, when observable interim returns are lower than a certain threshold (this is the minimal threshold that induces the manager to exert effort, a higher threshold would just increase the costs associated with liquidation). The threat of liquidation disciplines banks managers, but typically there is excessive liquidation and fragility (that is, "excessive" coordination failure; see Rochet and Vives, 2004). The reason is that competitive banking will typically reward investors over and above the optimal liquidation threshold. The challenge of regulation and supervision is to permit sufficient crises to keep the right incentives for bankers, while taking into account the degree of competition in the market. We will return to this question in section 6.

In short, banks are unique because of their particular mix of features: high (short-term) leverage, dispersed debtholders (implying a low level of monitoring), and opaque bank assets of long maturity, which exacerbate moral hazard, fragility and a high social cost of failure, and vulnerability to contagion (via interbank commitments or indirect market-based balance sheet linkages). All of these factors add up to enormous potential for systemic impact. At the same time, banks are central—indeed, essential—to the economic system. When banks stop functioning, so does a modern monetary economy.

The situation may be even worse in an emerging economy, where the role of banks is relatively more important, since asymmetric information problems are more acute and financial markets less developed. Banks and their monitoring capacity are, therefore, central to economic development, and any potential fragility may dramatically worsen downturns.

2.2 Market Failures and Regulation

Financial markets involve the whole range of major market failures: externalities, asymmetric information, and market power. The banking system's inherent fragility leads to the failure of institutions, panics, and systemic crises that potentially have a major impact because of economy-wide externalities. The great depression of the 1930s and the subprime crisis are good examples, as were the financial crises in the United States, Scandinavia, Mexico, East Asia, and Russia, all of which remind us of the potential for severe economic disruption. A bank's failure hurts non-financial firms precisely because individual bank-firm relationships are valuable (Petersen and Rajan, 1994). In fact, even a contraction of bank capital may induce a credit crunch, with severe disruption to the private sector. A major market failure is, therefore, the lack of internalization by financial intermediaries of the social cost of bankruptcy and potential systemic risk. Contagion may occur because of network effects in the payment system, interbank market, or derivatives markets. Market liquidity and funding liquidity may interact, causing downward spirals.[20]

Asymmetric information is in fact the *raison d'être* of financial intermediaries. However, as we will see in section 3.2, in a bank the agency problem leads to excessive risk taking, because of moral hazard and risk-shifting incentives. Adverse selection in credit and financial markets may lead to the failure of competition and even market breakdown. An unregulated market leaves small investors unprotected.

Imperfect competition is the norm and not the exception in banking. Very important frictions prevent banking from being perfectly competitive. Indeed, asymmetric information creates barriers to entry or results in competition not delivering efficient outcomes. For example, in the case of credit rating agencies, conflicts of interest due to the issuer-pays model, entry restrictions, and a failure of the reputation mechanism seem to produce a race to the bottom. Other sources of friction are switching costs, network effects (in retail banking, credit cards, or markets in general), and the ubiquity of two-sided competition in the banking sector.

Generally speaking, competitive banking will be excessively fragile, requiring policies such as lender of last resort (LOLR) facilities, deposit insurance, too-big-to-fail approaches and prudential regulation to rush to the rescue. These measures protect the system against negative economy-wide externalities. Regulation, meanwhile, aims to make banking and financial systems more stable, to avoid the negative effects associated with failing institutions and systemic crises. Regulation also aims to protect the small investor. Other policies promote a competitive system and maintain competitive markets (competition policy).

20. See Brunnermeier and Pedersen (2009) for a model of a liquidity spiral combining market and funding liquidity.

Financial regulation has side effects though. The most important one is potential moral hazard induced by protection and bailouts extended to failing institutions.[21] The LOLR and deposit insurance are two basic instruments on which the stability of the banking system rests. Blanket insurance, however, is often offered to banks and depositors, according to a too-big-to-fail (TBTF) policy, which is usually justified by the potentially system-wide consequences of a large institution's failure, but this help may reflect a problem of time-inconsistency. In the presence of moral hazard in the banking sector (for example, the banker's level of effort in monitoring projects), a well-intentioned regulator will find it optimal to help ex post if this salvages the value of projects. Bankers, anticipating the help, will tend to exert suboptimal effort (see Gale and Vives, 2002). This is an example of the time-inconsistency problem facing a central bank. After the fact, costly liquidation of projects will not be optimal, so the central bank may be soft. The commitment problem is compounded by the bank manager's interest in the bank continuing. Investing a central bank with a "tough" reputation can alleviate the time-inconsistency problem. Similarly, suspension of convertibility may remove incentives encouraging depositors to run (Diamond and Dybvig, 1983), but if the banking authority cannot pre-commit to such a deposit freeze and uses an ex post efficient (softer) intervention, this will encourage runs (Ennis and Keister, 2009).

In emerging markets, asymmetric information problems are more acute and reliance on the banking system to overcome them is more important. Moreover, these economies face a more severe policy commitment problem, which leads to excessive bailouts and potential devaluation of claims from foreign investors. This exacerbates moral hazard and provides a reason for importing external discipline (for example, acquiring foreign short-term debt). However, external discipline may come at the cost of excessive liquidation of entrepreneurial projects (the tradeoffs involved are examined in Vives, 2006).

3. Competition and Stability

Competition may influence stability, basically through the liability or asset side of a financial intermediary's balance sheet. Competition,

21. We will come back to this issue in sections 3.2 and 5, where we examine some regulatory pitfalls.

in particular, may increase instability by (i) exacerbating depositors/ investors' coordination problem on the liability side, and fostering runs and/or panics, which may affect the system overall; and (ii) increasing the incentives to take risk (on either the liability or asset sides), thus increasing the probability of failure. I will examine each of these possibilities in turn. For (i), I will sketch a model, since it is not yet well understood.

3.1 Competition, Runs, and Fragility

The first thing to note is that competition is not responsible for fragility. Indeed, vulnerability to runs may emerge independently of market structure. This conclusion is based on work by Matutes and Vives (1996) with a model that combines Diamond's banking model (Diamond, 1984) with a differentiated duopolistic structure à la Hotelling. In this model, depositors' expectations determine the probability of a bank failing endogenously. These expectations are self-fulfilling, due to diversification-based scale economies: a bank that is perceived to be safer commands a larger margin and attracts a higher market share, allowing a better diversification. The model admits multiple equilibria, with corner solutions where only one bank is active or an equilibrium where no bank is active, for example during a system-wide crisis of confidence. This arises due to the coordination problem between depositors (as noted in the network externalities literature) and its presence does not depend on market structure. A monopoly bank may suffer a run. However, an increase in rivalry does increase the probability of failure in an interior equilibrium of the depositor's game, where banks have positive market shares.[22]

Chang and Velasco (2001) present a model of financial crisis in emerging markets in the Diamond and Dybvig (1983) tradition. They find that financial liberalization increases the expected welfare of depositors, but may also increase fragility. Liberalization is modeled as moving away from a monopoly toward an increasingly competitive situation. A monopolist bank holds depositors to their reserve level, which implies that they remain indifferent to an autarchic system with no financial intermediation. The monopolist bank does so by reducing payments to depositors and therefore

22. Smith (1984) links instability in a model à la Diamond and Dybvig (1983) to a lack of equilibrium.

its short-run liabilities. Profits act as a buffer against unexpected withdrawals. Consequently, the bank is less likely to fall within the range where a self-fulfilling crisis occurs than in a competitive situation. Furthermore, monopoly banking has to deliver a lower level of welfare, since a competitive bank maximizes depositors' ex ante utility, taking into account the probability of a run, associated with an exogenous sunspot, and autarchy is a feasible allocation.[23]

The recent reconciliation of the self-fulfilling theory of crises with the information- and fundamentals-driven views offers some insight into the competition-stability relationship, without having to resort to sunspot variables to explain how investors coordinate in equilibrium.

Traditional bank runs typically resulted from massive withdrawals by individual depositors. Modern bank runs are typically the outcome of non-renewal of short-term credit in the interbank market, as in the Northern Rock case or the 2007 run on structured investment vehicles (SIVs).

Let us consider a stylized banking crisis model based on Rochet and Vives (2004) and Vives (2010c). The model has three dates: $t = 0,1,2$. On date $t = 0$, the bank has equity E (or, more generally, stable funds including insured deposits) and collects uninsured certificates of deposit (CDs) or short-term uninsured debt worth $D_0 \equiv 1$. These funds are used to finance risky investment I and cash reserves M. The returns θI on these assets are collected on date $t = 2$. If the bank can meet its obligations, the CDs are repaid at their face value, D, and the bank's equity holders obtain the residual (if any). A continuum of fund managers make investment decisions in the interbank market. At $t = 1$ each fund manager, after the observation of a (conditionally independent) private signal about the future realization of θ decides whether to cancel ($y_i = 1$) or renew his or her CD ($y_i = 0$). It is assumed that all random variables follow a Gaussian distribution with $\theta \sim N(\overline{\theta},\tau_\theta^{-1})$ and the private signal for investor i is $s_i = \theta + \varepsilon_i$ with independent and identically distributed noise $\varepsilon_i \sim N(0,\tau_\varepsilon^{-1})$ orthogonal to θ.

Let $\tilde{y}$ be the amount of withdrawals. If $\tilde{y} \geq M$, then the bank has to sell some assets to meet payments. A fund manager or investor adopts a behavioral rule of the type: cancel the investment if and only if the probability that the bank fails is above threshold $\gamma \in (0,1)$. This will occur, for example, if the fund manager is rewarded for

23. Todd Keister raised a similar point when discussing the paper.

taking the right decision (that is, withdrawing if and only if the bank fails).

Let $m \equiv M/D$ be the liquidity ratio; $\theta_L \equiv (D - M)/I$, the solvency threshold of the bank; $\lambda > 0$ the fire sale premium on early sales of bank assets; and $\theta_H \equiv (1 - \lambda)\theta_L$ the "supersolvency" threshold, such that a bank does not fail, even if no fund manager renews their CDs. Under these conditions the bank fails if $\theta < \theta_L$, or when $\theta \geq \theta_L$ but

$$\tilde{y} \geq m + \frac{1-m}{\lambda}\left(\frac{\theta}{\theta_L} - 1\right).$$

When taking into account the balance sheet constraint at $t = 0$, $E + D_0 = I + M$, we have $\theta_L \equiv (1 - m)/(\ell^{-1} + d^{-1} - m)$, where $\ell = D/E$ is the short-term leverage ratio and $d = D/D_0$ the return on short-term debt. An increase in the face value of debt D may result from the bank facing a more competitive environment.

The model can be reinterpreted, replacing banks with countries and the short-term debt with foreign-denominated, short-term debt.

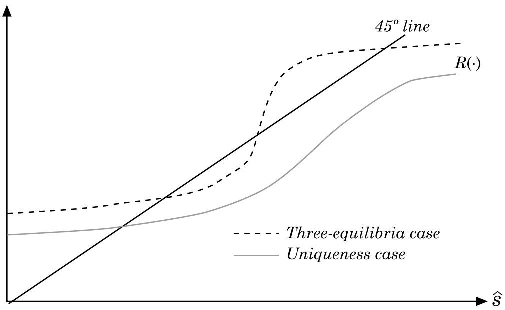
Investors, therefore, engage in a symmetric binary action game of strategic complementarities.[24] If the state of the world is known, then if $\theta > \theta_L$, the dominant strategy will involve withdrawal; if $\theta > \theta_H$, then the dominant strategy will be to remain (not to withdraw); and for $\theta \in (\theta_L,\theta_H)$ both equilibria coexist. We can show that with incomplete information, an equilibrium is characterized by two thresholds (s^*,θ^*) with s^* yielding the signal threshold below which an investor withdraws and $\theta^* \in [\theta_L,\theta_H]$ the state-of-the-world critical threshold, below which the acting mass of investors makes the bank fail. There are at most three equilibria. There is a critical liquidity ratio, $\overline{m} \in (0,1)$, such that $\theta^* = \theta_L$ for $m \geq \overline{m}$, and for $m < \overline{m}$ we have $\theta^* > \theta_L$. In this case, the equilibrium is unique if $\tau_\theta \tau_\varepsilon^{-1/2} \leq \sqrt{2\pi}(\ell^{-1} + d^{-1} - m)\lambda^{-1}$.[25] The reason is as follows. Let $R(\hat{s})$ be a player's best reply threshold to the (common) signal threshold $\hat{s}$ used by other players. The game then involves strategic complementarities, with $R' \geq 0$. A higher threshold $\hat{s}$ applied by others induces a player to a higher threshold as well. We can show that if $\tau_\theta \tau_\varepsilon^{-1/2} \leq \sqrt{2\pi}(\ell^{-1} + d^{-1} - m)\lambda^{-1}$, then

24. Related examples can be found in Morris and Shin (1998, 2004) and Corsetti and others (2006). In a game of strategic complementarities, the marginal return on a player's action increases in the level of the actions of rivals. Best replies, then, are monotone increasing. See Vives (2005).

25. All the results presented in this section are to be found in Vives (2010c).

$R'(\hat{s}) \leq 1$. This ensures that $R(\cdot)$ crosses the 45º line only once and that the equilibrium is unique. In figure 8, the uniqueness case is illustrated by the flatter best reply curve and the three-equilibria case by the steeper best reply curve.

Figure 8: Best Response of a Player to Threshold Strategy, $\hat{s}$, Used by Rivals



Source: Author's drawing.

Multiple equilibria come about when strategic complementarity is strong enough (the steeper best response in figure 8). This is a function of the slope of the best response. The maximal value of the slope is $(\tau_\theta + \tau_\varepsilon) \Big/ \left[\tau_\varepsilon + (\ell^{-1} + d^{-1} - m)\lambda^{-1}\sqrt{2\pi\tau_\varepsilon}\right]$. Strategic complementarity will be larger in a more competitive situation (d larger) and when the fire sales penalty λ is higher. It will tend to be smaller when noise in the signals is small in relation to the prior, that is, $\tau_\theta / \sqrt{\tau_\varepsilon}$ small. With small noise in the signal, a player faces greater uncertainty about others' behavior, reducing complementarity.

At equilibrium with threshold θ^*, when $\theta < \theta^*$, the acting mass of withdrawing investors make the bank fail and therefore the probability of a "crisis" occurring is $\Pr(\theta \leq \theta^*)$. A crisis occurs due to low values of fundamentals. In contrast, the complete information model contains multiple self-fulfilling equilibria in the range (θ_L, θ_H). Consequently, the model bridges between the self-fulfilling theory of crisis (for example, Diamond and Dybvig, 1983) and theory linking crisis to fundamentals (for example, Gorton, 1985).

In the range $[\theta_L, \theta^*)$, coordination fails from the perspective of the institution being attacked. Thus, the bank is solvent but illiquid—that is, the bank would have no problem if only investors would renew their CDs, but it has fallen into a range where they do not, and thus becomes illiquid. Thus, the risk of illiquidity is represented by $\Pr(\theta_L \le \theta < \theta^*)$ and the risk of insolvency by $\Pr(\theta < \theta_L) = \Phi\left[\sqrt{\tau_\theta}(\theta_L - \bar{\theta})\right]$, where $\bar{\theta}$ is the prior mean or public signal and Φ is the cumulative normal distribution $N(0,1)$.

Whenever $m < \overline{m}$ and there is a unique equilibrium, an increase in d or λ boosts both θ^* and s^*, the probability of crisis $\Pr(\theta < \theta^*)$, and the range of fundamentals $[\theta_L, \theta^*)$ for which there is coordination failure (Vives, 2010c).[26] Any rise in bank vulnerability, whether it affects the face value of bank deposits or the fire sale premium for early liquidation, increases fragility by increasing the degree of strategic complementarity. Furthermore, if released, the public signal $\bar{\theta}$ has a negative multiplier effect on equilibrium thresholds, which is enhanced if d or λ are higher. Indeed, the equilibrium signal threshold is determined by $R(s^*; \bar{\theta}) - s^* = 0$. From this, it follows that:

$$\left|\frac{ds^*}{d\bar{\theta}}\right| = \frac{\left|\partial R / \partial \bar{\theta}\right|}{1 - R'} > \left|\frac{\partial R}{\partial \bar{\theta}}\right|$$

whenever $R' < 1$ is met, since $R' > 0$. As a result, a rise in $\bar{\theta}$ will affect the equilibrium threshold s^* more than the direct impact on the best response of a player $\partial R / \partial \bar{\theta}$. This multiplier effect is largest when R' approaches 1, that is, when strategic complementarities are strong, and we approach the region of multiplicity of equilibria. This is so when d or λ are large. Public information has a coordinating potential beyond its strict information content (as emphasized by Morris and Shin, 2002). Every investor knows that an increase in $\bar{\theta}$ will shift the best replies of other investors downward and everyone will be more cautious about withdrawals.

Consistent with this result, experimental evidence reveals that bank runs occur less frequently when banks face less stress, in the sense of a larger number of withdrawals being necessary to induce insolvency.[27]

The presence of market power in the interbank market may either facilitate liquidity provision—because liquidity is a public good, so sound banks may have an incentive to provide liquidity to

26. Goldstein and Pauzner (2005) also show how increasing the deposit rate increases the probability of a run of depositors in a model of the global games type.

27. See Madies (2006) and Garratt and Keister (2009).

a bank in trouble to avoid contagion (Allen and Gale, 2004; Sáez and Shi, 2004)—or may impede its provision because banks with surplus funds underprovide lending strategically to induce fire sales of the bank-specific assets belonging to needy intermediaries (Acharya and others, 2010).

The comparative statics results hold even if there are multiple equilibria for the extremal (stable) equilibria. It can be shown that extremal equilibrium thresholds (θ^*, s^*) decrease with $\bar{\theta}$ and with decreases in stress indicator d or λ. Considering out-of-equilibrium adjustment in the form of best-reply dynamics where, at any stage after the perturbation from equilibrium, a new state of the world θ is drawn independently and a player responds to the strategy threshold used by other players at the previous stage, a similar result holds, since the middle "unstable" equilibrium becomes irrelevant. Interestingly, the region of potential multiplicity $\tau_\theta \tau_\varepsilon^{-1/2} \leq \sqrt{2\pi}(\ell^{-1} + d^{-1} - m)\lambda^{-1}$ is enlarged with an increase in stress indicator d or λ and/or an increase in the precision of the public signal in relation to the private ones $\tau_\theta / \sqrt{\tau_\varepsilon}$.

Regulation in the form of solvency and/or liquidity requirements may help to control the probabilities of insolvency and illiquidity (Vives, 2010c). Indeed, the probability of insolvency $\Pr(\theta < \theta_L)$ is decreasing in $m = M / D$ (assuming that $1 - \ell^{-1} - d^{-1} < 0$, as is usual in a commercial bank), the solvency ratio $\ell^{-1} = E/D$, and d^{-1}, since $\theta_L \equiv (1 - m)/(\ell^{-1} + d^{-1} - m)$. The probability of a crisis $\Pr(\theta < \theta^*)$, including the probability of illiquidity, is decreasing in m, ℓ^{-1} (and also in d^{-1} and λ^{-1}) since θ^* is as well.

From this it follows that both solvency and liquidity requirements required to control the probability of insolvency and illiquidity may have to become tighter in a more competitive environment, where d is higher. Furthermore, the liquidity requirement may have to become tighter when λ is higher.[28] However, note that there is a partial substitutability between m and ℓ^{-1}, since they both contribute to reducing θ_L and θ^*. In the limit case of almost perfect signals, $\tau_\varepsilon \to \infty$, which allows for a closed-form solution, we can check that in a more competitive environment (with higher return on short-term debt d), the solvency requirement (but not the liquidity ratio) should be strengthened, while in an environment where the fire sales penalty λ increases, the liquidity requirement must be strengthened, whereas the solvency requirement can be relaxed.

28. See Vives (2010a).

Consistent with these results, there is evidence that banks that relied less on wholesale funding and had higher capital cushions and liquidity ratios, fared better during the crisis.[29]

In short, runs can happen independently of competition levels, but rising competitive pressure worsens investors'/depositors' coordination problem, and increases the following: (i) potential instability (enlarging the multiplicity of equilibria region); (ii) the probability of a crisis; (iii) the range of fundamentals for which there is coordination failure of investors (and the institution is solvent but illiquid); (iv) the impact of bad news on fundamentals; and (v) the solvency requirement. Generally speaking, the socially optimal probability of crisis is positive because of its disciplining effect. These results, then, do not mean that competitive pressure should be minimized.

3.2 Competition and Risk Taking

Banks will have excessive incentives to take risk in the presence of limited liability (for shareholders and managers) and moral hazard (non-observable risk on the asset side). This is exacerbated by deposit insurance with flat premiums. The problem is particularly acute for banks close to insolvency/bankruptcy. Indeed, limited liability means that banks will take excessive risk on the asset side, unless the bank's risk position can be assessed (for example, by large holders of CDs). A bank, then, cannot increase its market share and profits by taking more risk, because investors will discount it. However, introducing flat premium deposit insurance (or bailouts) destroys the market's disciplinary effect, by eliminating investor concerns about potential bank failure.

Intense competition may worsen the excessive risk taking problem, because high profits provide a buffer and increase the bank's "charter value." In a dynamic setting, market power enhances the bank's charter value, making it more conservative. Indeed, a bank with more market power enjoys higher profits and has more to lose if it takes more risk, fails and its charter is revoked. If future profits weigh enough, the bank will moderate its risk taking. Besanko and Thakor (1993) make this point with reference to the value created through relationship banking, and Boot and Greenbaum (1993) with

29. See Ratnovski and Huang (2009) with evidence from the 72 largest commercial banks in OECD countries.

regard to reputational benefits, both of which may be eroded by more competition.[30] Matutes and Vives (2000) consider an imperfect competition model where banks are differentiated, have limited liability, and failure involves social costs (which could include a systemic component). The authors show that deposit rates are too high when competition is intense and the social cost of failure high. If the risk assumed by bank investments is not observable, then the incentives to take risk become maximal. Flat premium deposit insurance tends to make banks more aggressive, by increasing the elasticity of the residual supply of deposits available to the bank (this is also the result in Matutes and Vives, 1996). Furthermore, with risk-insensitive insurance, deposit rates will be too high amidst intense competition, even with no social cost of failure and no discipline on the asset risk taken. Allen and Gale (2004) consider banks competing à la Cournot in the deposit market and choose a risk level on the asset side. With insured depositors they show that as the number of banks grows, banks have maximal incentives to take risk on the asset side.[31]

With heterogeneous borrowers, tougher competition may lead to a riskier bank portfolio and higher probability of failure. This is because more rivalry may reduce incentives to screen borrowers (the bank has fewer informational rents; see Allen and Gale, 2004). A larger number of banks may also increase the chance that bad borrowers get credit by reducing each bank's screening ability, due to the adverse selection/winner's curse problem (Broecker, 1990; Riordan, 1993; Gehrig, 1998).[32]

However, competition tends to push down the rates that firms pay for loans and may, therefore, improve the average quality of loan applicants and/or reduce the need to ration credit. For example, better terms for entrepreneurs mean that they earn more profits and become more cautious, thus reducing the likelihood of the bank failing (Caminal and Matutes, 2002; Boyd and De Nicolò, 2005). Martinez-Miera and Repullo (2008), however, show that this argument does not consider the fact that lower rates also reduce the banks' revenues from non-defaulting loans. When this is accounted for, there is a U-shaped relationship between competition and the risk of bank

30. A better reputation reduces the cost of outside finance to the bank.

31. See also Hellman and others (2000) and Cordella and Yeyati (2002).

32. Note also that endogenous fixed costs due to information gathered via lending may induce a natural oligopoly in banking (Dell'Ariccia and others, 1999; Dell'Ariccia, 2001).

failure (in particular, when the number of banks is sufficiently large, the risk-shifting effect is always dominated by the margin effect). In summary, when both banks and firms have to monitor their investments, there is a potentially ambiguous relationship between market structure and risk taking.

A bank faces both adverse selection and moral hazard problems when lending to firms. A higher rate set by the bank will tend to draw riskier applicants (adverse selection) and/or induce the borrower firms, which also have limited liability, to choose riskier projects (moral hazard). We know that banks may then prefer to ration credit rather than raising the interest rate. A bank with market power has more incentive to alleviate this asymmetric information problem by monitoring the firms' projects and establishing long-term relations with customers.[33] This effect tends to increase firms' access to credit. As usual, market power also increases the lending rate and therefore the tendency to ration credit to avoid an increase in the average risk for a pool of applicants. Even if we forget about the possibility of banking failure for a moment, market power presents a welfare trade-off, since more bank market clout reduces the bank's moral hazard, but aggravates the problem for the entrepreneur. The result is that some market power tends to be good, unless monitoring is very costly. If banking failure is a possibility, then the analysis becomes more complex. Higher lending rates due to market power tend to depress investment and, under plausible assumptions with multiplicative uncertainty, decrease the bank's overall portfolio risk. More rivalry should, therefore, increase the probability of bank failure. However, more competition may also destroy incentives to monitor, and thereby reduce lending. If the latter effect is strong enough, a monopolistic bank may end up more exposed to aggregate uncertainty (because it tends to ration credit less) and therefore more likely to fail.[34]

All in all, despite the complexity of the relationship between competition and risk taking, it seems plausible to expect that, once a certain threshold is reached, an increase in the level of competition will tend to increase risk taking incentives and the probability of bank failure. This tendency may be checked by reputational concerns, by the presence of private costs of managerial failure, or by appropriate regulation and supervision.

33. Besanko and Thakor (1993), Petersen and Rajan (1994, 1995).
34. Caminal and Matutes (2002).

4. Evidence

Increased competition after liberalization and deregulation in the United States in the 1980s led banks to take more risks (Keeley, 1990; Edwards and Mishkin, 1995; Demsetz and others, 1996; Galloway and others, 1997). Keeley finds that a higher Tobin's q (as a measure of charter value) was positively associated with high capital-to-asset ratios in U.S. bank holding companies for the period 1971–86. Furthermore, he finds that interest rates on large CDs for large bank holding companies between 1984 and 1986 were negatively related to q. It also seems that the increase in risk was held by large, TBTF banks in particular (Boyd and Gertler, 1993). There is controversy, however, over whether this increase in competition led to lower or higher loan losses (see Jayaratne and Strahan, 1998; Dick, 2007, respectively). Saurina and others (2007) claim that non-performing loans in Spanish banks fell as the loan market's Lerner index rose.[35] Salas and Saurina (2003) found that 31 years of liberalization measures in Spain increased competition and eroded banks' market power (measured again by Tobin's q), banks with lower charter values tended to have lower equity-to-asset ratios (lower solvency), and to experience higher credit risk (loan losses over total loans).

Liberalization in a weak institutional environment and/or with inadequate regulation shifts risk to the taxpayer and increases the likelihood of systemic crisis (Demirgüç-Kunt and Detragiache, 1998, 2001). A similar situation seems to have arisen in the wake of the subprime crisis, with declining lending standards associated with securitization (Dell'Ariccia and others, 2008).

The relationship between concentration and stability is complex. On the one hand, a concentrated banking system with a few large banks may be easier to monitor and banks are potentially more diversified. On the other hand, large banks may be TBTF, receive larger subsidies, and have incentives to take more risk. Furthermore, large banks tend to be more complex, harder to monitor, and more interdependent (increasing systemic risk). The evidence also points to a complex relationship between concentration and stability.

Several studies have attempted to provide cross-country evidence on the effects of liberalization and increasing competition on both individual and systemic bank failures. In a cross-country study of

35. However, a problem with their approach is that the risk premium in the Lerner index is a function of loan losses ratio, which is a measure of non-performing loans.

23 developed nations, Berger and others (2009) show that market power (as measured by the Lerner index and Herfindahl index for deposits or loans at the national level) increases banks' loan portfolio risk but decreases overall risk, because banks with market power hold more equity capital. In a cross-country study of 69 nations (1980–97), Beck and others (2006) show that systemic crises are less likely in concentrated banking systems (measured by the three-firm concentration ratio on total assets, controlling for macro, financial, regulatory, institutional, and cultural characteristics) and that fewer regulatory restrictions (on entry, activities, facility for competition) are associated with less systemic fragility. This suggests that concentration is no proxy for competition and questions whether market power is really a stabilizing influence. The pertinent connection, however, is between concentration in relevant markets (which need not be directly linked to aggregate asset concentration) and competition. Furthermore, concentration is endogenous and more competition may increase concentration in a free entry world, since there is less room for entrants.[36] In this sense, it should come as no surprise to find that both concentration and competition are positively associated to stability. Concentrated systems tend to have larger and better-diversified banks (controlling for the size of the domestic economy eliminates the relationship between concentration and crises), but no connection is found with the ease of monitoring banks. The message of Beck and others (2006) seems to be that "more competitive banking systems are associated with less fragility, when controlling for concentration." Schaek and others (2009) reach a similar conclusion, using the Panzar-Rosse H-statistic as a proxy for competition, with data from 45 countries (1980–2005). These authors, however, find that concentration itself is associated with a higher probability of crisis.

In a cross-country study using individual bank data, Boyd, De Nicolò, and Loukoianova (2009) apply a model-based definition of stress or crisis to find that more concentration leads to a higher probability of a systemic shock, but no greater probability of government intervention. The authors claim that in the literature, indicators of banking crises are in fact indicators of government response to the crisis, and that these are predicted by base indicators such as sharp reductions in profits, loans, and deposits. These authors interpret the results in Beck and others (2006) as an indication that

36. See Vives (2000).

more concentration leads to less intervention (more forbearance by regulators) and more systemic crises, and that fewer entry barriers lead to less intervention and fewer crises. In a cross-country study with individual bank data (in emerging economies and U.S. banks), Boyd, De Nicolò, and Jalal (2009) also find that more concentration increases the probability of bank failure and that competition fosters more willingness to lend. Using cross-country data (1973–2002), Shehzad and De Haan (2009) find that certain aspects of liberalization reduce the likelihood of systemic crises, provided there is adequate supervision.

Diversification can be achieved through mergers between financial institutions, but large banks need not be more diversified. Empirical studies in the United States find strong benefits of consolidation (improving profitability and production efficiency, and reducing insolvency risk) when the degree of macroeconomic (geographic) diversification increases (Hughes and others, 1996, 1998).[37] Specifically, these authors find that geographic diversification offsets the tendency of larger banks to risk insolvency more when controlling for diversification. Expanding assets is associated with a less than proportionate increase in expected profit and a more than proportionate increase in risk. An expansion in asset size and the number of branches within the same state is associated with a more than proportionate increase in expected profit and a less than proportionate increase in risk. An expansion in asset size, branches and diversification across states is associated with an improvement in value efficiency and reduction of insolvency risk. Consolidation within the state reduces insolvency risk, but does not improve market value. It has also been claimed that greater consolidation has increased systemic risk in the United States, by looking at the positive trend of stock return correlations for large and complex banking organizations in the period 1988–99 (De Nicolò and Kwast, 2002).

Internationalization is a way to achieve diversification. Furthermore, allowing multinational banks into previously protected markets may increase the range of financial services offered in the domestic market and reduce margins. A side effect may be the erosion in the charter value of domestic banks, inducing them to take on more risk. Some observers have found that both cross-border banking and foreign bank entry have improved financial intermediation, fostered growth, and reduced fragility (see Claessens, 2006; Barth and others,

37. See also Demsetz and Strahan (1997).

2004). This reflects the direct and indirect effects of domestic banks' competitive reactions. Some evidence, however, points to mixed distributional effects of foreign bank entry. Detragiache and others (2008) find that foreign bank entry in poor countries may reduce private credit growth. Berger and others (2001) find that large foreign-owned institutions concentrate on large-scale projects and may leave out small firms. Still, large, well-capitalized foreign banks may provide stability to the domestic financial system of an emerging economy. Because the brand name and franchise value of the bank are at stake, the headquarters of foreign banks could be expected to help a subsidiary should a problem develop, but this need not hold for systemic problems (for example, the collapse of Argentina's currency board).[38] Moreover, even if foreign bank headquarters were willing to help, they may not do so at the optimal social level, since they will not take into account the external effects of their help. For example, the headquarters of foreign banks may want to limit their exposure to a country facing a currency crisis and could therefore tighten liquidity provision to branches or subsidiaries in that country. Finally, the incentives of a foreign lender of last resort and supervisor may not line up with local interests. A foreign supervisor will not consider the consequences (systemic or not) for domestic residents of restructuring a local branch or subsidiary, but only the consequences of a crisis of a subsidiary abroad in terms of systemic stability at home.[39]

Finally, there is ample evidence that institutions close to insolvency have incentives to gamble for resurrection (for example, the savings and loan crisis).

It is worth noting that the financial crisis seems to have affected banks in countries with different concentration levels and market structures. Although it has been pointed out, for example, that concentrated banking systems like those in Australia and Canada have fared better in the crisis than unconcentrated ones, such as those in the United States or Germany, countries with concentrated systems, such as the Netherlands or the United Kingdom (retail banking), also ran into trouble. Moreover, other factors come into play: in Canada (and to a lesser extent Australia), bank funds come mostly from deposits and not the wholesale market and are subject to strict regulations. Reliance on non-interest income has also proved

38. Headquarters have to back the deposits in a branch, but need not do it for a subsidiary.

39. See Vives (2006) for further discussion.

to be a source of increased risk and vulnerability.[40] By the same token, it is not evident that certain types of institutions have been more vulnerable than others. Both specialized investment banks (in fact, all the U.S. ones have collapsed or converted to commercial banks), insurance companies like AIG, and universal banks (UBS, Citigroup, or German and U.K. banks) have suffered.

In conclusion, the evidence points to the following:

—Liberalization increases the occurrence of banking crises, while a strong institutional environment and adequate regulation mitigate them.

—There is a positive association between some measures of bank competition (for example, low entry barriers, openness to foreign entry) and stability.

—The association between concentration and stability presents mixed results.

—Larger banks tend to be better diversified, but may also assume more risks.

5. Can We Regulate away the Competition-Stability Trade-Off?

We have seen how limited liability means that banks may assume excessive risks on the asset side, unless that risk position is observable and market discipline works. Disclosure requirements may help to uncover the bank's risk position (or, more realistically, ensure better assessment). This is represented by the top row in table 1. If the bank's asset risk position is not observable, then incentives to assume more risk increase considerably (second row of table 1), becoming maximal when risk-insensitive insurance is introduced, since it destroys monitoring incentives (third row in table 1). Risk-based deposit insurance moderates risk-taking incentives and undoes the bank's limited liability charter, but banks may still take too much risk in the presence of a large social cost of failure, which they do not internalize (bottom row in table 1). In the top and bottom rows, an instrument such as capital requirements may effectively control risk taking, but in the middle rows we need to complement capital requirements with asset restrictions.[41]

40. See Baele and others (2007), De Jonghe (2010), Demigüç-Kunt and Huizinga (2010), and Ratnovski and Huang (2009).

41. See Matutes and Vives (2000), Hellmann and others (2000), and Repullo (2004).

Table 1. Banking Regimes, Risk Incentives, and Regulatory Instruments When Charter Values Are Low and the Social Cost of Failure is High

	Risk-taking incentive		
Banking regime	*Liability (rates)*	*Asset (investment)*	*Necessary regulation*
Free banking (observable risk/high disclosure)	Medium-low	Absent	Capital requirements
Free banking (unobservable risk/low disclosure)	Medium-high	Maximal	Capital requirements and asset restrictions
Risk-insensitive insurance	High	Maximal	Capital requirements and asset restrictions
Risk-based insurance	Low	Absent	Capital requirements

Source: Author's compilation.

The general trend in banking regulation has been to control risk-taking through capital requirements and appropriate supervision. Both risk-based deposit insurance and disclosure requirements have been proposed to limit risk-taking behavior. Advanced economies have tried to move towards the top and the bottom rows of table 1. This shift came with reforms to the 1988 Basel Accord on capital requirements to better adjust them for risk (Basel II). Capital requirements, supervision and market discipline are the three pillars on which the Basel II regulatory reform was based.[42] Transparency has its limits, though. While introducing disclosure requirements for banks' market positions is feasible, assessing the risk level of a bank's illiquid loan portfolio is more difficult. Furthermore, more disclosure may in fact induce information-based runs among investors, generating instability.

The present crisis is a testimony to the failure of the strategy to move towards the top and bottom rows of the table. Disclosure and

42. According to Basel II's guidelines on capital requirements, banks can choose between a "standardized" approach in which external rating agencies set the risk weight for the different types of loans (say corporate, banks, and sovereign claims) or an internal-rating-based approach in which banks estimate the probability of default and also the loss given default, in an advanced version of the method. The idea is to calibrate the capital requirement so that it covers the value at risk (expected and unexpected) from the loan under some assumptions.

risk assessment have been deficient because of the failure of rating agencies—among other reasons—and market discipline has been ineffective because of the blanket insurance offered by TBTF policies. Furthermore, capital regulation has not taken into account systemic effects (the social cost of failure) and asset restrictions have been lifted under the pressure of investment bank lobbies.[43]

We are stuck in the "risk-insensitive insurance" row with maximal risk-taking incentives. We need therefore to design appropriate capital requirements and asset restrictions. Optimal regulation would need a combination of risk-based insurance for deposits (which implies that insurance premiums are contingent on the rates offered by banks and their asset risk position, eliminating or exactly offsetting limited liability) and systemic capital charges that internalize the social cost of failure of banks. If banks' asset risk position is not observable, then insurance cannot be contingent on it and banks will be induced to take maximal risk on the asset side. This will have to be controlled using asset restrictions (for example, separating banking and proprietary trading/investment banking activities). Furthermore, the appropriate level of the systemic capital charge will depend in general (in an increasing way) on the intensity of competition, and will be binding in a low or medium friction environment.

According to Matutes and Vives (2000), the capital requirement level is an increasing function of both the social cost of failure K and the intensity of competition (inverse friction) in the market (λ, which in the model goes from maximal differentiation $\lambda = 0$ to no differentiation $\lambda = 1$). This is because typically the level of friction is not only a behavioral parameter but one that enters the utility function.[44] In this case a capital requirement should be set as a function of the level of λ. This result is consistent with the analysis in section 3.1, which requires that the solvency requirement be tightened in a more competitive environment.

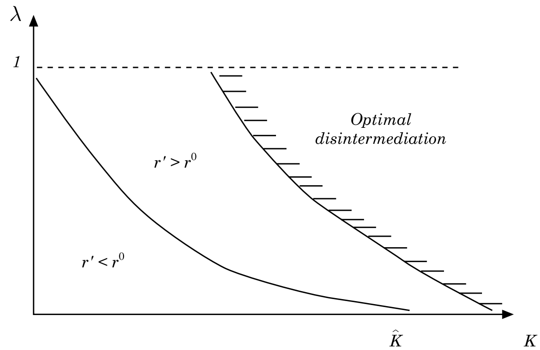
Figure 9 depicts the regions in the space of intensity of competition λ (with $\lambda = 0$ for an independent monopolies situation

43. The fact that financial regulation is subject to strong lobby pressure is well known. Kroszner and Strahan (1999), for example, document its role in the abandonment of branching restrictions in the United States.

44. For example, customers value differentiation, a source of friction and market power. Thus, an increase in differentiation means that banking customers will value the volume offered by the bank more and therefore a more lenient capital requirement becomes appropriate.

and $\lambda = 1$ for perfect competition) and social cost of failure K for which it is optimal to disintermediate ("optimal disintermediation"), and for which deposit rates are too high ($r' > r^o$) or too low ($r' < r^o$), from the welfare point of view. For a given level of competition λ, if K is very large it is optimal to disintermediate, if K is intermediate then banks are too aggressive, taking too much risk on the liability side, and a binding capital charge (as a function of λ) should be imposed. If K is low, then banks are not aggressive enough, the capital charge will not be binding, and an increase in competitive pressure would be welfare-enhancing. Competition policy pressure is needed in a high friction environment.

Figure 9: Comparison of Market and Optimal Deposit Rates, as a Function of the Friction in the Market (1/λ) and Social Cost of Failure (*K*)



Source: Matutes and Vives (2000, figure 3).

With precise knowledge of K and $1/\lambda$ the competition-stability trade-off can be regulated away. Just set up the appropriate capital charge and let banks compete (with the usual enforcement of competition policy).

The competition-stability trade-off also applies to emerging economies. An emerging market economy is characterized by high uncertainty, increased likelihood and incidence of financial and currency crises, a predominantly financial role for banks, and a weak supervisory structure. These characteristics make it much more difficult to apply the regulatory strategies applied by developed countries in an emerging market economy. This reflects several factors. First, moving toward a disclosure strategy is more difficult, because information problems are more acute and producing information is more expensive. Second, risk-based deposit insurance can work only when insurance can be priced according to objective indicators of bank risk, which will be more difficult to obtain in an emerging market economy (and we know that even in a developed economy they can be hard to get). This makes it harder to move toward a risk-based insurance strategy, as the potentially problematic application of Basel II shows. It follows that banking and financial market regulation must be adapted for emerging market economies. These will tend to have higher project liquidation costs and social costs of failure, and a higher level of friction. The first two factors will push policymakers to tighten the regulations, while higher friction may pull them in the opposite direction.

In conclusion, the trade-off between competition and stability is complex, but seems real (at least along some dimensions). Well-designed regulation may alleviate this trade-off, but needs to consider it. Specifically, this means capital requirements that allow for systemic externalities must be adjusted to the level of friction in the market, becoming tighter when competition is more intense. In a world where fine-tuning regulations is difficult (and the experience to date with banking regulation seems to confirm this), it seems unwise to try to completely eliminate market power in banking. This may have implications for the optimal degree of concentration, which is likely to be intermediate. In emerging economies, optimal policy needs to carefully balance the impact of the different levels of friction and social cost of failure. In any case, it is clear that competition should be limited for institutions close to insolvency. This should be done in a framework that permits prompt corrective action, allowing the supervisor to intervene as soon as red flags indicating depleting capital go up.[45]

45. In fact, according to the U.S. Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA), when solvency falls below a certain limit, the bank cannot expand its assets. A further decline in solvency may trigger the need to recapitalize or even the imposition of rate ceilings. The FDICIA seeks to reduce regulatory discretion through rigid intervention rules, which are gradually applied (see, for example, Dewatripont and Tirole, 1994).

6. The Policy Response to a Financial Crisis[46]

6.1 Interventions and distortions

When a systemic crisis hits, the pressure to stabilize the system is tremendous. In the 2007–08 crisis, we saw an array of interventions: asset purchase and guarantee schemes (including extensions of deposit insurance, and guarantees in the interbank market and in mutual funds), capital injections, outright nationalization, and forced mergers. These interventions represent a large distortionary potential in terms of moral hazard, long-term effects on market structure, protection of inefficient incumbents, and creation of an uneven playing field (among different institutions and different countries). For example, TBTF institutions receiving help may end up with lower capital costs than others (not only in the short term, but also in the long term, because of the implicit guarantee involved). The result is that, ex ante, the incentives are to take excessive risk. This is compounded by subsidy races to help national champions and marketplaces. This effect is particularly apparent in the European Union, posing a threat to the single market. The help provided to the system may foster regulatory forbearance to cover losses. There is indeed evidence that regulatory forbearance is prevalent and that government is less likely to close or take over failing banks when the sector is weak: the cases of the savings and loan crisis in the United States, Japan's banking crisis, and evidence on 21 emerging countries (Brown and Dinç, 2010). Finally, help to banks spills over into other sectors that demand more help (such as car manufacturing).

The crisis has brought forced mergers backed by government subsidies and/or guarantees.[47] The upshot is that surviving incumbents enjoy more market power and lower capital costs, because they are

46. This section is based on Vives (2010b).

47. In the United States, backed by the Federal Reserve, Bear Stearns merged with J.P. Morgan in March 2008. Later that year, J.P. Morgan acquired the banking assets of Washington Mutual from the Federal Deposit Insurance Corporation, and Merrill Lynch merged with Bank of America (thereby exceeding the 10 percent national market share deposit threshold established by the Riegle-Neal Act of 1994, as did Wells Fargo when it acquired Wachovia in 2008). In the United Kingdom, the merger of HBOS and Lloyds TSB was approved against the Office of Fair Trading's opinion (with partial nationalization), despite the merged entity ending up with a 30 percent market share in current accounts/mortgages and competition problems in small and medium enterprise banking services in Scotland. It is worth noting that Lloyds was not allowed to take over Abbey in 2001.

TBTF (and/or because of the public help). Remember that merger policies affect both competition and dynamic incentives. The takeover of a failed bank may reward an incumbent with temporary, monopoly rents, inducing monopoly inefficiency but prudent behavior. This is optimal only if subsequent entry is facilitated (Perotti and Suarez, 2002). The danger now is that incumbents increase their market power and are protected from new entries. A merger policy must have a long horizon, and even in a crisis situation, must consider the optimal degree of concentration in the industry, dynamic incentives for incumbents to be prudent, and ease of entry.

State intervention and even outright ownership have been necessary to stabilize the system. Indeed, when the taxpayer is footing the bill, the public sector must have a say in how the institution receiving help is run. Government ownership is distortionary, however: government sits on both sides of the regulatory relationship; if not disciplined by competition, it makes the banking system less efficient and encourages inefficiency, less financial stability, higher risk exposure, and more bank losses (Barth, Caprio, and Levine, 2004; Caprio and Martinez Peria, 2002; De Nicolò and Loukoianova, 2007); and political objectives and incentives rule.[48] It also eliminates the market for corporate control, creates an uneven playing field with implicit and explicit guarantees, and leads to less competition and lower financial development.

In a crisis, policy makers must walk a tightrope between the supportive measures necessary to avoid contagion and ensure stability, and the desire to nourish vigorous competition over the long term. Some trade-off between the two objectives, particularly in the short-term, is unavoidable. When a systemic crisis strikes, there is little time to react and support measures must be implemented very quickly. Central banks, regulators, and fiscal authorities provide the support measures and the competition authorities must watch for distortions affecting competition (including the formation of market structures that hamper competition).

Help to a bank typically provides a positive externality to other banks, since it limits the spread of a crisis and protects the system, mostly by avoiding contagion, be it informational or because of

48. The evidence presented by Hau and Thum (2009) on board incompetence in German public banks (there is an enormous difference between private and public sectors, in terms of education, financial and management experience in the 29 largest German banks) is suggestive, linking larger losses borne in the crisis to the lack of professionalism in boards.

interbank exposures. This does not distort competition if it is liquidity help that allows a fundamentally sound bank to avoid contagion and ride out the turbulence. If the bank in distress has a solvency problem, then it should be restructured and help should come with strings attached, so that competition is not distorted by "bad" banks displacing "good" ones in customer business. The counterfactual for evaluating whether help is distortionary has to consider what would have happened if there had been no coordination failure among investors from the perspective of the distressed institution, that is, by removing the panic component from market behavior. This is not easy, particularly when compounded by regulatory failures that induce excessive risk taking.

The main tools of intervention to limit distortions are structural (asset divestitures) and behavioral (pricing, advertising, acquisitions) restrictions. Structural commitments may help reduce the post-crisis overcapacity in the banking sector, accumulated during the asset boom in many countries. Indeed, an added component in the present crisis is the extent of overcapacity in the banking system. The period of expansion at low interest rates has led banking to over-expand via credit, particularly in those countries where there has been a real estate bubble (United States, Ireland, United Kingdom, Spain). This means that branches and personnel must be cut, together with the balance sheet, even if credit is normalized (because it should stabilize below the pre-crisis bubble levels). In general, care must be taken to ensure that any commitments, whether structural or behavioral, leave the restructured bank a viable competitor. This is obvious if the bank is a fundamentally sound one. If it is not, then restructuring should prevent the bank from taking over business from healthy rivals that have not enjoyed help. In either case, the restructured bank has to be a viable competitor. To check moral hazard, it is important to remove the imprudent management of the institution receiving help. In this case, the behavioral restrictions on the helped bank could be relaxed.

6.2 Approaches in the United States and in the European Union

The role of the competition authority in the United States has been different from that of the European Union, because the E.U. competition authority has the unique capability, among competition authorities, to control state aid. Since the crisis, the European Union has dealt with many banking aid cases, taking 22 decisions in 2008 alone, and 81 decisions in total as of 17 December 2009. Seventy-five of the cases were approved without objection.[49] The European Union has explicit conditions for state guarantees and recapitalization, which have been formalized as temporary guidelines on restructuring aid to banks. The conditions imposed on helped institutions are mostly sensible, since they try to minimize the distortions introduced by public help, in particular for fundamentally unsound institutions.[50] The European Commission has toughly imposed or influenced significant balance sheet reductions and behavioral restrictions on helped entities such as ING, Northern Rock, RBS, Commerzbank, or WesLandesbank. Interestingly, in the case of RBS, which has been ordered to sell some retail operations, insurance, and its commodity-trading business, the Commission mentioned concentration concerns, with RBS being the leader in retail and corporate banking for small and medium-sized enterprise segments. It also mentioned the benefits of divestment, in terms of limiting moral hazard in the insurance and commodity-trading business.[51]

Some measures can be understood as efforts to minimize competitive distortions of the aid, and others in terms of restraining moral hazard in the future. In principle, the role of the competition authority is to preserve competition and not to limit moral hazard, which is the regulator's role. The important point is that measures focusing solely on competitive distortions will also affect ex ante incentives (and moral hazard), since a bank will know that in the event of trouble, help will come with restrictions. This connects to the TBTF issue. More broadly, the concept of competitive distortion may address the issue of competition for those enjoying the advantages of a TBTF umbrella. In this sense, restrictions on business activities that fall outside regulated, core banking business may make sense, although they go beyond the standard competition concerns and

49. Sixty-six more cases have been cleared under a temporary framework to support lending to firms. See the European Commission's Directorate General for Competition's State Aid report of 17 December 2009, which includes an overview of national measures adopted as a response to the economic and financial crisis.

50. There is a potential exception in the behavioral requirement, which implies a commitment to expand lending. This is contradictory to the restrictive behavior that some want to impose on institutions receiving help and may induce bad practices, since the business of a private bank is to lend and what has to be attacked are the causes behind why the bank is not lending.

51. See the European Commission's Directorate General for Competition's State Aid report of 14 December 2009, in which the Commission approves an impaired asset relief measure and restructuring plan of RBS.

analysis. The RBS case points to the need for coordination between the competition authority and the regulator.

The activism of the European Commission poses the question of the future competitive balance with U.S. banks that received assistance requiring no divestitures. This may prove important, particularly in those segments in which there is global competition. On the advice of Paul Volcker, the Obama administration is advocating limits on size and scope (mostly proprietary trading) of banks, to avoid the too-big-to-fail problem and control risk-taking.[52] Thus, the United States may accomplish through regulation what the European Commission is trying to accomplish through state aid controls. An important side benefit of state aid control in the European Union is that it limits bankers' incentives to take excessive risk, under the expectation of a bailout if things go wrong. Thus, it addresses the TBTF issue. The competition authority may internalize the fact that if an institution that fails gets help, competition will be distorted. The option of limiting the size (or better, the systemically corrected size) of an institution that breaks up once it has received public help (something that the European Union seems to be implementing) expands the realm of competition policy. When ordering divestitures, however, the competition authority should not take into account systemic considerations. So far, the United States seems to be following another route, where TBTF is explicitly not an antitrust problem (see White, 2009).

In any case, size and scope restrictions are a blunt instrument to deal with the TBTF issue. Controls on size are problematic, because interconnectedness and business specialization are more relevant to systemic risk. In terms of scope, conflict of interest is what leads to potential market failure and should be the focus of any limitations. Higher capital and insurance charges for systemically important institutions, together with effective resolution procedures, may be a better approach to the problem. This should be coupled with a serious look at conflicts of interest in financial conglomerates. The upshot is that in its role of protecting competition, the competition authority may have a say in the TBTF issue and therefore its actions should be coordinated with the regulator. The potential for competition policy to provide a commitment device to partially address TBTF issues should not be dismissed.

The Obama administration's move is reminiscent of the

52. See White House (2010) for details.

nineteenth century antitrust tradition of looking at large firms with suspicion because of the excessive concentration of power. Later on, antitrust evolved with size becoming less important as attention shifted to the issue of market power in particular markets. The influence that investment banks have had in the deregulation of financial intermediaries and the huge rise in leverage that ensued and led to the crisis is backfiring. We have entered the territory of political economy and the question is how to best control excessive concentrations of power in a democratic society.

7. Summary and Conclusions

Liberalization has come with an increase in the competition facing financial intermediaries and in the appearance of crises. Bank assets have not declined in relation to total financial assets and banking has shifted toward service provision. This restructuring has tended to increase aggregate concentration, although the consequences may have varied in relevant local retail markets in the United States and Europe. The crisis points to a return to traditional banking and may tend to exacerbate the consolidation trend.

Banks are unique because of their particular mix of features, which makes them vulnerable to runs with potentially systemic impact, and very important negative externalities for the economy. The fragility of a competitive banking system is typically excessive. Financial regulation comes to the rescue at the cost of side effects and regulatory failure. The most important one is the potential moral hazard induced by protection and bailouts extended to failing institutions. The present crisis is a testimony to the failure of the three pillars of the Basel II system. Disclosure and risk assessment have been deficient (think of the failure of rating agencies), and market discipline has been ineffective because of the blanket insurance offered by TBTF policies. Capital regulation has not taken into account systemic effects (the social cost of failure) and asset restrictions have been lifted under pressure from investment bank lobbies. Supervision has proved ineffective, since it has allowed a shadow banking system to grow unchecked.

Theory and empirics point to the existence of a trade-off between competition and stability along some dimensions. Indeed, runs happen independently of the level of competition, but more competitive pressure worsens the coordination problem of investors/depositors and increases potential instability, the probability of a crisis, and the impact of bad news on fundamentals. This does not imply that competitive pressure has to be minimized, since in general the socially optimal probability of a crisis is positive because of its disciplining effect. On the asset side, once a certain threshold is reached, an increase in the level of competition will tend to boost risk-taking incentives and the probability of bank failure. This tendency may be checked by appropriate regulation and supervision. The evidence points to liberalization increasing banking crises, while a strong institutional environment and adequate regulation reduces them. At the same time, there is a positive association between some measures of bank competition (for example, low entry barriers, openness to foreign entry) and stability.

Regulation can alleviate the competition-stability trade-off, but the design of optimal regulation has to take into account the intensity of competition. For example, capital charges should reflect the degree of friction and rivalry in the banking environment, with tighter requirements in more competitive situations. Given that fine-tuning of regulation has proved very difficult in practice (this is probably an understatement given the massive regulatory failure that the crisis has uncovered), the trade-off between competition and stability is bound to persist, suggesting that coordinating regulation and competition policy is necessary. Banks' uniqueness, not only during crises, should be recognized and the appropriate lessons drawn and applied during competition policy implementation.

The competition-stability trade-off also applies to emerging economies. An emerging market economy is characterized by high uncertainty, increased likelihood and incidence of financial and currency crises, the predominant financial role played by banks, and weak supervisory structures. These characteristics make it much more difficult to follow the regulatory strategy typically followed in developed countries. Emerging economies tend to have higher project liquidation costs and social costs of failure, and a higher level of friction. The first two factors tend to push for tighter regulations, while higher friction may pull in the opposite direction. In emerging economies, optimal policy should carefully balance the impact of the different levels of friction and the social cost of failure.

Merger policy in banking should be consistent over time and keep in mind an optimal degree of concentration and dynamic incentives (rewarding prudence and easing entry). How to deal with TBTF institutions remains an open issue. In the United States, TBTF is not an antitrust issue, whereas in the European Union the competition authority controls distortions of competition which arise out of state aid, and this has implications for TBTF. The credibility of the competition authority to impose conditions once an institution has been helped may provide a commitment device which has been lacking in bank bailouts. Controls on size are problematic because interconnectedness and line of business specialization are more relevant to systemic risk than size. In terms of the scope of any bank's activities, conflict of interest is what leads to potential market failure and should be the focus for any limitations.

All this calls for close collaboration between the regulator (in charge of stability and prudential control) and the competition authority (in charge of keeping competition healthy). First of all, regulatory requirements and competition policy need to be coordinated. Capital charges may have to be fine-tuned to match the intensity of competition in different market segments. Second, a protocol for cooperation between the regulator and the competition authority should be developed. This is particularly important in crises. The competition authority can commit to addressing TBTF problems that lead to competition distortions; the regulator can address the TBTF issue and moral hazard through systemic capital charges, effective resolution procedures, and restrictions on the scope of banking activities that target conflicts of interest. Finally, crisis procedures should be established that define liquidity help from recapitalization and conditions for restructuring to avoid competitive distortions. Entities close to insolvency should be tightly regulated (and activities restricted) in a framework permitting prompt corrective action.

On the political economy of regulation, the debate over whether to let firms, banks in particular, get so large that they significantly influence regulation remains open.

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