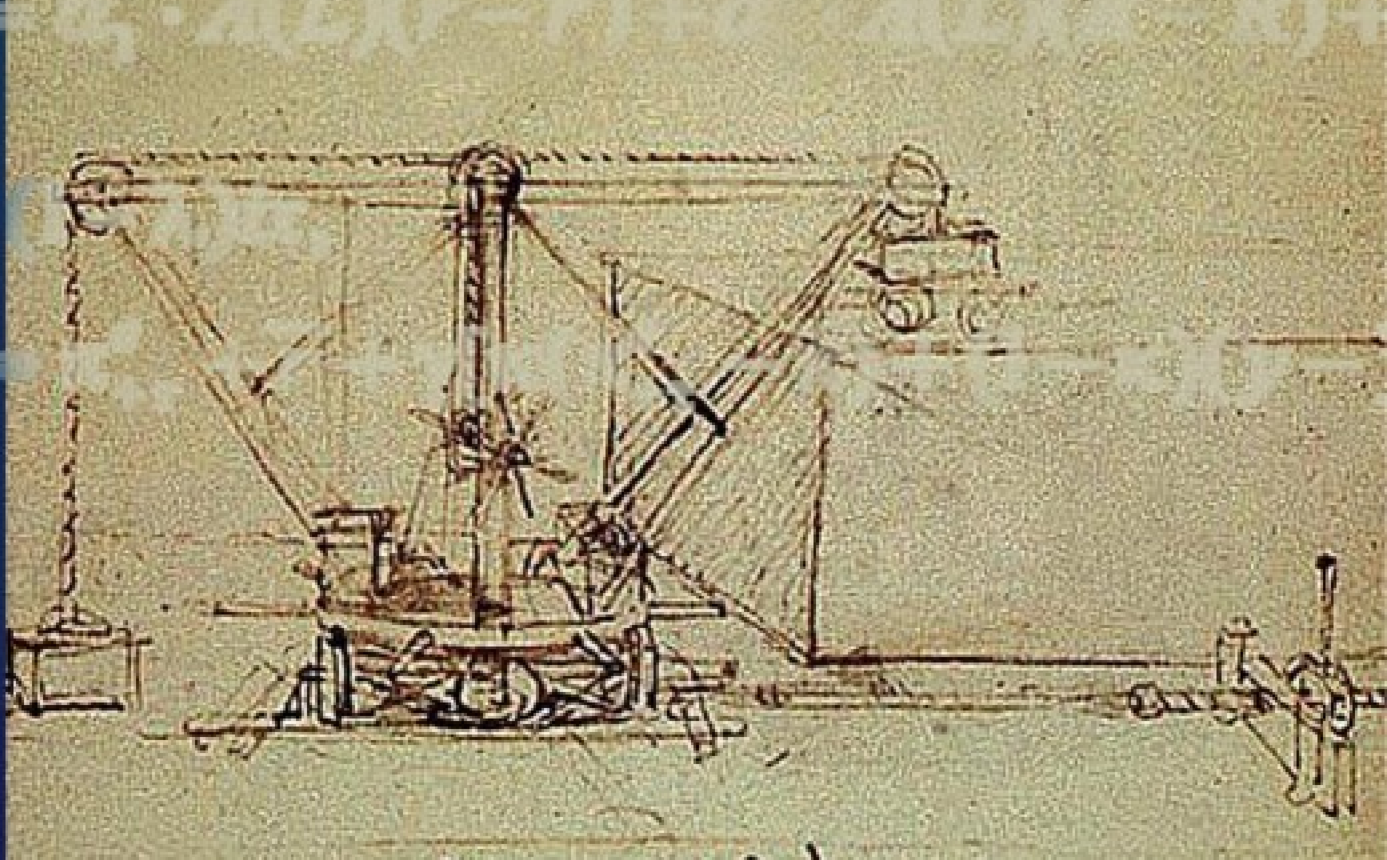
BANCO CENTRAL DE CHILE

CENTRAL BANK OF CHILE MACROECONOMIC MODELS AND PROJECTIONS 2003



Central Bank of Chile Macroeconomic Models and Projections

Central Bank of Chile

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Preface

The Board of the Central Bank of Chile has interpreted its constitutional mandate regarding price stability to mean that it must keep inflation centered on 3% annually, with some fluctuation, ranging from 2% to 4%. This book contains a detailed description of the economic models that assist the Board in this task. These are used in a pragmatic, eclectic and non-mechanical way to carry out projections. In a constantly changing economy, no single model can fully integrate all the factors relevant to implementing monetary policy. Making judgments regarding these diverse factors and their implications for monetary policy is the Board's prerogative and cannot be left to models alone, nor to those who build and run them.

The models that the Central Bank of Chile currently uses are published in this volume as part of its commitment to increasing transparency. However, it is not the purpose of this paper to provide a view of the decision-making process as a whole; rather, this effort is limited to making known the main tools used to prepare projections, which represent one set of inputs into this process.

This book describes the current status of development of Central Bank of Chile models, which are constantly being studied and improved as techniques for dealing with macroeconomic policy problems advance. The Board of the Central Bank of Chile will determine its approach to future advances in this area, according to the challenges that arise.

Many people have participated in the preparation of this work, some of whom are no longer at the Bank. This list, which is not complete, includes William Baeza, Héctor Bravo, Rodrigo Caputo, Gabriela Contreras, Helmut Franken, Carlos García, Pablo García, Luis Óscar Herrera, Felipe Liendo, Eduardo López, Leonardo Luna, I. Igal Magendzo, Juan Pablo Medina, Ernesto Pastén, Jorge Restrepo, Luis Salomó and Rodrigo Valdés. The process of preparing this document received the benefit of comments from members of the Board of the Central Bank of Chile and economists working inside and outside the Bank.

This volume is divided into four chapters. The first deals with the reasons and usual ways of applying models, emphasizing their non-mechanical use in formulating monetary policy. The second describes in detail the Structural Projection Model (*modelo estructural de proyección*, MEP), with particular emphasis on determining inflation and aggregate demand. The third chapter provides auxiliary models, including time series models for projecting current conditions, and accounting coherency models. The fourth chapter provides some exercises typical of the kind of question that models can answer, aside from providing projections.

At the end we provide a glossary with a list and description of the different variables that form part of the respective models.

1. Introduction

The constitutional rules governing the Central Bank of Chile establish that the monetary authorities will "ensure the stability of the currency."[1] The Board has interpreted this constitutional mandate to mean achieving an annual inflation rate centered on 3%, with fluctuations remaining within a 2% to 4% range. To meet this objective, the Central Bank has made a significant effort to increase the transparency with which it communicates and formulates monetary policy, by publishing its *Monetary Policy Report* (*Informe de Política Monetaria)*, the minutes of Board sessions, and a calendar providing advance warning of its monthly monetary policy meetings (*reuniones mensuales de política monetaria, RPM*). The importance of transparency lies in the fact that it allows different agents to understand the rationale behind Central Bank of Chile policies. This, in turn, contributes to making these policies effective in meeting agreed upon objectives, increasing market confidence that the inflation target will be met, and allowing the Central Bank to report to society on how it is fulfilling its constitutional mandate.

This volume forms part of the transparency building process, by providing information on the current status of instruments used by the Central Bank to formulate its projections. Aside from providing the different models used, the chapters that follow this introduction explain how these models are used in practice.

The prime role played by models is to organize the analytical framework that is behind the monetary policy transmission mechanism. The casual observation of current conditions is not enough to understand the forces influencing inflation. Rather, these must be organized in a prudent fashion. This order is easier to establish with the assistance of a model. Secondly, once a model that reflects the relevant monetary policy transmission mechanism is available, the most direct way to use it is to support the Board's judgment in formulating inflation projections. These projections are very important in inflation targeting schemes, because they constitute the intermediate objectives of monetary policy, in the sense that policy actions usually respond to how projections evolve with regard to the inflation target. Thirdly, a model for the monetary policy transmission mechanism makes it possible to understand and quantify the most likely way that the economy, and especially inflation, will respond to different events or news, as well as evaluating the response to changes in monetary policy itself.

The Central Bank of Chile has found it useful to deal with model development using a main model, supported by a series of auxiliary or satellite models. The main model captures precisely the transmission mechanisms considered relevant, and is the one used the most. The auxiliary models, meanwhile, make it possible to validate and contrast projections and exercises resulting from the main model. Moreover, they make it possible to prepare some of the inputs used in projections. The way this volume is structured reflects these criteria. Chapter 2 presents the structural projection model, MEP, with its variants, while chapter 3 provides the different auxiliary models. Chapter 4 provides some traditional exercises carried out using the models presented in this volume, referring to monetary policy's effect on economic activity and inflation, the sacrifice ratio, the relationship between exchange rate depreciation and inflation, and the effect of several external shocks. Comparing the

1 At www.bcentral.cl/esp/fuyorg/leyorganica/Basic Constitutional Act of the Central Bank of Chile (*Ley Orgánica Constitucional*), can be found, as published in the Official Gazette (*Diario Oficial*), on 10 October 1989, with its later amendments.

results of these exercises for Chile with those of a set of countries shows that the models used by the Central Bank do not differ much from international experience. This also indicates that the kind of models used by the Central Bank of Chile are not very different from those used by most central banks involved in inflation targeting schemes.

Finally, it is important to note that model development is an ongoing process, which advances in different dimensions. First, because empirical and theoretical advances are incorporated, to the degree that they are considered relevant to monetary policy conduction, and second, because the gradual inclusion of new information leads to differences between model results and actual economic performance, which are very informative to examine possible ways of improving model structure. The Central Bank's experience in recent years has been precisely in this sense, making it possible to gradually increase the sophistication and the quality of the models used. This volume, therefore, reflects only the current status of model development, as future versions are to be expected that provide variations and extensions, improving their current content.

1.1 Use of Macroeconomic Models

The basis of all monetary policy decision-making processes is the careful observation of current conditions, in light of accumulated experience with the economy's behavior. In this sense, it is not easy to interpret the lessons of the past. Nor is it easy to know if the characteristics of the economy today are different from yesterday's. These difficulties make it possible to understand the reasoning behind using models. An economic model makes it possible to clarify and organize this decision-making process. A model provides a quantitative measure of how the economy behaved in the past in the face of a series of events, which may have involved fiscal or monetary policy decisions, or events within the world economy. Similarly, the model makes it possible to quantify the effect of foreseeable future trends in these variables, taking into account, also how agents react to eventual policy decisions.

Models as Organizers of the Analysis

The specific way in which models help to organize the discussion and the analysis of monetary policy is by bringing together, in the same conceptual framework, factors determining inflation and the quantification of magnitudes and lags involved in the different monetary policy transmission channels. Because of this, the model must have an internal structure that reflects the views on how inflationary pressures are generated in Chile, as well as the monetary policy and foreign exchange regime currently in effect, which goes beyond purely historic evidence. It is necessary to include the Board's judgments and its prudent view of what factors are more relevant today than in the past in determining inflation. It is vital to be able to organize the quantitative importance of the different elements that determine the rise in prices, such as supply and demand conditions in different markets, expectations, changes in the quantity of money and others, to be able to make informed and consistent monetary policy decisions. This same identification of the main factors behind inflationary trends makes it possible to communicate in a more precise and orderly fashion, which suitably reflects policy rationales.

In general, the relative importance of transmission mechanisms depends on structural factors in each economy, among them the degree of openness to trade and financial flows, the depth of financial markets and institutional development. For example, in Chile it is believed that the main transmission channel along which monetary policy reaches inflation is through the structure of market interest rates, including prices on longer-term Central Bank instruments, which in turn affect consumption and investment decisions by economic agents. These changes in the aggregate demand for goods and factors influence inflationary pressures.

Given that a macroeconomic model is built based on a set of precise relationships between variables, it serves as a suitable way of achieving the necessary quantifications. Thus, it is possible to distinguish the main forces determining inflationary tendencies within the relevant horizon for monetary policy, a discussion that then gives rise to policy decisions and the preparation of the *Monetary Policy Report*. There is therefore a close parallel between the communication of the rationale behind policies adopted by the Bank and the form assumed by macroeconomic models.

Models and Preparing Projections

Changes in monetary policy interest rates affect inflation with a long and variable lag, so monetary policy decisions cannot be based solely on what is happening to inflation today. Rather, it is necessary to determine if the current policy approach is compatible with an inflationary trajectory that will meet the price stability objective. In this sense, inflation projections assume an important role, and could be considered an intermediate objective in themselves. In any case, the relationship between inflation projections and change in monetary policy is far from mechanical.

Inflation projections and economic growth occur as part of a continuous iterative and interactive process, but their main landmarks are the monthly monetary policy meetings and the *Monetary Policy Report*. This process uses as inputs the opinions of the Board on the most likely future course of the variables that influence inflation and economic activity, and expected changes in the external scenario, normally provided by the estimates included in Consensus Forecasts and the main investment banks. On this basis, and through the in-depth use of the models presented in this paper, a process begins that makes it possible to define the main or baseline scenario, to project inflation and other relevant variables over the next eight quarters. Moreover, the models make it possible to analyze the risks associated with alternative scenarios to the one involving the most likely trajectory for variables.

There is no simple, mechanical relationship between inflation projections and (actual or foreseeable) change in monetary policy. In fact, the objective of monetary policy is to keep inflation low and stable at about 3%, in a persistent fashion, and not simply for a given horizon. Because of this, although the eight-quarter horizon is the main focus for monetary policy action, this action must also consider the prospects for inflation before and beyond this period.[2]

Policy Exercises and Evaluation

A model that suitably reflects monetary policy transmission mechanisms is useful not only for carrying out projections, but also can be implemented in artificial environments that are not associated with the reality of historical data, to analyze different policy exercises and simulations. A first set of relevant exercises deals with the effects of short- and long-term changes, which may be temporary or permanent, in exogenous variables on monetary policy conduction, such as the international environment and fiscal policy. These exercises are important, not only because of their implications for inflation's trajectory, but also because they suggest recommended monetary policy responses. In the same sense, having a model makes

2 For more details about these aspects, see Central Bank of Chile (2000).

it possible to evaluate the impact of changes in monetary policy, in terms of the magnitudes and the lags with which they affect inflation and short-term growth.[3] Alternatively, given the economic model constructed, the optimum way of applying monetary policy can also be evaluated.[4]

Another way of using models, which is implicitly similar, consists of evaluating inflation and output volatility that result from specific forms of monetary policy responses to changes in different variables. For example, with models such as those presented in this volume, it is feasible to evaluate the effects that some more or less aggressive or more or less persistent monetary policy approaches would have on these volatilities over time.[5] At the same time, this makes it possible to quantify the uncertainty that the economy is subject to, by conjugating the volatility of variables that are out of the Central Bank's control with specific monetary policy responses to different sources of volatility.

1.2 The Role of Judgment

Economic models are developed, implemented and used by economists, and therefore cannot replace their good judgment. In other words, formulating monetary policy should rely on a permanent dialogue between models and judgment. On one hand, economic judgment indicates the priorities for research and introduces ingredients that are not easily quantified into projections, while models, as discussed, make it possible to structure the discussion of monetary policy, providing some key quantifications regarding lags in and magnitudes of movements in both exogenous and policy variables.

The importance of judgment is apparent with the basic problem in this kind of exercise, which is obtaining estimates for the main parameters required to carry out forecasts or simulations. Traditional statistical methods are subject to profound identification problems, because of the simultaneousness of economic events and difficulties in precisely measuring variables. This is compounded by the widely recognized fact that the relationships between economic variables are determined by existing policy regimes, given that the economic links between different agents within the economy do not occur in a vacuum, but rather are affected by these agents' expectations about the future course of economic policies themselves.[6] Finally, the availability of information is an important restriction when it comes to empirically estimating the relationships between different variables.

Hence, establishing the appropriate monetary policy approach requires a prudent combination of qualitative and quantitative considerations. Progress in economic theory and statistical and econometric techniques is ongoing, and the monetary authorities would be sinning by omission if they did not incorporate them in the design of economic models supporting monetary policy formulation. This is apparent in the use of complementary models. Some of these emphasize a more detailed

3 One example of this kind of exercise is the impact on inflation of a permanent rise in the real exchange rate. In the final chapter of this document, there are some estimates of this nature.

4 The study of the optimum monetary policy goes beyond the sphere of this volume. Initial approaches to this subject in Chile can be found in Medina and Valdés (2002a) and Medina and Valdés (2002b). Recent exhaustive theoretical treatment can be found in Walsh (2003), Svensson and Woodford (2003) and Woodford (2003).

5 García, Herrera and Valdés (2002) deal with this subject for the case of Chile. For similar studies in other economies with monetary schemes and models similar to Chile's, it is worth mentioning Batini and Haldane (2002) and DeBelle and Cagliarini (2002). Taylor (1999) provides a broad review of exercises such as those mentioned for a variety of models.

6 In economic literature, this problem is known as the Lucas critique, following Lucas (1972).

description of the transmission mechanisms that the Board considers relevant, while others place more emphasis on significant predictive ability.

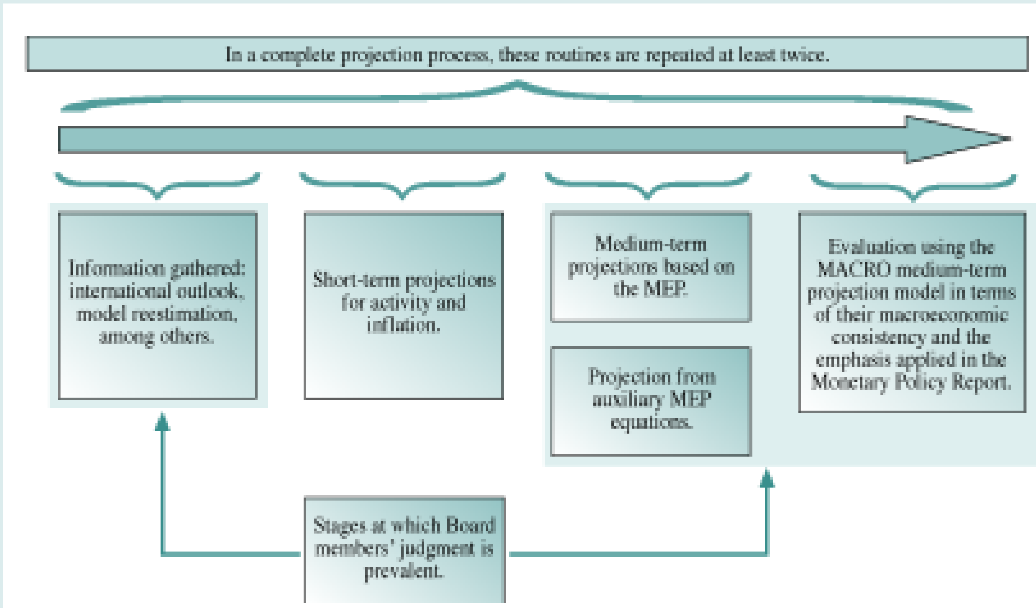
Monetary policy credibility depends on the professionalism with which the Central Bank deals with its objective of achieving stable prices. The use of economic models in the prudent and not mechanical manner described here is one ingredient in achieving this purpose. Thus, it should be noted that the criteria of Board members is relevant to more than the process of constructing the inflation projection. The decision about the policy itself also depends on a series of additional considerations that involve strategic or opportunity-related aspects that are hard to quantify when projecting inflation, but are decisive when it comes to make decisions.

BOX 1:
MODELS AND JUDGMENT IN THE PROJECTION PROCESS

The set of models presented in this volume are used at different times and with different intensity during the periods in which projections are being developed. Some of these, particularly the import and export projection models, are used often, on a weekly basis. This reflects the high frequency with which foreign trade figures are updated. This information is available weekly and in fact is published as soon as it arrives internally. This weekly information is extremely volatile, not only due to the nature of foreign trade series themselves, but also due to a set of idiosyncratic aspects associated with working days during the week, the impact of the exchange rate on import decisions, and the effect of volatility in certain commodity prices. Thus, a simple comparison of the level of imports for a given week with the equivalent data from one month or one year earlier is not useful. To be able to evaluate, therefore, the real informational content of the weekly foreign trade series, the models presented here are used.

A second set of models is used for bi-monthly or monthly periods, to evaluate short-term growth and inflation prospects. In the first place, manufacturing projections are of prime importance to short-term change in activity, given the direct and indirect impacts of manufacturing activity. The model presented here is one of the inputs used to project the short-term change in this sector and complements the judgmental analysis based on informal conversations with relevant firms in the different sectors. In the second place, leading indicators and those coinciding with the Imacec provide a short-term perspective for evaluating change that may be occurring in growth trends. Thirdly, time series models provide a reference about the impact of relevant news on inflation projections over a somewhat less immediate horizon, providing the basis for Research Division analysts to develop short-term inflation and growth projections.

These elements are used rather often and provide preliminary data for policy discussions. However, they also play a somewhat different role, that of feeding the medium-term scenario resulting from MEP projections. This complete projection process occurs at least during preparation of the *Monetary Policy Report* and requires an intense interaction between Board members and staff, so that the resulting projections are consistent with the macroeconomic vision of the different Board members. The following time line describes in a simple fashion how one iteration of the projection process is structured, along with instances when judgment is decisive to preparing final figures. In general, a complete projection process is carried out on the basis of two or more iterations of the activities presented in the following figure.



Judgment's contribution to the projection process is essential at several stages. For example, the prospects for potential growth, interest rates, margins and the real equilibrium exchange rate can be evaluated using specific methodologies or models, but in the end this data only informs the Board's decisions. Similarly, although for some international variables there is highly credible data available (for example, growth projections from Consensus Forecasts), for others, such as the copper and oil price, there is no clear reference. Moreover, medium-term macroeconomic prospects cannot be resolved mechanically in a projection process, because they involve a vision that must be consistent with the balance between saving and investment, productivity trends, external financing conditions, and of course, the emphasis and issues highlighted in each *Monetary Policy Report*.

Thus, judgment's role in this projection process is no minor one, given the environment of uncertainty that always surrounds monetary policy decisions. It is impossible to mechanically include, through theoretical models, the sources and implications of this uncertainty, not only because measuring and quantifying it is far from a trivial task, but also because its implications in decision-making depend on the Board's preferences and their concrete interpretation of their constitutional mandate.

This book mainly focuses on the macroeconomic models used to prepare projections; its main purpose is not to present the Board's decision-making process as a whole. This would go far beyond the sphere of the statistical and econometric techniques included here, as it is more closely involved with the precise interpretation of the price stability mandate and the inflation targeting scheme implemented to date in Chile. A more detailed treatment of these aspects will be the subject of future Central Bank of Chile publications.

1.3 Structure of this Document

This volume is structured to reflect the practice accumulated in recent years in developing and using models. It starts by presenting the central or main projection model, the Structural Projection Model (*modelo estructural de proyección*, MEP) whose internal structure, as the name indicates, precisely reflects the Bank's perceptions about how the main determinants of inflationary pressures are currently generated in Chile. This model is presented in chapter 2. With money and interest rates, the functioning of financial markets plays a key role here, determining the foreign exchange rate, changes in the labor market, employment and wages, inflation's own dynamics, actual and potential economic growth, and in general, supply and demand conditions in different markets. It is no coincidence that these are the same issues presented qualitatively in the *Monetary Policy Reports*. As mentioned above, the *Monetary Policy Report* and the MEP together reflect a consistent view of the economy.

Aside from the MEP, the Central Bank develops and uses a series of other models, which are presented in the chapter on auxiliary models. These models serve a variety of purposes. Some, such as the time series (VAR), serve to provide alternative short-term projections, for example from six months to one year, which make it possible to validate and reconfirm MEP projections for the same period. At the same time, several simple models are useful to project changes in the Imacec over even shorter periods of one to two months, based on up-to-date information of a public nature, such as manufacturing production and sales, mining production, and changes in money, among others. Models for the external trade are also included, which, based on weekly foreign trade information provided by the Central Bank, are useful for projecting exports and imports for the present month or the next few weeks. Finally, a model of macroeconomic consistency, ensures that macroeconomic projections are consistent with trends in the balance of payments and, particularly, the current account, from an accounting perspective.

Finally, the last chapter of this volume provides the results of traditional exercises using these models. These exercises respond to the usual questions in economics and monetary policy: How do inflation and growth respond to changes in monetary policy, in terms of magnitude and lags? To what degree are changes in the foreign exchange rate passed through to prices? What is the relationship between short-term inflation and growth? How does the economy respond to external shocks? Clearly, none of these three questions is easy to answer, mainly because they require precise formalizations that go beyond the general way they are expressed in this introduction. This is why models are useful for this type of question, because they force us to determine precise details that at first glance do not seem important but ultimately turn out to be crucial to the coherency of monetary policy.

Aside from these sections, we have included a Glossary of Variables. This glossary should make reading easier, given the large number of variables included in this work. Moreover, the glossary provides relevant information, such as the source of data, the construction of the variable, the unit of measurement, and the seasonal adjustment method used, where appropriate. The glossary clarifies the notation for logarithms, variations and dummy variables.

2. Structural Projection Model (*Modelo Estructural de Proyección*, MEP)

This chapter describes the main macroeconometric model used by the Central Bank of Chile to project the most relevant variables and carry out economic policy exercises and simulations. The different equations in this model describe both short-term movements within the economy and long-term equilibrium relationships. This model reveals variable dynamics. For example, it tells us about the lags and magnitudes involved in monetary policy transmission mechanisms. At the same time, a long-term equilibrium toward which the economy necessarily moves is imposed, making the short-term dynamic consistent with a long-term vision of the economy.

The techniques used to estimate the parameters of the different equations make it possible to distinguish between short- and long-term effects. In most cases, both the long-term relationship and the short-time dynamic are estimated together. In these cases, long-term relationships have been previously tested using conventional cointegration methods.[7]

These methods, as with all econometric methodology, are subject to important degrees of uncertainty, reflecting the estimated parameters' sensitivity to the deep structure of the economy, which clearly is not directly known. Ideally, one should have an evaluation of out-of-sample errors. Something of this nature is presented by Albagli et al. (2003). As an indication of the statistical properties of the equations estimated, t-statistics (corrected for heteroscedasticity using the Newey-West method) are reported here, along with the adjusted R-squared, the equation's standard deviation, the LM test for serial correlation (since the data is quarterly, four lags were chosen for all equations), the c^2 statistic for the Jarque-Bera normality test, and the R^2 statistic multiplied by the number of observations for the White heteroscedasticity test.[8] Also reported is the estimation period, which depends on the availability of figures. Note that some equations pose serial correlation problems (to 5% significance). However, these equations are maintained because we have no better specifications whether from the statistical or theoretical perspective.

To deal with situations where the estimation is poor, when there are well-founded indications of structural change in the different relationships, or when economic theory itself has important implications, even when empirically rejected we opt for imposing specific parameters. Imposing parameters also has to do with institutionally determined prices in the economy, particularly public utility rates. The MEP explicitly incorporates these institutional mechanisms in modeling the inflationary process. At the same time, the structure of lags, variable selection and inclusion of specific dummy variables has been motivated not only by economic theory and the restrictions mentioned, but also to improve the normality of residuals and the model's predictive capacity in and especially out-of-sample.

The MEP has a significant number of exogenous variables that must be projected outside the model to feed it. Projecting some of them, such as equilibrium values or long-term variables, is explained below. Others, particularly international variables such as the oil price, the copper price, import values, the terms of trade, trading partners' growth or inflation, international interest rates, the current account of industrialized countries, and the risk premium are projected by specialized analysts. These analysts use their own models, projections from international bodies such as Consensus Forecasts or investment banks, sectoral information, their own judgment, and the judgment of Central Bank authorities. Of these assumptions, the most important for determining current conditions are mentioned in *Monetary Policy Reports*.

In the MEP neither domestic expenditure nor external accounts are modeled directly. However, auxiliary models for expenditure and macroeconomic identities exist that allow estimations of these variables at different aggregation levels,

7 As the purpose of this book is not to justify equations, but rather make them known, we have omitted cointegration tests. For more details on each equation, please see the corresponding study as cited.

8 Although t-statistics are corrected for possible heteroscedasticity in every case, the White test is nonetheless reported so the reader knows if this correction is relevant.

consistent with structural model predictions. There are also auxiliary equations to estimate demand for money and the multilateral exchange rate.

Given the large number of variables, a glossary with their names and sources is attached. This glossary should facilitate the reading of this and following chapters. We refer the reader to this glossary to understand the notations regarding logarithms, variations and dummy variables.

BOX 2: THE EQUILIBRIUM REAL EXCHANGE RATE

The real exchange rate is a key relative price in a small, open economy such as Chile's. In the MEP, changes in the real exchange rate are modeled using a parity interest rate version, in which the real exchange rate moves toward a long-term equilibrium thanks to the dynamics of monetary policy, which provides the economy's nominal anchor. Similarly, the level of the equilibrium real exchange rate is imputed externally, based on a set of prudently combined data, which is briefly summarized in this box.

The equilibrium real exchange rate is a non-observable variable. Estimating the value of the equilibrium real exchange rate is particularly complicated, given that there are different theories on the subject and empirical evidence does not support any of them with sufficient clarity. The Central Bank has taken an eclectic approach to this issue, using a variety of information to deal with it. This includes the statistical properties of the real observed exchange rate series and recent changes, the differential between Chile's long-term rates and those of other countries, changes in variables suggested by different versions of the purchasing power parity theory, market expectations as expressed in multiple forms, with all this weighted by the judgment of the Central Bank's authorities.

One way of determining the current level of the equilibrium real exchange rate is by using statistical filters. This approach to the problem assumes that the measured real exchange rate tends toward its equilibrium level, which is gentler and more stable than the former. Thus, the equilibrium level is calculated as a smoothed version of the level measured. Unfortunately, these methods are not very informative for projecting the variable into the future. One possibility is to think that the current level of the real exchange rate will remain the same in the future (the random path).

An alternative to the purely statistical method is to resort to uncovered interest rate parity theory. According to this theory, the differential between rates in Chile and those of other countries, for example the United States, must be offset by expectations of changes in currency values, so that investing in both currencies would be equivalent and there would be no opportunity for arbitrage. In nominal terms, this theory states that:

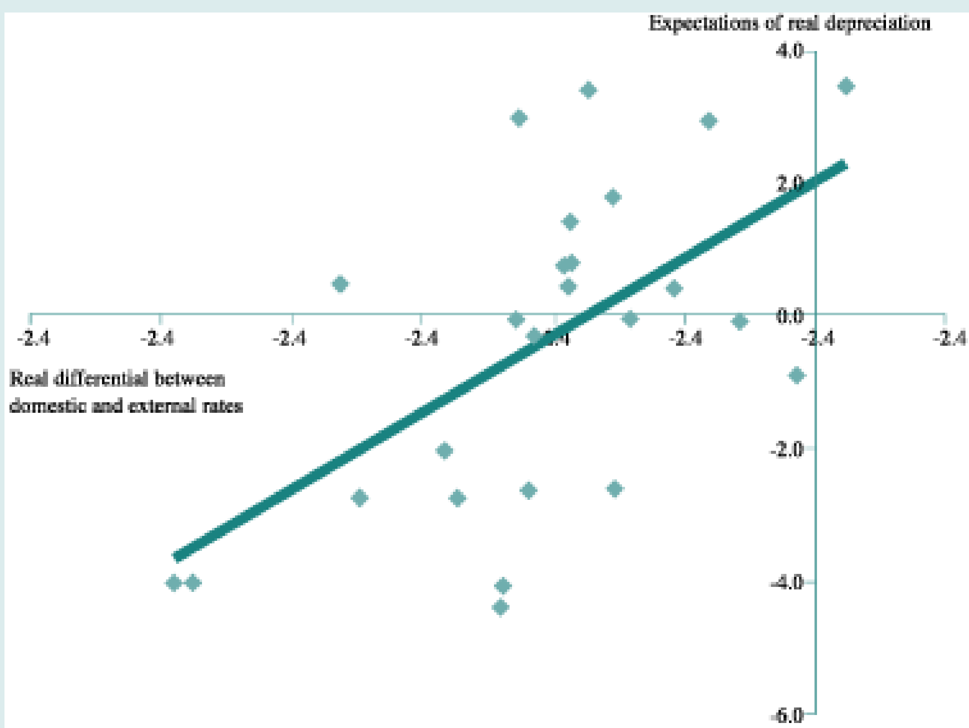
$$i = i^* + \frac{TCN^e - TCN}{TCN}$$

where i is the domestic interest rate, i^* is the external interest rate, TCN^e is the nominal exchange rate expected in future and TCN the nominal exchange rate currently in effect. If moreover we introduce the Fisher equation, which tells us that the nominal interest rate must be equal to the real interest rate plus inflation expectations, the interest rate parity equation can be expressed in real terms as:

$$r = r^* + \frac{TCR^e - TCR}{TCR}.$$

In this case, and if interest rates are for sufficiently long-term operations, TCR^e will correspond to the real exchange rate expected in the long term. If moreover we assume that in the long term the real exchange rate tends to move toward its equilibrium level, this theory will provide us with information about the possible value of the equilibrium real exchange rate in the long term. In practice, this information is deduced by comparing rates on Central Bank promissory notes and the US Treasury for similar maturities. The figure below was built using this interest rate differential corrected for taxes and sovereign spread[9] and with expectations regarding devaluation and inflation extracted from surveys of expectations by the Central Bank and Consensus Forecasts. The figure shows that, contrary to the theory, negative interest rate differentials are associated with expectations of depreciation. However, on average, the greater the interest rate differential (or the less negative), the greater are expectations of depreciation, which is in line with interest rate parity theory. From this it can be deduced that, more than the level of the interest rate differential itself, the relevant information can be deduced from the changes in this differential.

Expectations of Real Depreciation



Another approach arises from different versions of purchasing power parity theory. In its simplest form, this theory states that the price index must be the same in different countries (when measured with the same currency) or at least

9 This is the differential between the BCU5 (previously the PRC8) and inflation-indexed Treasury promissory notes, monthly data since 2001.

the changes in prices must be the same (relative parity). This is equivalent to saying that the real exchange rate must be constant, or at least revert to a constant equilibrium level. The empirical evidence, as Calderón and Duncan (2003) show, reveals that this relationship seems to hold for Chile, but over extremely long periods (two or three years). More flexible alternate versions of the purchasing power parity theory indicate that the real equilibrium exchange rate fluctuates according to a number of fundamental variables. One of these versions indicates that purchasing power parity functions on average for tradable goods (with possible temporary deviations), but not necessarily for non-tradable goods. According to this theory, deviations in non-tradable goods apparently reflect factors such as the level of net external assets, productivity differentials between tradable and non-tradable sectors and the terms of trade. Calderón (2002) uses data from 67 countries from 1966 to 1997 and cointegration techniques for panel data to estimate the relationships between the real exchange rate and the variables mentioned above. This author concludes that there is a robust relationship between the variables, so these can be considered as determinants of the equilibrium value of the real exchange rate. Based on these findings, the Central Bank uses information on the fundamental variables described above to determine the current and expected trajectory of the equilibrium real exchange rate.

Nonetheless, the theories mentioned here have not achieved sufficient consensus and the empirical evidence is not conclusive. Because of this, it is important to use alternative information. The view of different market analysts on the equilibrium value of the real exchange rate, at least in the long term, can be partially deduced from surveys of expectations conducted by the Central Bank and Consensus Forecasts. These surveys ask about the changes expected in different variables composing the real exchange rate: the nominal exchange rate and inflation.

Finally, all the above information is carefully combined by Central Bank authorities to reach an estimate for the current value of the equilibrium real exchange rate and its future behavior.

2.1 The Model's General Characteristics

The MEP is a simple, relatively small quarterly model. The model is linear in logarithms,[10] with 23 endogenous variables, 48 variables that are definitions, and a code containing about 600 lines. The code was initially implemented using WINSOLVE®,[11] although currently it is implemented using TROLL®. The parameters, when estimated, have been obtained using E-Views® or TROLL®. Data bases are managed in Excel®. To avoid spurious correlations, all seasonal variables have been seasonally adjusted using the X12-ARIMA method, correcting for working days, as per Bravo et al. (2002).[12]

10 The model is linear except for the equations corresponding to the sum of the components for total CPI, the sum of total GDP components, and the sum of bus fare components, which are linear at the variable level but not their logarithms.

11 A free evaluation version of this program can be obtained at no charge from www.econ.surrey.ac.uk/winsolve/download.html.

12 The program used to seasonally adjust series and a description of same can be downloaded from www.bcentral.cl/esp/estpub/estudios/documentostrabajo/177.htm.

Basic Structure of the MEP

Although the MEP is not a microfounded model, that is, its equations do not derive directly from the maximization of agents restricted by a budget, recent literature presents similar models with structures derived from microfundamentals.[13] The MEP moreover is like models that have been used by other central banks, among them the Bank of England, the Australia Reserve Bank and the Central Bank of Brazil.

In its basic structure the MEP includes a short-term Phillips curve that relates inflation and the output gap, an aggregate demand or IS that determines the dynamics of the output gap, a monetary policy rule that determines changes in short-term interest rates, a yield curve that describes the dynamics of medium-term rates and an interest rate parity that describes the dynamics of the real exchange rate. The Phillips curve corresponds to an equation in which inflation (π) depends on inflation expectations (π^e), past inflation, A(L)π where A(L) is the lag with an imported inflation operator (π^*), as well as representing the gap between output and its potential level $(y-\overline{y})$:

$$\pi = \beta_1 \pi^e + \beta_2 A(L)\pi + (1-\beta_1-\beta_2)\pi^* + \gamma(y-\overline{y}) \text{ .} \tag{2.1}$$

As can be seen, dynamic homogeneity is imposed, that is, when GDP reaches its potential, inflation is a weighted average of expectations, lags and imported inflation. In the long term, all these figures equal each other out. Aggregate demand, meanwhile, relates changes in the GDP gap, $\Delta(y-\overline{y})$, to real short- (r) and long-term (R) interest rates, constituting the main mechanism for transmitting monetary policy. Aggregate demand reverts to the mean, taking GDP toward its potential level. The GDP gap can also depend on other variables, particularly external variables, such as the terms of trade and external interest rates. All variables are expressed as deviations from their neutral level:

$$\Delta(y-\overline{y}) = \alpha_1 \cdot A(L)(r-\overline{r}) + \alpha_1 \cdot A(L)(R-\overline{R}) + \alpha_3 (y_{-1} - \overline{y}_{-1}) + \alpha_4 \cdot \xi \text{ ,} \tag{2.2}$$

where x represents the other variables affecting the gap. The short-term interest rate is represented by a monetary policy rule for the nominal interest rate (i). This rule indicates that the interest rate deviates from its neutral level to the degree that projected inflation over a given horizon ($\pi^e_{+\tau}$) moves away from its target level ($\overline{\pi}$). At the same time, the rule depends on the output gap. Moreover, the rule incorporates the fact that the Central Bank tends to smooth interest rate movements, making them depend on their past value. Thus, the rule is represented by:

$$i = \lambda i_{-1} + (1-\lambda) ix,$$

$$\text{where} \quad ix = \pi^e_{+\tau} + \overline{r} + \gamma[\kappa(\pi^e_{+\tau} - \overline{\pi}) + (1-\kappa)(y-\overline{y})] \tag{2.3}$$

The λ parameter defines how smoothly the short-term interest rate changes, parameter g defines the aggressiveness of monetary policy and parameter k the relative importance assigned to the output gap. Variable $\pi^e_{+\tau}$ could consist of average inflation expectations over several horizons. Inflation expectations also fall between the nominal and the real short-term interest rate: $i = r + \pi^e_{+\tau}$. In the long term, the real interest rate must move toward its neutral level $\overline{r}$.

13 See for example McCallum and Nelson (1998, 2000), Galí and Monacelli (2002), Parrado and Velasco (2002), Clarida, Galí and Gertler (2002) and Svensson (1998).

The short-term interest rate is transmitted to the long-term interest rate assuming arbitrage. The long-term interest rate must reflect the behavior expected from short-term interest rates, along with a premium for maturity (ϕ_R). The behavior expected from short-term rates is summarized in the expected long-term rate for the next period. Thus, the real long-term rate's behavior is represented by:

$$R = \chi R^e_{+1} + (1-\chi)\cdot(r+\phi_R)\ . \tag{2.4}$$

Finally, the real exchange rate (q) is represented by parity interest rates, including a sovereign risk premium (ρ). Using a logarithmic approach and a real version of parity interest rates, produces:

$$q = q^e - r - (r^* + \rho)\ , \tag{2.5}$$

where q^e corresponds to expectations about the real future exchange rate and r^* the real external interest rate.

These five equations summarize the main monetary policy transmission mechanism according to the MEP. If projected inflation moves higher than target inflation, the equation (2.3) indicates that the short-term interest rate will tend to rise.[14] As the short-term interest rate rises, according to the equation (2.4), so does the long-term rate. The increase in interest rates leads to a decline in GDP against its potential level or a negative output gap, which is the same, as shown in the equation (2.2). At the same time, the equation (2.1) shows that this negative gap pressures inflation downward, bringing the projection toward its target level. At the same time, according to the equation (2.5), the rise in the interest rate causes the real exchange rate to appreciate. Given price levels, this in turn leads to a decline in the nominal exchange rate and imported inflation. While real exchange rate appreciation could at first make the output gap more negative, the decline in imported inflation leads to lower inflation, thus constituting a secondary transmission channel.

Additional Characteristics

The MEP contains a series of additional aspects that have not been described in the simple structure presented above. These refer to the treatment of non-core inflation components, labor market and margin modeling, the role of natural resource-related productive sectors, and government policy.

First, the MEP models regulated rates, highly indexed product prices or those of others that are especially volatile, separately. For the first of these groups, current legislation establishes exactly how public utility and other rates will be established. In some cases, such as bus fares in Santiago, indexing formulae are simple enough to be included directly in the projection process. In other cases, such as electric power utility rates, indexing rules are complex and calibrated equations are used that in general terms capture the link between the different model variables and the respective rate. The second of these product groups includes prices that normally copy the behavior of the some of the model's endogenous variables rather mechanically. For example, road tolls or the cost of financial servicing, which are linked to inflation and market interest rate lags. Finally, the third product group includes foods such as meat and fish, which are sufficiently volatile and separate from supply and demand conditions in the macroeconomic sphere to merit separate treatment.

14 This, considering that λ is positive and less than one. In some cases, an exercise in which monetary policy remains fixed can be considered, at least for a given horizon.

Another particularity of the MEP is that it models the output gap excluding natural resources (electricity, gas, water, mining and fishing). These components are projected outside the model using sectoral information gathered in National Accounts. Because these are primarily supply- and not domestic demand-driven sectors, short-term growth in their activity responds to investment decisions, which normally have been made years in advance, so they are not necessarily related to macroeconomic conditions within the normal projection horizon. However, new information from these sectors reflects commercial supply decisions, which can be captured directly from the main firms' production plans, or changing weather conditions, which by their very nature are unpredictable.

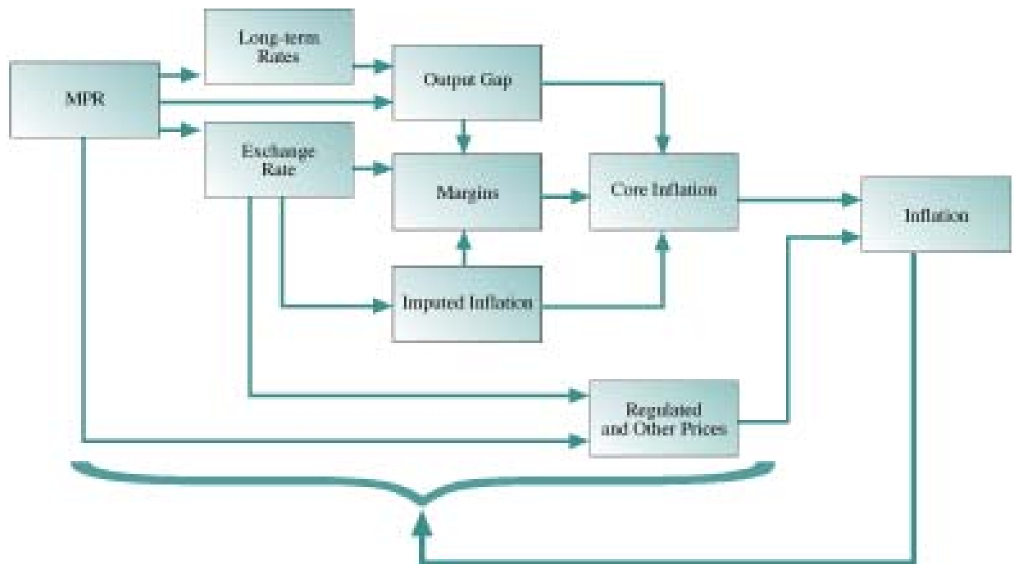
The MEP moreover considers pressures from retail margins and cost structure on prices. Thus, the Phillips curve contains a term that reflects movements of these margins away from what is considered their equilibrium level. Margins are calculated over private unit labor costs, costs associated with personal services and imported costs, related to both the direct imported component included in the consumption basket and the importance of imported inputs to local production of final consumption goods. To estimate changes in labor costs, a labor block with equations for setting wages and labor demand has been added. It should be noted that some variables used in the MEP are projected outside the model, among them potential GDP, the equilibrium real exchange rate, external prices for imported goods, and the labor force.

Another element that is not covered in detail in the previous structure, but which is present in the background of projections, is government policy. In general, its impact is reflected in movements in key variables, such as the real exchange rate and long-term interest rates, which are influenced by sovereign spread. This transmission channel is quantitatively relevant. At the same time, changes in short-term government policy, for example news on public investment trends, current expenditure and taxes can be assimilated as shocks in the aggregate demand equation, affecting the composition of same to the degree that these shocks become long-lasting.

By including all the elements present in the MEP, monetary policy's passthrough to inflation is summarized by figure 2.1. As is clear, the monetary policy rate (MPR) exercises a direct influence on the output gap, as well as indirectly affecting long-term rates. Likewise, the output gap affects core inflation both directly, as it is the main transmission mechanism present in the model, and indirectly, through the labor market and retail margins. The monetary policy rate (MPR) also influences the exchange rate, thus becoming a secondary monetary policy transmission mechanism.[15] Finally, other channels exist through which the monetary policy rate (MPR) and the exchange rate directly affect prices that do not form part of underlying prices, such as financial services, fuels, bus fares, etc. These other prices, along with core inflation make up total inflation, which affects monetary policy to the degree that it tends to move away from the inflation target.

15 As will be seen below, for statistical reasons, it is not possible to detect the effect of the exchange rate on the output gap, separately from the impact of the interest rate and the external environment.

Figure 2.1
Monetary Policy Transmission Mechanism



2.2 The Stationary State

The MEP has a stationary state that is explicitly and exogenously defined. This stationary state consists of balanced economic growth, incorporating demand and supply conditions in goods and factor markets, which reflect full employment of resources and constant relative prices. Table 2.1 provides a summary of the stationary state conditions imposed on the model.

Table 2.1
Stationary State Relationships

Financial Markets	Labor Markets and Costs	Activity and Inflation
$MPR = LIBORR + \rho$	$IPCX1 = (1+\mu)*costs$	$Y = YE$
$BCU5 = MPR + \phi$	$P*Y = \alpha W*EMP$	$\pi^{imp} = META$
$TCR = TCRE$	$U = UN$	$\pi IPCX1 = \pi other = META$

In practice, equilibrium conditions are imposed to guarantee the model's movement toward a specific stationary state, compatible with what the theory expects for the Chilean economy over a long-term horizon. For example, the stationary state is consistent with the hypothesis of money neutrality in the long term, that is, with a Phillips curve vertical, which is reflected in the economy's nominal anchor. Nonetheless, these conditions are empirically testable. Similarly, variables adjust slowly to their long-term equilibrium levels, whether they are exogenous or endogenous: inflation, short- and long-term interest rates, real exchange rate, wages, employment and output growth.

In the long term, GDP (Y) tends to move toward its potential level (YE). Potential GDP, or productive capacity is projected outside the model. As a result, the product level and its long-term growth rate are exogenously imposed. In practice, a series of procedures can be used to estimate trend output, with the most common being statistical filters (such as the Hodrick-Prescott or Baxter-King) or a breakdown of sources of growth. This last has been used in projections.

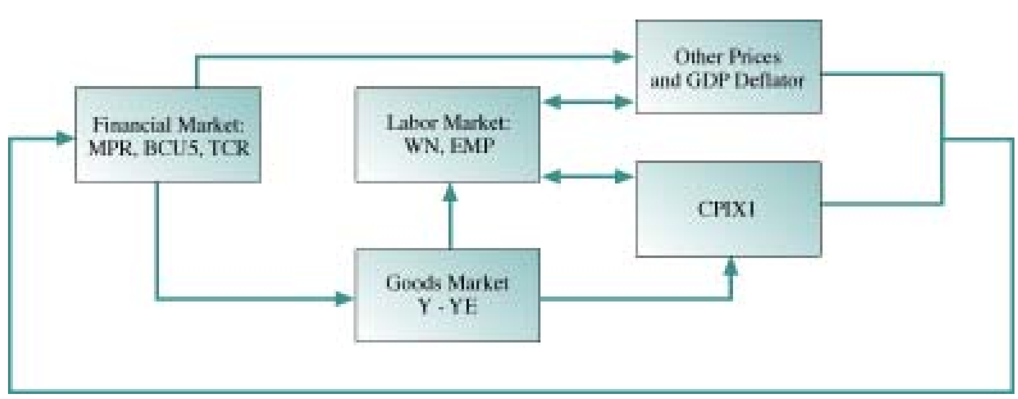
The model assumes that price inflation minus core inflation (IPCX1) (πothers, including bus fares, indexed rates, perishables, etc.) is equal to target inflation in the long term. In terms of core inflation (πIPCXI), the model assumes that it is constant in the stationary state. This in effect requires that the Phillips curve post dynamic homogeneity. At the same time, the interest rate (MPR) moves toward its neutral long-term level only if inflation equals target inflation. This mechanism ensures that core inflation (IPCX1) and total inflation move toward the target figure.

The treatment of relative prices is very simple, assuming that nominal and real short- and long-term interest rates (BCU5) and the real exchange rate (RER) are constant and exogenous in the stationary state. In the stationary state, the yield curve also reflects arbitrage conditions between short- and long-term rates. At the same time, these rates are consistent with potential output growth in the long term and with the cost of external financing. For the labor market, in the long term it is assumed that wages' share (W*EMP) of income (P*Y) is constant. At the same time, unemployment (U) tends toward natural unemployment (UN), causing employment in the long term to grow with the labor force, which is projected outside the model.

2.3 Dynamic Behavior

The MEP includes five blocks, as figure 2.2 shows. Each block, which defines the MEP variables, is explained in detail below.

Figure 2.2
MEP Blocks and the Main Variables



Core Inflation

Core inflation has been modeled using a Phillips curve, which explains the changes in the underlying consumer price index (IPCX1). This index excludes from total CPI the prices of regulated utility rates, indexed prices, perishable goods and meat and fish. The IPCX1's weight within total CPI is presented in table 2.2. Inflation as measured by this index depends on:

a) Expectations about future core inflation, in principle generated by a combination of leading and lagging of same. The imposition of dynamic homogeneity, which is explained below, eliminates the lagging term from the Phillips equation in one period. In the model, agents perfectly foresee future inflation, that is, the leader $\Delta LIPCX1_{+1}$ in the equation (2.9) reflects actual inflation in the next period. However, given existing endogeneity, solely for the purpose of estimating the parameters, the lead in the equation (2.9) is treated with an auxiliary regression (least squares in two stages), using leads and lags in the inflation (META):

$$\Delta \widehat{LIPCX1} = \underset{(-1.23)}{-0.001} + \underset{(7.98)}{0.24}\, META_{+1} - \underset{(-2.13)}{0.31}\, META_{-1} + \underset{(2.21)}{0.39}\, META_{-2} - \underset{(-2.47)}{0.17}\, META_{-4} + \underset{(4.87)}{0.08}\, META_{-7} \tag{2.6}$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.92$
Standard error of regression= 0.45%
LM test for serial correlation (4 lags): F = 2.6129 (p-value 0.0459)
Jarque-Bera normality test: $c^2 = 13.445$ (p-value 0.0012)
White heteroscedasticity test: $N{\cdot}R^2 = 5.9190$ (p-value 0.8220)
Estimation period: 1987:4 2002:4

b) The output gap (BRECHA), which is the variable that indicates aggregate demand pressure on future inflation. The more underused productive resources are, the more future inflationary pressures are controlled. The output gap is calculated using the methodology proposed by Contreras and García (2002)[16] and is projected using the equation (2.29).

c) Retail margin deviations from their equilibrium level. Here it is assumed that companies that produce goods contained in core inflation (IPCX1) follow a simple rule to set the prices for their products: adding a margin over costs, excluding capital cost. Thus, retail margins represent the difference between the price level and wage, service and imported costs. To approximate private wage costs, the unit labor cost is used (CLU). This is the quotient of the private labor cost index (*CMOPRN*) and trend mean labor productivity (QE) defined in the equation (2.33), plus the corresponding value added tax (*IVA)*:

$$LCLU = LCMOPRN - LQE + \log(1 + IVA) \tag{2.7}$$

Service costs, such as community services, have been approximated using public wages (*CMOPUN*). These have been included to capture public service price fluctuations. Finally, to construct the imported cost component (PIMP) an imported goods value index is used (*IVUM*),[17,18] along with the nominal exchange rate (*TCN*), the value added tax and the average tariff (TM).

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16 This methodology proposes a Cobb-Douglas potential production function that depends on the capital stock, the labor force and a smoothened version (using HP filters) of the Solow residual. Each of these components is projected separately to obtain a potential output projection.

17 This value index is constructed using the import unit value index (*Índice de Valor Unitario de las Importaciones*), which is a Paasche index. For a quarterly series, the base year (1996) was quarterized, using the quarterly profile for values. The index was then composed chaining together changes over four quarters. This methodology was used for import and export value indices employed in this document.

18 The total *IVUM* includes the price of capital and intermediate goods that serve as production inputs and consumption goods that must be commercialized. Because of this, we have preferred to use total *IVUM* rather than some specific disaggregation. Statistical results support this choice.

$$LPIMP = \log(IVUM \cdot TCN \cdot (1+IVA) \cdot (1+TM)) \qquad (2.8)$$
$$= LIVUM \;+\; LTCN \;+\; \log(1+IVA) \;+\; \log(1+TM)$$

d) Dependent variable lags are included to reflect existing inertia, given that indexing rules transmit past inflation into the present.

e) Another variable considered to explain short-term behavior is external inflation, represented by the changes in imported prices specified in the equation (2.8).

A restricted version of the first difference model for inflation is estimated, which imposes the dynamic homogeneity of the inflationary process to guarantee neutrality, and a vertical Phillips curve in the long term. The estimation method is that of least squares in two stages, to instrumentalize leads in the dependent variable. Although the variable on the right-hand side of the equation (2.9) represents inflation's acceleration, this is obtained by subtracting lagged inflation from both sides of the equation. This is useful for interpreting results and only reflects the imposed dynamic homogeneity. It should be remembered that the core inflation lead is instrumentalized using the equation (2.6). The results of the aggregate supply model follow:

$$\begin{aligned}\Delta LIPCX1 - \Delta LIPCX1_{-1} = &\underset{(5.21)}{0.63}\left(\Delta LIPCX1_{+1} - \Delta LIPCX1_{-1}\right) + \underset{(3.86)}{0.06}\, BRECHA_{-1} \qquad (2.9)\\ &- \underset{(-2.48)}{0.08}\{LIPCX1_{-1} - \left(\underset{(3.84)}{0.63}\, LCLU_{-1} + \underset{(5.35)}{0.32}\, LCMOPUN_{-1} + \underset{(0.48)}{0.05}\, LPIMP\right) - \phi_{mkup}\}\\ &+ \underset{(4.21)}{0.04}\,\Delta LPIMP_{-3} + \underset{(1.58)}{0.13}\left(\Delta LIPCX1_{-2} - \Delta LIPCX1_{-1}\right)\\ &+ \underset{(3.27)}{0.32}\,\Delta\log(1+IVA_{-1}) + \underset{(11.90)}{0.01}\, D984 - \underset{(-11.30)}{0.01}\, D022\end{aligned}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.58
Standard error of regression= 0.37%
LM test for serial correlation (4 lags): F = 1.5833 (p-value 0.1943)
Jarque-Bera normality test: c^2 = 4.3909 (p-value 0.1113)
White heteroscedasticity test: $N \cdot R^2$ = 31.950 (p-value 0.8139)
Estimation period: 1987:3 2002:4

The Phillips curve used requires that in stationary state core inflation remains constant. A requirement for this is that, in the long term, imported price inflation must be equal to total domestic inflation. Given that the real long-term exchange rate is assumed to be constant, this is the equivalent of requiring that the IVUM grow, in the long term, at the same rate as the United States price index.[19] Overall, in the model it will be monetary policy, through the policy rule, that will have to ensure that core inflation will constantly tend toward the target level in the long term.

Other Prices

Aside from core inflation, estimates are also included for changes in prices for fuel, financial services, public utilities, indexed prices and perishable good prices. Although certain behavior is imposed on these prices, to ensure the model's convergence in the long term (after the 16 quarters making up the projection horizon) these prices must rise at the same rate as total inflation.

19 See equation (2.25).

Table 2.2
Components of Inflation

Price Component		Share (%)
Core	IPCX1	69.71
Public utilities	IPCSP	5.51
Financial services	IPCSF	1.92
Indexed	IPCINX	7.12
Bus fares	IPCMICRO	2.75
Meat and fish	IPCCP	5.25
Fruit and vegetables	IPCVF	3.77
Fuels	IPCCOM	3.97

For bus fares an equation has been developed whose weights are adjusted to the indexing clauses established in the rules applied to auctions (of bus service routes). In the model, these increases/decreases depend on changes in the diesel fuel price ($\widetilde{\mathrm{PDI}}$), labor costs ($\widetilde{\mathrm{CMON}}$), tire prices ($\widetilde{\mathrm{PNEU}}$) and the price of buses themselves ($\widetilde{\mathrm{PBUS}}$). The basis for these indices has been adjusted to accommodate the IPCMICRO base. The projection for the diesel fuel price is found in the equation (2.12). Labor costs are endogenous to the model and are projected using equations (2.34) and (2.35). The price of tires is not very relevant and changes little over time, so its projection corresponds practically to a trend. At the same time, the bus price depends mainly on the nominal exchange rate. The equation for bus fares is:

$$\Delta LIPCMICRO = \Delta\log\{0.26\widetilde{PDI} + 0.33\widetilde{CMON} + 0.04\widetilde{PNEU} + 0.37\widetilde{PBUS}\} \tag{2.10}$$

The changes in the fuel price index (IPCCOM) are estimated using an equation that includes current 93 octane gasoline prices (PG93), liquefied gas (PGLI) and kerosene (PKER):

$$\Delta LIPCCOM = \phi_{COM} + \underset{(9.16)}{0.53}\Delta\log(PG93) + \underset{(2.21)}{0.08}\Delta\log(PKER) + \underset{(5.68)}{0.39}\Delta\log(PGLI) \tag{2.11}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.79
Standard error of regression= 1.60%
LM test for serial correlation (4 lags): F = 5.2446 (p-value 0.0046)
Jarque-Bera normality test: c^2 = 1.9409 (p-value 0.3789)
White heteroscedasticity test: N·R2 = 20.589 (p-value 0.0567)
Estimation period: 1996:2 2002:4

The prices of diesel, gasoline, kerosene and liquefied gas are calculated, respectively, using the following formulae:

$$PDI = (PAJDI \cdot TCN \cdot (1+IVA) + UTM \cdot \tau_{UTM}) \cdot \mu_{di} \tag{2.12}$$

$$PG93 = (PAJG93 \cdot TCN \cdot (1+IVA) + UTM \cdot \tau_{UTM}) \cdot \mu_{g93} \tag{2.13}$$

$$PKER = (PAJKER \cdot TCN \cdot (1+IVA)) \cdot \mu_{ker} \tag{2.14}$$

$$PGLI = (PAJGLI \cdot TCN \cdot (1+IVA)) \cdot \mu_{gli} \tag{2.15}$$

Each of these prices is calculated using parity-corrected dollars. This is the import price (including tariffs), applying a correction for the oil stabilization fund (*Fondo de Estabilización del Petróleo*) where appropriate. In the case of diesel and gasoline, aside from the value added tax (*IVA*), there is an additional tax calculated as a percentage of an accounting unit, the *Unidad Tributaria Mensual* (UTM), per liter. In every case, a retail margin is also applied. The retail margin is projected using the average from a recent period. Corrected parities are projected using projected trends for the oil price[20] and the seasonal corrections appropriate to each fuel in international markets. As can be seen, these prices depend on change in the nominal exchange rate, which is endogenous to the model. Accordingly, the nominal exchange rate significantly affects fuel prices and, through them, bus fares. The latter is also affected by the nominal exchange rate because of its effect on the price of buses themselves.

The logarithm for financial service prices (LIPCSF) is estimated assuming that this responds to change in interest rates, using as a proxy the Monetary Policy Rate (MPR), an endogenous variable determined by the model. Also included are lags in the same variable and lagged growth in the Monetary Policy Rate (MPR):

$$\Delta LIPCSF = \phi_{CSF} + \underset{(3.44)}{0.37}\Delta LIPCSF_{-1} + \underset{(5.89)}{0.63}\Delta LIPC_{-1} + \underset{(2.17)}{0.42}\Delta TPM + \underset{(4.04)}{1.10}\Delta TPM_{-1} + \underset{(2.08)}{0.88}\Delta TPM_{-2} - \underset{(-20.96)}{0.13}D944 \quad (2.16)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.46$
Standard error of regression= 4.53%
LM test for serial correlation (4 lags): F = 2.1965 (p-value 0.0862)
Jarque-Bera normality test: $c^2 = 0.8598$ (p-value 0.6505)
White heteroscedasticity test: $N{\cdot}R^2 = 27.832$ (p-value 0.0469)
Estimation period: 1990:2 2002:4

The equation for the public utility price logarithm is estimated using growth in public utility labor costs (CMOPUN),[21] CPI growth, growth in the exchange rate and change in the copper price (PCU) and the oil price (POIL):

$$\Delta LIPCSP = \underset{(4.55)}{0.36}\Delta LIPCSP_{-1} + \underset{(5.81)}{0.55}\Delta LIPC_{-1} + \underset{(2.58)}{0.28}\times\frac{1}{4}\sum_{i=1}^{4}\Delta LTCN_{-i} + \underset{(2.28)}{0.03}\times\frac{1}{2}\sum_{i=1}^{2}\Delta LPOIL_{-i} + \underset{(1.73)}{0.06}\times\frac{1}{4}\sum_{i=1}^{4}\Delta LPCU_{-i} + \underset{(10.73)}{0.04}D901 - \underset{(-8.22)}{0.02}D992 \quad (2.17)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.81$
Standard error of regression= 1.05%
LM test for serial correlation (4 lags): F = 0.5094 (p-value 0.7290)
Jarque-Bera normality test: $c^2 = 0.8367$ (p-value 0.6581)
White heteroscedasticity test: $N{\cdot}R^2 = 28.773$ (p-value 0.7985)
Estimation period: 1987:2 2002:4

20 For how these and other international variables exogenous to the model are projected, please see the introduction to this chapter.
21 The projection of labor costs for public utilities is explained below, along with the rest of the labor market.

For the indexed price logarithm (*LIPCINX*) the estimated equation reflects the fact that it moves in line with the *CPI*, with lags of from 3 to 12 months. The equation is as follows:

$$\Delta LIPCINX = \phi_{INX} + \underset{(7.75)}{0.40}\Delta LIPC_{-3} + \underset{(3.45)}{0.25}\Delta LIPC_{-4} + \underset{(2.62)}{0.20}\Delta LIPC_{-6} + \underset{(2.39)}{0.15}\Delta LIPC_{-12} \quad (2.18)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.86$
Standard error of regression= 0.62%
LM test for serial correlation (4 lags): F = 2.4874 (p-value 0.0570)
Jarque-Bera normality test: $c^2 = 47.154$ (p-value 0.000)
White heteroscedasticity test: N·R2 = 18.346 (p-value 0.1914)
Estimation period: 1990:1 2002:4

The previous equation was estimated assuming the sum of the coefficients accompanying price change to be one. Upon estimating a non-restricted version of the equation, this hypothesis cannot be rejected.

For perishable goods prices (IPCFV) an equation is used that defines the annual change as a function of the annual change in CPI and lags. The estimated equation is as follows:

$$\Delta LIPCFV = \phi_{FV} + \underset{(7.10)}{0.87}\Delta LIPC + \underset{(2.62)}{0.41}\Delta LIPCFV_{-1} - \underset{(-2.87)}{0.28}\Delta LIPCFV_{-2} \quad (2.19)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.33$
Standard error of regression= 5.69%
LM test for serial correlation (4 lags): F = 1.0278 (p-value 0.4001)
Jarque-Bera normality test: $c^2 = 2.966$ (p-value 0.227)
White heteroscedasticity test: $N{\cdot}R^2 = 21.141$ (p-value 0.0201)
Estimation period: 1986:1 2002:4

Finally, meat and fish prices (IPCCP) are modeled in the same way as perishable goods prices, that is, the annual change in the variable is determined as a function of lags in same and the contemporary annual change in the CPI:

$$\Delta_4 LIPCCP = \phi_{CP} + \underset{(6.46)}{0.75}\Delta LIPC_{-2} + \underset{(4.96)}{0.42}\Delta LIPCCP_{-1} - \underset{(-2.13)}{0.17}\Delta LIPCCP_{-4} \quad (2.20)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.43$
Standard error of regression= 2.43%
LM test for serial correlation (4 lags): F = 3.0690 (p-value 0.0228)
Jarque-Bera normality test: $c^2 = 40.4372$ (p-value 0.000)
White heteroscedasticity test: N·R2 = 21.719 (p-value 0.0407)
Estimation period: 1986:2 2002:4

Change in the GDP deflator must also be modeled. This is particularly relevant for changes in labor demand, as the equation shows. As we will soon see, in the long term (PE) the GDP deflator must be consistent with the stationary state of margins, wages and imported prices. Because of this, the parameter for reverting to the long-term level has been maintained, even when it is not statistically significant to 5%

significance, although it is significant to 10%. In the short term, this deflator is determined by its deviation from its equilibrium value, as well as the change in the CPI, an index for changes in export prices (LTDI+LIVUM+LTCN), change in the copper price (PCU) and change in the oil price (POIL). This last term is expected to have a negative weight, thus removing the imported goods component from the CPI. It has been imposed that the parameter accompanying the changes in CPI and lags in the deflator add up to one, so that in the long term the GDP deflator will grow at the same rate as other prices in the economy. The equation for the deflator is represented by:

$$\Delta LP = \underset{(10.20)}{0.82}\Delta LIPC + \underset{(2.29)}{0.18}\Delta LP_{-1} + \underset{(1.93)}{0.03}\Delta LPCU - \underset{(-1.75)}{0.02}\Delta LPOIL \tag{2.21}$$
$$+ \underset{(2.55)}{0.07}\{\Delta LTDI + \Delta LIVUM + \Delta LTCN\} - \underset{(-9.72)}{0.06}D961 + \underset{(8.64)}{0.06}D962 - \underset{(-1.91)}{0.13}\{LP - LPE\}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.70
Standard error of regression= 1.31%
LM test for serial correlation (4 lags): F = 1.5200 (p-value 0.2133)
Jarque-Bera normality test: c^2 = 0.8989 (p-value 0.6379)
White heteroscedasticity test: $N{\cdot}R^2$ = 37.848 (p-value 0.2979)
Estimation period: 1989:3 2002:4

Financial Markets

In order to carry out simulation exercises, a reaction function is specified for Central Bank policy that leaves some degree of freedom in the choice of parameters. How this rule is used and calibrated depends on the type of projection or simulation exercise. For simplicity's sake, a linear specification is used, although it is not hard to include more complex functional forms. The policy rule associates the monetary policy rate in nominal terms (MPRN) with expected inflation (Δ_4LIPC^E), the output gap, the gap between expected and target inflation (META), and lags in itself. A constant is included that reflects a neutral instance for monetary policy.

According to the rule contained in the model, monetary policy reacts to expected inflation, not only due to deviations from the target, but also because these affect real *ex ante* rates in the economy, which ultimately affect consumption and investment decisions. This policy rule also includes idle capacity, that is, the difference between output and potential output. This does not necessarily imply that full employment is among the direct, immediate objectives of the Central Bank, since this gap is one of the main variables affecting medium-term inflationary pressures.[22] Third, the rule permits some inertia over time for the guiding rate.[23] Likewise, alternative policy rules can incorporate other arguments, such as the balance of payments current account, or be non-linear reflecting the existence of a target range instead of a target point. These considerations can lead to a more aggressive monetary policy stance in one direction or another, if conditions so require.[24] Overall, the equation for the policy rule used in the MEP remains flexible and takes the form:

$$TPMN = \Delta_4 LIPC^E + \phi_{R0} + \phi_{R1}\left(\Delta_4 LIPC^E - META\right) + \phi_{R2}BRECHA + \phi_{R3}TPMN_{-1} \tag{2.22}$$

22 This point is emphasized by Svensson (1997) and Agénor (2002). The same argument for the Chilean case can be found in García, Herrera and Valdés (2002).
23 Some argue that faced with uncertainty, a gradualist monetary policy is better. Woodford (1999).
24 Morandé (2002) and Medina and Valdés (2002a) include the Current Account of the Balance of Payments in the policy rule for Chile. Medina and Valdés (2002b) include non-linearities in inflation objectives, among them the target range and the aggressiveness of monetary policy.

Although this policy rule involves the nominal interest rate, most estimations carried out in this and other sections of this paper include the period during which the policy rate was set in indexed terms. Because of this, to use these models to project within the current scheme, the Fisher equation is used, which indicates that the real *ex ante* rate (MPR) is equivalent to the nominal rate minus expected annual inflation:

$$TPM = TPMN - \Delta_4 LIPC^E \quad (2.23)$$

The proposed policy rule ensures that, in the long term, inflation will move toward its target level and remain there. The constant ϕ_{R0} is adjusted so that when inflation is at its target level and the output gap is closed, the monetary policy rate (MPR) has reached its stationary state level (LIBORR + ρ).

This rule is also used to model market expectations regarding changes in the monetary policy rate (MPR)N. These expectations are relevant for determining the market interest rates and the exchange rate.[25]

Monetary policy passes through to other interest rates, reflecting natural arbitrage prevailing on Chile's financial markets. Long-term indexed rates are particularly relevant, as they decisively influence decisions on spending by economic agents. At the same time, the exchange rate depends on changes in the monetary policy rate (MPR). In this case the relevant monetary policy rate (MPR) is that expected by the market, which is approached using the rule described above.

The yield curve is based on a version of the expectations hypothesis, imposing an arbitrage condition between short- and long-term rates.[26] The difference between long-term Central Bank bond rates (BCU5) and the short-term rate (MPR) reflects expectations of capital losses or gains associated with holding these bonds. In concrete terms, this can be reflected in the fact that the long-term bond rate is a weighted average of expectations for this rate and the short-term rate, where the weight depends on the maturity of the long-term bond.[27] Here it is assumed that expectations regarding the long-term rate depend on its own lags and leads.

The estimation was carried out using instrumental variables for leads. The instruments included are: the difference between the logarithm of the CPI and the target, the logarithm of the real exchange rate and its difference, the position of the exchange rate within the foreign exchange band, the misalignment of the real exchange rate against its trend value, lags in the long-term rate and the deposit rate, the monetary policy rate and its lag, and the lagged output gap. Using these instruments the resulting equation for longer term rates is:

$$BCU5 = \underset{(9.89)}{0.38} BCU5_{-1} + \underset{(16.12)}{0.59} BCU5_{+1} + \underset{(1.83)}{0.03} (TPM + \phi_{bcu5}) \quad (2.24)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.92$
Residual standard deviation = 0.25%
LM test for serial correlation (4 lags): F = 8.7315 (p-value 0.0681)

25 For some policy or projection exercises it is possible to hold the TPMN constant, while the rule acts to determine the relevant expectations for the exchange rate and market interest rates.
26 For an application of the yield curve to the Chilean case, see Herrera and Magendzo (1997).
27 Campbell, Lo and McKinlay (1999) provide a detailed treatment of the expectations hypothesis, while Blanchard (1982) and Blanchard and Fischer (1989) apply this theory to a simple macroeconomic model.

Jarque-Bera normality test: $c^2 = 1.5292$ (p-value 0.4655)
White heteroscedasticity test: $N{\cdot}R^2 = 15.721$ (p-value 0.0153)
Estimation period: 1989:1 2002:2

Upon estimating the equation without restrictions, the hypothesis that the sum of the coefficients that accompany the lag and lead on BCU5 and the monetary policy rate (MPR) add up to 1 cannot be rejected; this is imposed by the previous estimation. Moreover, a constant is included, which reflects the possible existence of a reward for maturity in the long term. Thus, in the long term this rate moves toward the stationary state level of the monetary policy rate (MPR) plus the premium mentioned above.

The exchange rate is a relevant relative price for a small, open economy such as Chile's. To model this variable, we used uncovered interest parity. According to this, expectations of currency appreciation or depreciation depend on the differential between external and domestic interest rates. It is assumed that this relationship is complied with in the case of 180-day external rates in dollars, as well as for the real exchange rate against the United States (TCR). The TCR is calculated using the nominal exchange rate (TCN), the US' CPI (PUS) and Chile's CPI (IPC):

$$TCR = \frac{TCN \cdot PUS}{IPC} \tag{2.25}$$

The short-term real exchange rate assumes that three factors are key to determining the expected real exchange rate: expectations consistent with the model's own projection; inertial expectations, which only consider the lagged exchange rate; and expectations associated with the real long-term exchange rate (TCRE).[28] The sum of the weights for these three variables must be 1. The interest rate differential is calculated in real terms, taking the difference between the real external interest rate in dollars LIBORR and the real monetary policy rate (MPR). The external interest rate is constructed based on the sum of real Libor, the spread and the reserve requirement (*encaje*).

As occurs with international evidence, it is not possible to validate the uncovered parity theory empirically in Chile. However, this arbitrage ratio has been imposed so as to have a conceptually coherent dynamic for the real and nominal exchange rates.[29] The parameters for expectations are based on econometric estimates, although the weight of the long-term value has been increased slightly for the purposes of model convergence, with no major effects on dynamics within the relevant period. For estimation, instrumental variables for the exchange rate lead were used: lags in the logarithm of the real exchange rate and the real long-term exchange rate, real money lags and differences, the difference between inflation and the target, the position of the nominal exchange rate within the foreign exchange band, the output gap, the monetary policy rate, and lags of the nominal exchange rate and the multilateral exchange rate. The results of the estimation are not reported; however, the parameters chosen are:

28 For details on projecting the equilibrium real exchange rate (TCRE), see the corresponding box.

29 While interest rate parity cannot be confirmed empirically, there are no better alternatives for modeling the exchange rate. One alternative would be to assume that the exchange rate follows a random path, but this alternative has been discarded due to its poor theoretical foundation. For international studies on interest rate parity, see Meese and Rogoff (1983a,b, 1988) and Chinn and Madarassy (2002). These same studies compare exchange rate projections using parity with those using a random path.

$$LTCR = 0.6LTCR_{+1} + 0.3LTCR_{-1} + 0.1LTCRE + \log(1+LIBORR) + \log(1+SPREAD) - \log(1+TPM) \tag{2.26}$$

The behavior of the surcharge on external financing (SPREAD) and the long-term real exchange rate are projected outside the model. For the long-term real exchange rate a series of figures are combined.[30] For changes in the long-term surcharge the main figure used is a calculation based on the methodology proposed by Alfaro (2002) associating this surcharge to variables such as the current account deficit and surcharge affecting category A- firms in the United States. In stationary state, in this model a constant surcharge and real exchange rate are imposed, so that the nominal exchange rate changes according to the differential between local and external inflation.

Aggregate Demand

The aggregate demand equation used in the MEP relates the change in the output gap to: a) the level of the output gap; b) monetary impulse, captured by deviations in the real monetary policy rate (MPR) and the real long-term interest rate (BCU5) against their neutral or long-term values; c) external conditions, identified by the real external interest rate (LIBORR plus SPREAD), the terms of trade (TDI), world output growth (YEXT), which captures external elements that are not reflected in the terms of trade, and a measure for the availability of external financing (FKYEXT),[31] all related to their long-term neutral level (indicated using an E at the end of the variable's name). It has become apparent that, while it may seem somewhat redundant to include all these external variables, all contribute to explaining change in the gap, possibly due to rigidities in international markets. A lag of the dependent variable is also included. Two variables have been left out of the equation for statistical reasons, although theoretical reasons would suggest their inclusion: these are the real exchange rate and government expenditure.

The productivity gap is calculated based on total GDP (*Y*) minus natural resource GDP (fishing, mining and energy) (YRN). This last is projected using sectoral information from the Balance of Payments and National Accounts. The GDP relevant to inflationary pressures is represented by:

$$YRA = Y - YRN \tag{2.27}$$

We have chosen this definition because YRN is essentially determined by supply factors, with gaps between potential and actual output levels being relatively irrelevant. This position has some empirical support in that the equation estimated here adjusts better to the data and because this definition is the one that correlates best with changes in inflation. Using the calculation for the productivity gap (BRECHA) introduced in this section, the potential level of GDP minus natural resources $\overline{LYRAE}$ be defined as follows:

$$\overline{LYRAE} = LYRA + BRECHA \tag{2.28}$$

30 See corresponding box.

31 This is the sum of the current account deficits in the US, Japan and the European Union, deflated by the CPI of industrialized countries, and divided by the sum of the GDP of these countries.

The results of estimating the model using MICO are:

$$\Delta(LYRA - LYRAE) = \phi_{YRA} \underset{(-6.13)}{-0.41} \cdot \frac{1}{2}\sum_{t=1}^{2}\left(LYRA_{-t} - LYRAE_{-t}\right) \tag{2.29}$$
$$- \underset{(-2.45)}{0.27}\left(\Delta LYRA_{-1} - \Delta LYRAE_{-1}\right) - \underset{(-3.04)}{0.31}\left(\Delta LYRA_{-2} - \Delta LYRAE_{-2}\right)$$
$$- \underset{(-1.89)}{0.06}\left(TPM_{-2} - TPME_{-2}\right) - \underset{(-5.19)}{0.21}\left(TPM_{-3} - TPME_{-3}\right)$$
$$- \underset{(-3.50)}{0.79} \cdot \frac{1}{2}\sum_{t=3}^{4}\left(BCU5_{-t} - BCU5E_{-t}\right)$$
$$- \underset{(-2.57)}{0.28}\left(LIBORR_{-4} - LIBORRE_{-4} + SPREAD_{-4} - SPREADE_{-4}\right)$$
$$+ \underset{(2.33)}{0.42} \cdot \frac{1}{2}\sum_{t=2}^{3}\left(\Delta_4 LYEXT_{-t} - \Delta_4 LYEXTE_{-t}\right) + \underset{(2.84)}{0.05}\left(LTDI_{-2} - LTDIE_{-2}\right)$$
$$+ \underset{(3.49)}{0.01} \cdot \frac{1}{4}\sum_{t=2}^{5}\left(FKYEXT_{-t} - FKYEXTE_{-t}\right) - \underset{(-11.39)}{0.02} D943$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.60$
Residual standard deviation = 0.87%
LM test for serial correlation: F = 0.310 (p-value 0.869)
Jarque-Bera normality test: $c^2 = 1.068$ (p-value 0.586)
White heteroscedasticity test: $N{\cdot}R^2 = 32.562$ (p-value 0.792)
Estimation period: 1987:1 2002:3

The constant is not significantly different from zero, but this value is imposed on it to carry out projections. Projecting international variables is carried out by specialized analysts, as mentioned in the introduction to this chapter. Equilibrium values are projected as a combination of economic theory, historic averages, statistical filters and bank authorities' judgments. For example, to project the MPRE the historic behavior of the MPR series is considered, along with its most recent changes, the arguments determining the monetary policy rate (MPR) in the long term (LIBORR and SPREAD) and Central Bank of Chile authorities' judgment of current monetary impulse. Once the monetary policy rate (MPR)E has been defined, the BCU5E is determined using an equation similar to (2.24), where MPR is replaced by *MPRE*, although judgment is also considered at this stage. For international variables the process is similar, although the historic average plays a more preponderant role.

Labor Market: Wages and Employment

The labor market is fundamental to establishing inflationary pressure currently in effect. Both wages and productivity determine unit labor costs, the main ingredient of producer's costs and retail margins. To project these variables, an equation is included for determining wages and an equation for labor demand.

The aggregate supply in the economy reflects the long-term cost structure. On one hand, the technology assumed is Cobb-Douglas, so the factorial distribution of costs is constant in the long term. This imposes restrictions on the behavior of employment, which is assumed to adjust to balance situations with higher or lower real wages compared to average productivity. On the other hand, wages are to an important extent governed by institutional determinants. Indexing clauses for past inflation have a significant impact on short-term wages' behavior, so public sector readjustments have a relevant effect on the service component.

The structure of retail prices, which determines retail margins, reflects a distribution technology that is also considered to be of a Cobb-Douglas nature, and that combines unit labor costs associated with the production of domestically produced consumption goods, imported costs that come with the imported component of inputs or directly due to imported goods, and services.

The imbalances in the distribution of factorial income are gradually corrected through changes in labor demand.[32] Due to the fact that some variables are included in indices, a constant is included that captures the conversion of indices to their original values. It is assumed that in the long term, when factorial incomes reach their equilibrium level, labor demand grows at the same rate as the labor force (FT). Future changes in the labor force are projected in the medium term, according to the judgment of specialized analysts, while in the longer term it is assumed that it grows at the same average population growth rate from the latest census. At the same time, changes in the productivity gap and lags affect the employment variable in the short term. The equation for employment (LEMP) is as follows:

$$\begin{aligned}\Delta LEMP = &-\underset{(-2.10)}{0.06}\left(LEMP_{-1} + LCMON_{-1} - LP_{-1} - LY_{-1} - \ln(\alpha_N) + \phi_{np}\right) \\ &+ \underset{(3.43)}{0.19}\Delta BRECHA + \underset{(11.81)}{0.85}\Delta LFT - \underset{(-2.10)}{0.15}\Delta LEMP_{-1}\end{aligned} \tag{2.30}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.72
Residual standard deviation = 0.51%
LM test for serial correlation (4 lags): F = 1.2859 (p-value 0.2887)
Jarque-Bera normality test: c^2 = 1.869 (p-value 0.4052)
White heteroscedasticity test: $N{\cdot}R^2$ = 26.554 (p-value 0.0878)
Estimation period: 1989:2 2002:4

where CMON is the nominal labor cost. For estimating the long-term share of wage income, the wage bill is divided by nominal GDP (PY).

$$\alpha_N = \frac{CMON \cdot EMPA \ + \ 0.6 \ \ WN \cdot EMPC}{P \cdot Y} \tag{2.31}$$

In calculating the wage bill it is necessary to weigh the different kinds of workers according to whether they are employees (EMPA) or self-employed (EMPC). The former contribute to social security, so their share of GDP is measured through labor cost (CMON). The latter, in contrast, do not make these contributions, so their wage is considered as a percentage of average nominal wages in the economy (WN). This assumes a worth of 60%.[33]

Unemployment (U) can be calculated by subtracting the level of employment from the labor force. The unemployment rate is represented by:

$$U = 1 - EMP / FT \tag{2.32}$$

32 This includes employment without employment programs and includes hiring subsidies.
33 For more details, see Contreras and García (2002).

The behavior of private nominal wages reflects changes in the difference between unemployment and a judgment of what is estimated to be their natural level (UN), and lagged CPI inflation, which reflects indexing clauses. The theory indicates that, in the long term, real private wages must grow proportionately to mean labor productivity, to ensure that the factorial distribution of income remains constant, as indeed can be empirically observed during the period analyzed. Because of this, the equation includes equilibrium labor productivity growth (LQE), which is the logarithm of the quotient of potential GDP (YE) and the labor force, minus natural unemployment:

$$LQE = \log\left(\frac{YE}{FT(1-UN)}\right) = LYE - LFT - \log(1-UN) \tag{2.33}$$

Because in the long term, real wages cannot depend on inflation, the coefficients of term for inflation and wage adjustments must add up to 1. The restrictions imposed have been previously tested and not rejected. Results of the equation estimated for nominal private labor costs (CMOPRN) through MICO are:

$$\begin{aligned}\Delta LCMOPR = {} & \Delta LQE + \underset{(8.04)}{0.56}\Delta LIPC_{-1} + \underset{(6.93)}{0.32}\Delta LIPC_{-2} + \underset{(1.90)}{0.23}\Delta LIPC_{-4} \\ & - \underset{(-1.80)}{0.10}\sum_{s=1}^{2}(U_{-s} - UN_{-s})/2 - \underset{(-8.93)}{0.03}D911 - \underset{(-7.05)}{0.02}D931 - \underset{(-5.74)}{0.01}D924\end{aligned} \tag{2.34}$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.91$
Residual standard deviation = 0.6%
LM test for serial correlation (4 lags): F = 1.6523 (p-value 0.2011)
Jarque-Bera normality test: $c^2 = 4.8758$ (p-value 0.0873)
White heteroscedasticity test: $N \cdot R^2 = 37.0126$ (p-value 0.1768)
Estimation period: 1987:2 2002:3

Similarly, public wages (CMOPUN) are adjusted according to an index for government employees. As a result, in equilibrium the rise in real wages should be composed of the increase in public sector productivity and real growth in the government adjustment. This has been introduced exogenously to the model, using the best projections for public sector adjustments in the medium term, according to current information.

Wages considered in the employment equation are the average of nominal wages in the economy, thus including private and public wages. Using a logarithmic approach, these are calculated as follows:

$$\Delta LCMON = 0.74\Delta LCMOPRN + 0.26\Delta LCMOPUN \tag{2.35}$$

Costs, Margins and the GDP Deflator in the Long Term

As can be deduced from the equation, retail margins (*MKUP*) are expressed as:

$$MKUP = LIPCX1_{-1} - \left(\underset{(3.79)}{0.66}LCLU_{-1} + \underset{(6.02)}{0.31}LCMOPUN_{-1} + \underset{(1.54)}{0.03}LPIMP\right) \tag{2.36}$$

In the long term these margins must tend toward a constant denoted by ϕ_{mkup} in the equation (2.9). These long-term margins are exogenously imposed on the model, using historic information, along with information from other sources, such as the FECUS *(Fichas Estadísticas Codificadas Uniformes*). Using equations (2.25), (2.35) and long-term values for the real exchange rate, real wages, IVUM and margins, and some algebra, it can be shown that in the long term the GDP deflator remains residually defined as:

$$\begin{aligned} LPE = {} & LIPCX1 - \frac{0.74}{0.66}(\phi_{mkup}) - (\frac{0.31 \cdot 0.74}{0.66} - 0.26)(LCMOPUN - LQE - LIPCX1) \\ & - \log(\alpha_N) - \frac{0.74 \cdot 0.69}{0.66}\log(1+TIVA) - \frac{0.74}{0.66} \cdot 0.03(LIPC - LIPCX1) \\ & - \frac{0.74}{0.66} \cdot 0.03(LTCRUSE + LIVUME - LPUSE + LTM) \end{aligned} \tag{2.37}$$

With the exception of the LIPCX1, all terms to the right of the equation are constant in the long term. This indicates that, in the long term, the GDP deflator will tend to reach a constant ratio of core inflation (IPCX1), which in turn tells us that both will grow at the same rate, which is the same rate as total CPI growth.

2.4 Equations that Supplement the MEP

In this section, we present the MEP's complementary equations. These equations use the same MEP assumptions and results as their inputs. With their assistance we can identify changes in important macroeconomic variables that do not form part of the model.

Domestic Expenditure

An equation for domestic expenditure (*DI*) has been estimated. This equation is auxiliary, since it does not interact in any way with the rest of the model, but it does help to form an idea of the breakdown of demand projections into domestic and external. The expenditure equation is:

$$\begin{aligned} \Delta LDI = {} & -\underset{(-3.98)}{0.01} - \underset{(-4.54)}{0.22}(LDI_{-1} - LYE_{-1}) - \underset{(-2.50)}{0.20} \cdot \frac{1}{3}\sum_{t=1}^{3} TPM_{-2} - \underset{(-2.98)}{1.14} BCU5_{-2} \\ & + \underset{(3.99)}{0.12}\Delta(LTDI_{-2} - LTDIE_{-2}) - \underset{(-1.80)}{0.15} LTCR_{-4} + \underset{(1.91)}{0.01} \cdot (FKYEXT_{-1} - FKYEXTE_{-1}) \end{aligned} \tag{2.38}$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.49$
Residual standard deviation = 2.10%
LM test for serial correlation (4 lags): F = 0.6546 (p-value 0.6262)
Jarque-Bera normality test: $c^2 = 0.7966$ (p-value 0.672)
White heteroscedasticity test: $N \cdot R^2 = 29.404$ (p-value 0.1337)
Estimation period: 1987:2 2002:3

Moreover, this includes equations for different components of domestic and external demand. Aggregate demand by GDP (*DA*) is obtained from the sum of five components:

$$DA = CP + I + CG + X - M \tag{2.39}$$

where *CP* denotes total private consumption, *I* is total investment, *CG* is final government expenditure on consumption, *X* total goods and non-financial service exports, and *M* goods and non-financial services and imports, all measured in constant 1996 pesos. Details of how these components are estimated follow, with the analysis divided into private consumption, investment and the external sector. Some components, such as service exports and imports and government expenditure on consumption are not projected using econometric equations, but rather exogenous projections are used from information gathered by sector.

Private Consumption

Total private consumption (CP) can be broken down into private consumption of non-durable goods (CH) and private purchases of durable goods,[34] as such:

$$CP = CD + CH \tag{2.40}$$

The specification for non-durable and durable consumption is based on the one proposed by Contreras, Magendzo and Soto (2003). These authors moreover explain the construction of variables such as non-durable consumption, durable consumption, the cost of using durable goods (CKD), durable capital stock (KD) and disposable private income (YPD). How these variables are constructed is detailed below. The projection used for disposable private income and the costs of using durable goods is consistent with GDP projections from the MEP, while projections for durable goods capital are consistent with those for durable goods purchases. The equation for short-term behavior, including correction for errors, is:

$$\begin{aligned}\Delta LCH = {} & \phi_{CH0} - \underset{(-6.94)}{0.28}\left(LCH_{-1} - LYPD_{-1}\right) - \underset{(-4.33)}{0.16}U_{-1} + \underset{(4.33)}{0.14}\left(BCU5_{-2} - TPM_{-1}\right) + \underset{(2.10)}{0.34}\Delta LYPD \\ & - \underset{(-18.70)}{0.04}D931 + \underset{(9.12)}{0.04}D932 - \underset{(-3.02)}{0.01}D012\end{aligned} \tag{2.41}$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.64$
Residual standard deviation = 0.9%
LM test for serial correlation: F = 5.245 (p-value 0.263)
Jarque-Bera normality test: $c^2 = 0.352$ (p-value 0.839)
White heteroscedasticity test: $N{\cdot}R^2 = 20.273$ (p-value 0.504)
Estimation period: 1991:1 2002:4

When estimating expenditure on the purchase of durable goods, a dummy variable is included, which captures the entire recent period, starting from the second quarter of 2001 (D0102), in which the purchase of durable goods was less than predicted by other explanatory variables. The demand for durable goods in the short term is represented by:

$$\begin{aligned}\Delta LCD = {} & -\phi_{CD0} - \underset{(-2.9)}{0.58}(LKD_{-1} - LCH_{-1} + LCKD_{-1}) - \underset{(-6.2)}{0.46}\Delta LCD_{-4} - \underset{(-1.90)}{0.52}\Delta LTCR_{-3} \\ & + \underset{(8.38)}{2.23}\left(BCU5_{-1} - TPM_{-1}\right) - \underset{(5.24)}{0.09}D0102 + \underset{(12.29)}{0.28}D022\end{aligned} \tag{2.42}$$

34 The durable goods purchases and stocks series is developed using the methodology proposed for Chile by Gallego and Soto (2001). See Contreras et al. (2003).

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.71$
Residual standard deviation = 5.1%
LM test for serial correlation: F = 0.145 (p-value 0.964)
Jarque-Bera normality test: $c^2 = 1.615$ (p-value 0.446)
White heteroscedasticity test: $N{\cdot}R^2 = 29.821$ (p-value 0.191)
Estimation period: 1991:1 2003:1

Investment

Total investment is composed of fixed capital formation and inventory changes. Investment in fixed capital in turn breaks down into gross fixed capital formation in machinery (FBM) and gross fixed capital formation in construction (FBC), which are estimated separately. In both cases, we assume that in the long term gross formation remains a constant proportion of the respective capital stock (KM and KC, respectively).[35] The construction of these stocks is explained in detail below and their projection is consistent with respective flow projections. In the long term, when variables are at their equilibrium level, it is assumed that these grow in a balanced way at the potential GDP growth rate.[36]

In the case of investment in machinery, the short-term equation includes lagged variables, as well as lags in the GDP growth rate to capture behavior throughout the economic cycle. Changes in the real exchange rate for the main industrialized countries are also included (TCR5*)*, given that much of this capital is imported from industrialized countries. In addition, investment in machinery depends as much on longer term interest rate levels as it does on the slope of the yield curve. Dummy variables are included to capture exceptional periods. Of particular note is a dummy variable that captures the entire recent period starting from the second quarter of 2001, during which, as with durable goods, gross capital formation in machinery and construction has been less than predicted by other explanatory variables. The reasons behind this lower growth are not the subject of this study, but reasonable conjectures include lower growth expected in potential GDP and less availability of external resources. The equation estimated for the behavior of gross formation in machinery is:

$$\begin{aligned}\Delta LFBM = {} & \Delta LYE + \phi_{FBM0} - \underset{(-4.34)}{0.20}\left(LFBM_{-1} - LKM_{-2}\right) - \underset{(-3.57)}{0.32}\left(\Delta LFBM_{-1} - \Delta LY_{-2}\right) \\ & - \underset{(-1.83)}{0.46}\,\Delta LTCR5_{-1} - \underset{(-4.79)}{6.95}\cdot\frac{1}{3}\sum_{i=1}^{3}\left(BCU5_{-i}\right) + \underset{(3.88)}{1.95}\cdot\frac{1}{3}\sum_{i=1}^{3}\left(BCU5_{-i} - TPM_{-i}\right) \\ & + \underset{(1.75)}{0.85}\left(\Delta LY_{-3} - \Delta LYE_{-3}\right) - \underset{(-10.56)}{0.17}\,D944 - \underset{(-6.88)}{0.13}\,D961 - \underset{(-5.09)}{0.11}\,D0102\end{aligned} \tag{2.43}$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.55$
Residual standard deviation = 5.6%
LM test for serial correlation: F = 0.397 (p-value 0.810)
Jarque-Bera normality test: $c^2 = 0.448$ (p-value 0.799)
White heteroscedasticity test: $N{\cdot}R^2 = 43.821$ (p-value 0.683)
Estimation period: 1987:1 2002:4

35 For more details about the derivation of long-term relationships, see Bustos, Engel and Galetovic (1998) and Bravo and Restrepo (2001).

36 In the equations presented here, the credit market plays a residual role, adjusting itself to the needs of demand. For an alternative view, see Alfaro et al. (2003), who have emphasized the importance of imperfections in Chile's credit market.

The equation for the short-term behavior of gross capital formation in construction includes the long-term relationship provided by the investment to capital stock ratio and the lagged difference between the growth rate of investment in construction and GDP, and the GDP growth rate lagged to one year. These variables capture the behavior of investment in construction throughout the economic cycle. They also include long-term interest rates and the slope of the yield curve. In addition, two dummy variables are used to capture unusual periods, including the dummy for the most recent period, mentioned above:

$$\begin{aligned}\Delta LFBC = {} & \phi_{FBC0} - \underset{(-4.48)}{0.12}\left(LFBC_{-1} - LKC_{-2}\right) - \underset{(-2.86)}{0.33}\left(\Delta LFBC_{-1} - \Delta LY_{-3}\right) + \underset{(4.27)}{1.13}\Delta LY_{-4} \\ & - \underset{(-6.38)}{2.82}\, BCU5_{-3} + \underset{(4.20)}{0.69}\left(BCU5_{-3} - TPM_{-3}\right) - \underset{(-9.19)}{0.05}\, D881 - \underset{(-3.74)}{0.04}\, D0102\end{aligned} \quad (2.44)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.57$
Residual standard deviation = 2.8%
LM test for serial correlation: F = 2.198 (p-value 0.082)
Jarque-Bera normality test: $c^2 = 0.479$ (p-value 0.787)
White heteroscedasticity test: $N \cdot R^2 = 33.134$ (p-value 0.060)
Estimation period: 1987:2 2003:1

In this case, the correction of deviations in the long-term stationary state is significant with a phase lag of two quarters. This reflects the fact that construction investment accounting is closely linked to building permits. Deviations from the long term influence building permits, thereby affecting investment, which is apparent is some lag.

Finally, the short-term behavior of inventory or investment in inventory must be estimated (IEX). For this purpose, it is assumed that in the long term the ration of the stock of inventory to GDP is constant. Given the GDP growth rate in the long term, this implies that investment in inventory to GDP in the long term is also constant. Aside from correcting errors, lagged terms are included to capture the behavior of this variable. An important part of accumulated stocks comes from imports, so the growth rate for total goods imports (MB) is also included, as an explanatory variable. The resulting equation is:

$$\begin{aligned}\Delta\frac{IEX}{Y} = {} & \phi_{IEX0} - \underset{(-2.50)}{0.18}\frac{IEX_{-1}}{Y_{-1}} - \underset{(-11.10)}{0.98}\cdot\frac{1}{2}\sum_{i=1}^{2}\Delta\frac{IEX_{-i}}{Y_{-i}} + \underset{(5.90)}{0.16}\Delta LMB \\ & + \underset{(17.41)}{0.04}\, D931 + \underset{(17.99)}{0.04}\, D952\end{aligned} \quad (2.45)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.71$
Residual standard deviation = 1.1%
LM test for serial correlation: F = 0.381 (p-value 0.821)
Jarque-Bera normality test: $c^2 = 1.475$ (p-value 0.478)
White heteroscedasticity test: $N \cdot R^2 = 14.486$ (p-value 0.697)
Estimation period: 1990:1 2003:1

External Sector

The external sector, composed of exports (X) and imports (M) is divided into goods (XB) and service (XS) exports, and goods (MB) and service (MS) imports:

$$X = XB + XS \tag{2.46}$$

$$M = MB + MS \tag{2.47}$$

Variables for goods exports and imports are estimated using amounts expressed in 1996 dollars. The amount of total goods exports (*XBQ*) can be calculated as the following sum of components:

$$XBQ = XMQ + XAQ + XIQ + XOQ \tag{2.48}$$

where XMQ denotes mining exports, XAQ agricultural exports, XIQ manufactured exports and XOQ denotes the rest. Mining and agricultural exports are projected exogenously as sectoral information on investment and production plans in these sectors is reliable enough to make economic projections unnecessary. For the rest of goods exports (manufactured exports), however, an econometric approach is used.

Total goods exports in constant 1996 pesos (XB) are calculated based on projected quantum figures, applying the following transformation:

$$XB = XBQ \cdot TCN96 = (XMQ + XAQ + XIQ + XOQ) \cdot TCN96 \tag{2.49}$$

where TCN96 is the average observed exchange rate for 1996.

For manufactured exports, it is assumed that in the long term these are proportionate to the GDP of Chile's main trading partners (YEXT). Although ultimately this long-term relationship does not depend on the level of the real exchange rate, the real exchange rate of the industrialized countries (TCR5) affects short-term behavior. Moreover, a lag is included and the lagged external GDP growth rate to capture the behavior of this variable throughout the economic cycle. Short-term behavior is represented by:

$$\begin{aligned}\Delta LXIQ = {} & \phi_{XRQ0} - \underset{(-6.20)}{0.77}\left(LXIQ_{-1} - \underset{(-9.93)}{1.01}\,LY_{-1} - \underset{(-1.82)}{0.52}\,LYEXT_{-3} + \underset{(6.33)}{3.82}\,LTM_{-1}\right) \\ & + \underset{(4.67)}{6.49}\,\Delta LYEXT_{-1} + \underset{(2.32)}{0.29}\,\Delta LTCR5_{-1} - \underset{(-3.04)}{0.25}\,\Delta LXIQ_{-4} \\ & - \underset{(-13.37)}{0.10}\,D992 - \underset{(-6.00)}{0.10}\,D001 - \underset{(-7.95)}{0.15}\,D002\end{aligned} \tag{2.50}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.58
Residual standard deviation = 3.5%
LM test for serial correlation: F = 0.434 (p-value 0.783)
Jarque-Bera normality test: c^2 = 1.021 (p-value 0.600)
White heteroscedasticity test: $N{\cdot}R^2$ = 15.569 (p-value 0.873)
Estimation period: 1989:1 – 2003:1

It should be noted that the rise in the growth rate of the real exchange rate significantly increases the rise in non-main exports, although in the long term this effect disappears.

The amount of total goods imports (MBQ) can be broken down into the sum of the following components:

$$MBQ = MCQ + MKQ + MIQ + MOQ = MCQ + MKQ + MICQ + MIRQ + MOQ \tag{2.51}$$

where MCQ denotes consumer goods imports, MKQ denotes capital goods imports, MIQ denotes intermediate goods imports, which in turn can be broken down into fuels (MICQ) and non-fuels (MIRQ), and MOQ, which denotes all other imports. As with goods exports, goods imports are expressed in constant 1996 pesos as follows:

$$\begin{aligned} MB &= MBQ \cdot CIF\_FOB \cdot TCN96 \\ &= (MCQ + MKQ + MICQ + MIRQ + MOQ) \cdot CIF\_FOB \cdot TCN96 \end{aligned} \tag{2.52}$$

For reasons similar to those provided for mining exports, fuel and other imports are also projected exogenously. Consumer goods imports are projected assuming that, in the long term, they are a constant ratio of private consumption. In the short term, growth of these imports is affected by changes in private consumption and the lagged difference between the growth rate in consumption imports and durable goods purchases. With a dummy variable, the equation for short-term behavior is:

$$\begin{aligned} \Delta LMCQ = \phi_{MCQ0} &- \underset{(-2.13)}{0.05}(LMCQ_{-3} - LCP_{-3}) - \underset{(-4.36)}{0.34}\left(\Delta LMCQ_{-1} - \Delta LCD_{-1}\right) \\ &+ \underset{(5.84)}{2.80}\Delta LCP - \underset{(-6.00)}{0.30}\Delta LMCQ_{-4} - \underset{(-9.11)}{0.14}D932 \end{aligned} \tag{2.53}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.69
Residual standard deviation = 4.0%
LM test for serial correlation: F = 1.062 (p-value 0.388)
Jarque-Bera normality test: c^2 = 0.700 (p-value 0.705)
White heteroscedasticity test: $N{\cdot}R^2$ = 16.134 (p-value 0.762)
Estimation period: 1991:1 2003:1

The coefficient for the growth rate of private consumption is almost the unit, indicating that with all else being constant, consumption imports remain very close to this variable throughout the economic cycle. It should be noted that the real exchange rate affects the purchase of durable goods and, by this route, consumer goods imports.

To estimate the behavior of capital goods imports it is assumed that they are, in the long term, a constant proportion of total investment in machinery. Similarly, the behavior of these imports is closely linked to what happens with investment in machinery. The equation describing short-term changes for these imports is as follows:

$$\begin{aligned} \Delta LMKQ = \phi_{MKQ0} &- \underset{(-2.41)}{0.13}\left(LMKQ_{-1} - LFBM_{-1}\right) + \underset{(18.74)}{1.01}\Delta LFBM \\ &+ \underset{(11.18)}{0.21}D014 - \underset{(-4.58)}{0.07}D0102 \end{aligned} \tag{2.54}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.78
Residual standard deviation = 4.6%
LM test for serial correlation: F = 1.126 (p-value 0.356)
Jarque-Bera normality test: c^2 = 1.641 (p-value 0.440)
White heteroscedasticity test: $N{\cdot}R^2$ = 5.557 (p-value 0.697)
Estimation period: 1989:1 2002:4

The fact that changes in capital imports seem to follow investment in machinery rather closely should come as no surprise, since more than 90% of investment in machinery is imported. Moreover, the effect of the real exchange rate on these imports is captured in the effect that this relative price has on investment in machinery.

Finally, intermediate non-fuel goods imports are estimated assuming a constant ratio to GDP in the long term, which depends on the level of the real exchange rate and tariffs. Demand for these imports is represented by:

$$\Delta LMIRQ = \phi_{MIRQ0} - \underset{(-4.96)}{0.70}\left(LMIRQ_{-1} - \underset{(-5.72)}{1.26}\,LY_{-1} + \underset{(3.68)}{0.47}\,LTCR_{-1} + \underset{(3.49)}{2.17}\,LTM\right) + \underset{(5.35)}{2.08}\,\Delta LY - \underset{(-2.58)}{0.36}\,\Delta LTCR_{-3} \tag{2.55}$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.65$
Residual standard deviation = 3.5%
LM test for serial correlation: F = 1.974 (p-value 0.118)
Jarque-Bera normality test: $c^2 = 1.679$ (p-value 0.432)
White heteroscedasticity test: $N{\cdot}R^2 = 17.501$ (p-value 0.230)
Estimation period: 1991:1 2003:1

The Current Account

The current account of the balance of payments measured in current dollars (CCF) is obtained as the following sum:

$$CCF = XBF - MBF + XSF - MSF + BSFIF + TNF \tag{2.56}$$

where XSF denotes non-financial service exports, MSF non-financial service imports, BSFIF denotes the balance of financial services and TNF net transfers from abroad. Exports and imports of goods are estimated by amount as explained above. The amount expressed in 1996 dollars is converted to current dollars using the corresponding unit value indices for exports and imports:

$$XBF = XMQ \cdot IVUXM + XAQ \cdot IVUXA + XIQ \cdot IVUXI + XOQ \cdot IVUXO \tag{2.57}$$

$$MBF = (MCQ \cdot IVUMC + MKQ \cdot IVUMK + MICQ \cdot IVUMIC + MIRQ \cdot IVUMIR + MOQ \cdot IVUMO) \cdot \phi_{CIF\_FOB} \tag{2.58}$$

were ϕ_{CIF_FOB} denotes a constant that makes it possible to convert goods imports estimated at cif to fob, which is calibrated according to recent figures. The projected figures for non-financial service imports provided by sectors are converted from constant 1996 pesos to current dollars using the service import deflator (PMS) and the nominal exchange rate. The conversion applied is:

$$MSF = MS \cdot \frac{PMS}{TCN} \tag{2.59}$$

where *PMS* denotes the deflator for non-financial service imports.

At the same time, non-financial service exports are converted to current dollars using a method similar to that applied to non-financial service imports, multiplying the value in constant pesos by the export deflator (*PX*) for non-financial services and dividing it by the nominal exchange rate. The unit conversion formula is:

$$XSF = XS \cdot \frac{PXS}{TCN} \tag{2.60}$$

The value of financial services and net transfers from abroad are not projected econometrically, but rather projections are provided by the Balance of Payments Department using sectoral information.

Costs of Capital Use in Durables, Machinery and Construction

The cost of capital in machinery (CKM) and the cost of capital in construction (CKC)[37] are calculated separately. The specification used for the cost of capital in machinery is:

$$CKM = FAIM(HIP + DEPM)\frac{PFBM}{P} \tag{2.61}$$

where FAIM is a tax adjustment factor, HIP denotes the interest rate on mortgages, DEPM is depreciation rate for capital in machinery, PFBM is the deflator of capital in machinery and P is the GDP deflator. The tax adjustment factor is represented by:

$$FAIM = (1 - 0.6TUT + DEPM)\frac{(1+TM)}{(1-IVA)(1-TUT)} \tag{2.62}$$

where TUT the tax rate on company profits, TM is tariff rate and IVA is the value added tax. Likewise, the cost of capital use in construction is obtained as:

$$CKC = FAIC(\ HIP + DEPC)\frac{PFBC}{P} \tag{2.63}$$

where the corresponding tax adjustment factor is represented by:

$$FAIC = (1 - 0.6TUT + DEPC)\frac{(1+TM)}{(1-IVA)(1-TUT)} \tag{2.64}$$

For the cost of using durable goods (CKD) the following specification is used:[38]

$$CKD = \frac{IPCD}{IPCH}\frac{BCU5 - DEPD}{(1+BCU5)} \tag{2.65}$$

This calculation indicates that the cost of using durable goods is a growing function of the interest rate (BCU5) and the relative price of durable goods compared to non-durable consumption goods (IPCD/IPCH) and an inverse function of the depreciation rate for these goods. The durable goods and non-durable goods CPI is calculated by selecting the corresponding outputs from the CPI basket calculated by the National Statistic Bureau (INE).[39]

37 The capital cost calculation is based on a study by Bustos, Engel and Galetovic (1998). See also Romer (1996).
38 For details on how to obtain and motivate this cost, see Obsfeld and Rogoff (1996).
39 For more details, see Gallego and Soto (2001).

Unit Value Indices

Unit value indices for imports (IVUM) and exports (IVUX) are calculated and published by the Central Bank of Chile's Balance of Payments Department. This department provides the corresponding IVUM and IVUX for each of the goods import and export components detailed above.

The IVUM and IVUX are Paasche indices, in which the current value of imports or exports is divided by the value of the same at prices for a given base year. While the index for quantities traded abroad has a base year equal to 100 (corresponding to the Laspeyres quantum index) the price index does not. Price indices are those in which the quotient between these and the quantity index corresponds to the value of exports (or an index of same).[40]

The unit value indices are consistent with assumptions about the prices of the main export and import goods, as well as the assumptions about inflation for the most significant world economies and their exchange rates. These projections are carried out by sector experts based on specific information for each sector.

Deflators of Aggregate Demand and GDP

In the case of expenditure on consumer goods, it is assumed that the relevant deflator (PC) moves in line with changes in the CPI:

$$\Delta LPC = \Delta LIPC \tag{2.66}$$

In the case of investment, we distinguish between the deflator of gross capital formation in machinery (PFBM), the deflator of gross formation in construction (PFBC), and the deflator of investment in inventories (PIEX). The former changes with the price of capital goods imports, because around half of this investment is imported. Moreover, we assume that, under the single-price law, the price of these goods of domestic origin should not deviate greatly from the price of imported goods. Thus, we get:

$$\Delta LPFBM = \Delta LIVUMK + \Delta LTCN \tag{2.67}$$

In the case of construction, whose costs are mostly of domestic origin, change in the deflator reflect a weighted average of change in labor costs and core inflation (IPCX1):

$$\Delta LPFBC = \phi_{PFBC}\Delta LCMON + (1-\phi_{PFBC})\Delta LIPCX1 \tag{2.68}$$

Changes in the inventory investment deflator, meanwhile, are associated with changes in import prices. As we have seen above, an important part of the formation of these inventories is imported. Change in this deflator is represented by:

$$\Delta LPIEX = \Delta LIVUM + \Delta LTCN \tag{2.69}$$

40 For more details, see Meza and Pizarro (1982).

For the deflator for government expenditure on consumption, changes are obtained from the rate of change in public sector wages, as well as changes in core inflation (IPCX1). Thus, it is assumed that:

$$\Delta LPCG = \phi_{PCG}\Delta LWPU + (1-\phi_{PCG})\Delta LIPCX1 \tag{2.70}$$

The deflator of goods imports (*PMB*) is given by converting the unit value index, expressed in constant dollars, to constant 1996 pesos:

$$LPMB = LIVUM + LTCN - LTCN96 + \phi_{PMB} \tag{2.71}$$

where TCN96 denotes the average nominal exchange rate for 1996, and a constant is included for the purpose of adjusting the base year. In terms of the deflator for service imports, which is necessary to convert projections in constant pesos to current dollars, it is assumed that this in turn depends on the nominal exchange rate and external prices for these services:

$$\Delta LPMS = \Delta LPEXT + \Delta LTCN \tag{2.72}$$

The case of the export deflator is treated similar to the import deflator. Thus, the goods export deflator (PXB) is represented by:

$$LPXB = LIVUX + LTCN - LTCN96 \tag{2.73}$$

At the same time, the service export deflator is assumed to change with domestic inflation:

$$\Delta LPXS = \Delta LIPC \tag{2.74}$$

The GDP deflator is the index relating nominal figures in current pesos with real constant pesos. As a result, the GDP deflator is simply the quotient between nominal and real GDP, expressed as:

$$P = \frac{PC \cdot CP + PI \cdot I + PG \cdot CG + PX \cdot X - PM \cdot M}{CP + I + CG + X - M} \tag{2.75}$$

where:

$$PM \cdot M = PMB \cdot MB + PMS \cdot MS \tag{2.76}$$

$$PI \cdot I = PFBM \cdot FBM + PFBC \cdot FBC + PIEX \cdot IEX \tag{2.77}$$

$$PX \cdot X = PXB \cdot XB + PXS \cdot XS \tag{2.78}$$

This deflator can be contrasted with that provided by the MEP in equation (2.21).

Demand for Money

The Central Bank of Chile uses the interest rate as a monetary policy instrument. As a result, in the monetary policy approach in use, demand for money is determined by residue. Thus, in the money demand presented below, the behavior of broad money depends on output and the nominal interest rate, and serves to project the quantity of money that will be demanded by the economy without the Central Bank having any objective for these aggregates. The cointegration vector relates the behavior of the real M1A money logarithm (LM1A) with the logarithm for seasonally adjusted

GDP (LY) and the logarithm of (a transformation of) the nominal (unindexed) 30- to 90-day deposit interest rate (CAPN). The way the interest rate is included is consistent with models that emphasize the existence of liquidity traps, since by construction money demand tends to grow exponentially as the interest rate approaches zero. This specification has proven to adjust better to the data than others, in which the interest rate is introduced in a linear form. The results of the MICO estimation are:

$$\begin{aligned} LM1A = &- \underset{(-19.51)}{10.3} + \underset{(28.71)}{1.02}\, LY - \underset{(-7.31)}{0.18} \log\left(\tfrac{CAPN}{1+CAPN}\right) \\ &+ \underset{(12.2)}{0.59}\left(LM1A_{-1} - 10.3 - 1.02 LY_{-1} - 0.18 \log\left(\tfrac{CAPN}{1+CAPN}\right)_{-1}\right) \\ &+ \underset{(2.39)}{0.37}\,\Delta LY_{-1} + \underset{(4.59)}{0.62}\,\Delta LY_{+1} + \underset{(5.58)}{0.12}\,\Delta \log\left(\tfrac{CAPN}{1+CAPN}\right) \end{aligned} \tag{2.79}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.99
Residual standard deviation = 2.1%
LM test for serial correlation (4 lags): F = 0.42 (p-value 0.79)
Jarque-Bera normality test: c^2 = 1.78 (p-value 0.41)
White heteroscedasticity test: $N{\cdot}R^2$ = 1.24 (p-value 0.28)
Estimation period: 1986:1 2002:4

Both interest rate elasticity and income elasticity in money demand show magnitudes of about those estimated previously, in Chile's case.[41] Demand for monetary balances depends on their alternative cost, expressed as the short-term nominal deposit rate. This reacts to shifts in the monetary policy rate over time (MPR)*N*, and retains a margin associated with the cost to banks of funds:

$$CAPN = \phi_{cap} + \underset{(3.02)}{0.19} CAPN(-1) + 0.81 TPMN \tag{2.80}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.92
Residual standard deviation = 1.03%
LM test for serial correlation (4 lags): F = 0.9268 (p-value 0.4624)
Jarque-Bera normality test: c^2 = 2.145 (p-value 0.342)
White heteroscedasticity test: $N{\cdot}R^2$ = 5.6187 (p-value 0.2294)
Estimation period: 1994:2 2002:3

Real Multilateral Exchange Rate

Because Chile trades with many countries other than the United States, the real exchange rate affecting the competitiveness of Chilean products is the real multilateral exchange rate (TCRM). This is the average, weighted by share of trade, of real bilateral multilateral exchange rates. Assuming that the real multilateral exchange rate is a geometric average of bilateral exchange rates, the difference between the real bilateral exchange rate bilateral with the US (TCR) and the multilateral exchange rate (TCRM) is represented by the difference between the external price index relevant to (PEXT)[42] and the US' CPI (PUS):

$$LTCRM = LTCR + LPEXT - LPUS \tag{2.81}$$

41 The article by Mies and Soto (2000) summarizes a great many money demand estimates for Chile.
42 Feliú (1992) describes the methodology for building external price index.

3. Auxiliary Models

3.1 VAR Models

This section presents models used by the Central Bank of Chile to project the main macroeconomic variables as time series. Specifically, these projections are done using monetary VAR,[43] that is, with time series models that include variables such as prices, output, money, the interest rate and the exchange rate, as well as exogenous variables to characterize a small, open economy. The assumptions used for these exogenous variables are consistent with those used in other model projections, particularly the MEP.

Specification

In this section, monetary VAR are estimated for the following variables: output, prices, policy rate, nominal money and the real exchange rate.[44] To suitably identify monetary policy, the monetary policy rate (MPR) was corrected for liquidity by capturing 1998 episodes, during which efforts to defend the peso and control expenditure pushed the actual, that is interbank, rate much higher than the Monetary Policy Rate (MPR). The correction consisted of replacing the monetary policy rate with the interbank rate in 1998.

Aside from the set of endogenous variables, exogenous variables such as the inflation target, external GDP,[45] the Libo rate adjusted for the reserve requirement, and copper and oil prices were incorporated. Variables are monthly and are measured in a natural logarithm, except the policy interest rate and the Libo rate. The sample considered runs from January 1986 to December 2002. All estimations and routines were carried out using Eviews®.

An important point with this modeling is the decision to treat the inflation target as an exogenous variable. In this sense, there are several options for modeling this variable in a VAR: one is to omit it from the system, which assumes that it is completely endogenous and therefore irrelevant (Parrado, 2001). Another is to assume that the inflation target is within the VAR, as García (2001) and Valdés (1997) do, by including the inflationary gap. Another option is that of Bravo and García (2002), who argue that the target can be modeled as an exogenous variable, that is, the hypothesis that the target was a conscious decision of the Central Bank based on its credibility in terms of stabilizing inflation would win out over the hypothesis of an opportunistic Central Bank that adjusted its target downward as economic conditions permitted.

For the estimations presented in this section, it is assumed that the target is exogenous for practical rather than theoretical reasons. First, the target enters each VAR with the same quantity of lags that it would have had were it endogenous, so estimations are not substantially affected and projection tasks become easier. Second, it is more reasonable to present response impulses in which the inflation target does not change, because currently this variable is fixed within a range centering on 3%. In this way, the results obtained using VAR are more comparable to those that really arise when the Central Bank decides to change the monetary policy rate (MPR).

43 A review of literature on VAR and its applications can be found in Stock and Watson (2001). Other classical references are Sims (1980) and Bernanke (1986).
44 This is the real bilateral exchange rate with the United States (nominal exchange rate * CPI US / CPI Chile).
45 This index was built using GDPs for the United States, Germany, Argentina, Japan and Brazil, weighting each series for its share of trade with Chile.

Once variables were defined, a levels model was selected, which is interpreted as the unrestricted model. This was then reparameterized to obtain not only the levels model, but also two other specifications covering most cases presented in the literature: first differences, annual differences, that is, it directly incorporates inflation and growth. In levels and first difference models, the variables were seasonally adjusted using the X-12 ARIMA method, as proposed by Bravo et al. (2002).[46] Moreover, a linear trend was included for estimating levels, the target was defined in annual terms, and the policy interest and Libo rates were not differentiated.

To select VAR lags, two fundamental aspects were considered. Initially, the traditional Hannan-Quinn and Schwarz criteria for defining the optimum lag were calculated. These indicated that the number of lags fell between one and two. These results were then complemented using the LM multivariate test for auto-correlation errors (Johansen, 1995). Thus, if estimations with the lags selected using the criteria mentioned pointed to auto-correlation, we opted for increasing the number of lags until this disappeared.

At the same time, to interpret impulse response functions as the result of structural economic shocks, this section specifies the identification assumptions for determining the simultaneousness of all variables forming the SVAR. First, from the broad literature about identifying monetary shocks, we chose to identify only the Central Bank reaction function and its effect on other variables. The first advantage of this approach is that restrictions are minimum, general and avoid having to identify a complete macroeconomic model. At the same time, the identification selected also has the virtue of having been used by a long list of researchers, among them: Christiano and Eichenbaum (1992), Christiano et al. (1996, 1997 and 1999), Eichenbaum and Evans (1995), Strongin (1995), Bernanke and Blinder (1992), Bernanke and Mihov (1995) and Gertler and Gilchrist (1994).

Specifically, the strategy consists of dividing the variables into three sets: (1) variables that are not contemporaneously affected by policy variables, (2) policy variables and (3) other variables that are contemporaneously affected by policy variables. In other words, the Central Bank reaction function is identified by distinguishing between variables that may or may not be rapidly affected by policy variables. To illustrate, let us assume that the economy faces an inflationary shock observed by the Central Bank but hard to modify right away. A possible Central Bank response is to boost the interest rate, which would affect other variables such as the quantity of money and the exchange rate. Although this response does not affect inflation during the first period, this variable could change in the following periods, as the result of a total change within the system.

Likewise, between the two policy variables, a realistic ordering of events is assumed: the Central Bank first defines an inflation target, which then enters the VAR exogenously and later the interest rate. This assumption is consistent with the fact that the interest rate has been used as a fine-tuning policy. Finally, the market endogenously determines the quantity of money once the Central Bank has set the interest rate and aligned inflation expectations.

Then, among the three non-policy variables, it is assumed that the Central Bank cannot contemporaneously affect output and inflation, especially because it is working with monthly data and the inflation rate shows a high degree of inertia due to the strong indexation present in the Chilean economy.[47] For the exchange rate, it is

46 The program used to seasonally adjust series and a description of it can be downloaded from www.bcentral.cl/esp/estpub/estudios/documentostrabajo/177.htm.

47 Jadresic (1996).

assumed that the Central Bank can affect this variable contemporaneously given that there is a more direct link between the nominal exchange rate, the interest rate and interventions in the foreign exchange market that can be carried out by the Central Bank.

Table 3.1 shows the specifications for each of the VAR models considered. The order and the exogenous variables are established for each. Finally, estimations calculate a confidence interval for the standard deviation of each impulse response function. It should be noted that often researchers use confidence intervals of this magnitude due to limitations affecting VAR estimates in small samples (Stock and Watson, 2001).

Table 3.1

Specifications Used in VAR Models

Levels model (Number of lags: 3)[1]	LY, LIPC, MPR, LM1A, LTCR &[2] LPOIL (0 a –3), LPCU (0 a –3), LIBORR[3] (0 a –3), LYEXT(–1 a –3), TARGET(0 a –3), constant and trend.
First difference model (Number of lags: 3)	ΔLY, ΔLIPC, MPR, ΔLM1A, ΔLTCR &[2] ΔLPIL(0 a –3), ΔLPCU (0 a –3), LIBORR[3] (0 a –3), ΔLYEXT(-1 a –3), TARGET(0 a –3) and constant.
12-month change model (Number of lags: 3)	Δ_{12}LY, Δ_{12}LIPC, MPR, Δ_{12}LM1A, Δ_{12}LTCR &[2] Δ_{12}LPIL(0 a –3), Δ_{12}LPCU(0 a –3), LIBORR[3] (0 a –3), Δ_{12}LYEXT(–1 a –3), TARGET(0 a –3) and constant.

1: The number of lags was chosen using Schwarz criteria adjusted using the LM text (Johansen, 1995).
2: From the "&" onward, exogenous variables appear, with their respective lags in brackets.
3: The D symbol is used to classify the first difference series and D_{12} for the 12-month series.

Evaluation

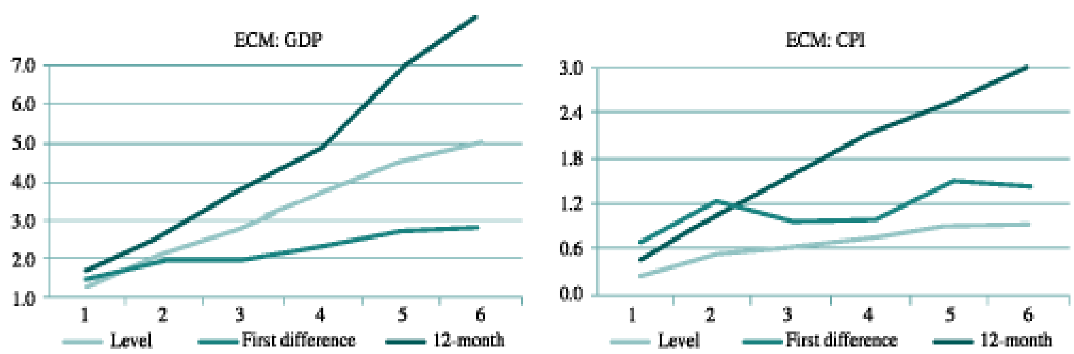
VAR models are mainly used as tools to project activity and inflation over a horizon of up to six quarters. The choice between different VAR models is made using the mean square error (ECM) and its response impulses. For example, for each of the models presented the ECM of two objective variables is calculated: GDP and CPI (inflation). The steps followed by the ECM calculation are:

- Each model is estimated with data for all but 42 periods of those available.
- The next 18 are projected, and the results kept.
- The same exercise is repeated 23 times, adding one month of information each time.
- Thus, 24 series are obtained, each with 18 data items projected. Because the purpose is a quarterly projection, fixed quarters are calculated as annual changes, generating a matrix for each model containing 24 series in columns, with 6 quarterly data items organized in rows as percentages.
- With real monthly data, a matrix of the same size is calculated, so that the months in each cell for calculating quarterly data coincide with the matrices containing the projections.
- The ECM is calculated (Albagli et al., 2002), that is the 12-month change.

Finally six results are obtained, one for each projection horizon, for each index and each objective variable (GDP and CPI). The projection horizon i is interpreted as the average error committed in the i-nth quarter projected. For example, a projection to six quarters implies an error of x1% for the first quarter (horizon 1), x2% for the second (horizon 2), etc. A foreseeable result of this kind of exercise is that the error will increase as the projected period moves further into the future, away from the end of the estimation period or, in other words, over a longer projection horizon.

The best model posts the lowest ECM. In the example analyzed in this section, see figure 3.1, the best model was that expressed as first differences. This result is complemented by the respective impulse responses to establish a definitive criteria for which VAR to use in projections.

Figure 3.1
Mean Square Error



The Bank is constantly developing new VAR models to improve inflation and growth projections. Also, to better understand projection changes month on month, a detailed analysis of changes is carried out for both exogenous variables (a new external scenario) and endogenous variables (new monthly information). All these elements are considered when analyzing periodic projections carried out with VAR models.

3.2 Imacec Leading and Coincident Indicators

In general, the idea behind leading indicators (IL) or those that coincide is that of capturing expansive and contractive processes that occur simultaneously in multiple economic sectors. These economic cycles are recurrent but not identical to each other. This kind of model has a three-part structure: selection of the series that will make up the indicator; grouping of these series in a new leading index, and finally, the process of evaluating signals, which makes it possible to explore how effective the indicator is for predicting phase changes in the economic cycle. The IL section starts with a general explanation of the methodology, then continues with international experience. Models follow that were obtained through this process and IL behaviors in the latest cycle are analyzed.

International Experience

The subject of leading indicators has been dealt with by many central banks, among them those of Germany, Australia, Brazil, Canada, France, Japan, United Kingdom, and some US Federal Reserves. There is a wide range of studies, with very diverse methodologies used.

In the case of Germany, Bandholz and Funke (2001) used models with dynamic factors (Kalman filter) to estimate with and without regime changes. As in Chile, the purpose of the indicator is to predict a phase change in the economic cycle. In Australia, in contrast, the objective has mainly been to project short-term change in output. The use of VAR models has been an element common to most of the work on this subject.[48]

In the case of the US Federal Reserves, Orr et al. (2001), most studies on this subject attempt to predict cycle phase changes using financial variables, especially the yield curve. Something similar has occurred in Japan, Canada and the United Kingdom.[49] In methodological terms, these studies tend to be based on probit models.

Finally, there is a series of studies, such as Dion (1999) for Canada, Chauvet (2000) for Brazil, and de Coelli and Jerome (1992) for Australia, which use leading indicators to predict inflation phase changes. Other areas that use leading indicators include portfolio analysis (Hayes, 2001), anticipating foreign exchange crises (Burkart, 2000), and even banking system studies (Bell, 2000 and Logan, 2001

Methodology

Indicators estimated by the Central Bank consist of building two kinds of indicators using variables that lead production, called the "leading indicator" and another that moves contemporaneously with it, called the "coincident indicator". To do so, the Auerbach methodology is followed.[50] The starting point consists of choosing a subset of series that possesses certain properties that make it possible to classify them as "leading" or "coincident". Seven selection criteria are used to create an evaluation scale similar to the one proposed by Silver (1991). The selection criteria are as follows:

Order
Magnitude
Persistence
Causality in sense Granger`s
}
These criteria are related to cross correlations of variables

Predictability
Economic Significancy
Promtness

The Auerbach method bases weighting of each series on the parameters obtained through an ordinary least square regression. In the case of both leading and coincident indicators, series are introduced into the indicator with a lag equivalent to their average lead over the Imacec.

The issue of interpreting signals mainly deals with formulating rules applicable to predicting phase changes in the economic cycle. There are rules with no theoretical

48 For a recent study, see Brischetto and Voss (2000).
49 In this sense, see work by Estrella and Mishkin (1996) for the United States, Clinton (1994) for Canada, Neiss and Nelson (2001) for the United Kingdom, and Hirata and Ueda (1998) for Japan
50 Cowan, 1995.

basis that arise solely from observing the series' past behavior. Formal evaluation procedures also exist based on certain assumptions regarding the stochastic behavior of the economic cycle. This work uses two evaluation criteria in a complementary manner: the first involves a simple rule implemented by the National Bureau of Economic Research (NBER), while the second uses the markovian regime shift methodology (Johnson, 2001).

In concrete terms, the series making up both leading and coincident leaders are expressed as standard deviation from their mean, normalized by standard deviation (similar to the t statistic). In both, the dependent variable is the Imacec. After testing an extensive number of variables and testing model properties, the leader ended up composed of months of housing stock (STOCKS) developed by the Chilean chamber of builders (*Cámara Chilena de la Construcción*), the copper price (PCU), the interest rate on mortgages (HIP), non-copper exports (XBF-XCUF), difference in working days (DIAS) and ARMA components. The weights provided for MICO estimation are:

$$IMACEC_t = \underset{(-2.76)}{1.088} - \underset{(-2.00)}{0.353}\,HIP_{t-7} - \underset{(-2.07)}{0.159}\,STOCKS_{t-5} + \underset{(3.27)}{0.115}(XBF_{t-9} - XCUF_{t-9}) + \underset{(0.59)}{0.070}\,PCU_{t-6} - \underset{(-3.27)}{0.007}\,DIAS + \underset{(6.44)}{0.609}\,AR(1) + \underset{(1.95)}{0.249}\,AR(2)$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.74
Residual standard deviation = 36.9%
LM test for serial correlation (4 lags): F = 1.978 (p-value 0.147)
Jarque-Bera normality test: c^2 = 0.843 (p-value 0.656)
White heteroscedasticity test: $N{\cdot}R^2$ = 23.8 (p-value 0.250)
Estimation period: 1997:1 2003:6

Meanwhile, the coincident indicator is constructed based on the average of projections according to four specifications, which group the following variables as exogenous: M6 monetary aggregate (M6), non-durable consumption sales from the National Statistics Bureau (IVCHINE), consumer credits (CREDCON), cement, concrete and construction material shipment figures from the Chilean chamber of builders (CEMENTO, HORMIGON and MATERIALES, respectively), Manufacturing development association, Sofofa manufacturing production index (PSFF), INE hydroelectric power generation (HIDROELEC), percentage of hydroelectric power generation over the total (HIDRORATIO), intermediate consumption sales for construction from Sofofa (VCONSTSFF), consumer imports (MCF), non-fuel and lubricant imports (MBF-MICF), and car sales from the national association of car dealers, ANAC (AUTOS).

Model 1

$$IMACEC = \underset{(-1.44)}{0.129} + \underset{(1.08)}{0.122}\,M6 - \underset{(4.21)}{0.125}\,IVCHINE + \underset{(2.29)}{0.358}\,CREDCON + \underset{(6.06)}{0.255}\,HORMIGON + \underset{(4.75)}{0.204}\,PSFF + \underset{(3.10)}{0.142}\,HIDROELEC - \underset{(-2.57)}{0.129}\,VCONSTSFF + \underset{(3.97)}{0.198}\,MCF - \underset{(-0.55)}{0.019}\,AUTOS + \underset{(3.77)}{0.320}\,AR(1) + \underset{(3.61)}{0.352}\,AR(2)$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.93
Residual standard deviation = 25.5%
LM test for serial correlation (4 lags): F = 1.982 (p-value 0.10)
Jarque-Bera normality test: c^2 = 5.13 (p-value 0.08)
White heteroscedasticity test: $N{\cdot}R^2$ = 75.2 (p-value 0.03)
Estimation period: 1995:1 2003:6

Model 2

$$IMACEC = \underset{(-2.67)}{-0.091} + \underset{(9.13)}{0.361} M6 + \underset{(4.27)}{0.141} IVCHINE + \underset{(1.55)}{0.112} CEMENTO + \underset{(2.05)}{0.18} HORMIGON + \underset{(3.63)}{0.140} PSFF$$
$$+ \underset{(5.66)}{0.221} HIDRORATIO - \underset{(-2.34)}{0.107} VCONSTSFF - \underset{(-3.42)}{0.182} MATERIALES + \underset{(5.66)}{0.281} MCF + \underset{(0.76)}{0.027} AUTOS$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.93$
Residual standard deviation = 25.5%
LM test for serial correlation (4 lags): F = 2.18 (p-value 0.08)
Jarque-Bera normality test: $c^2 = 0.24$ (p-value 0.88)
White heteroscedasticity test: $N \cdot R^2 = 66.9$ (p-value 0.41)
Estimation period: 1995:1 2003:6

Model 3

$$IMACEC = \underset{(-1.12)}{-0.068} + \underset{(4.19)}{0.250} M6 + \underset{(5.38)}{0.135} IVCHINE + \underset{(3.68)}{0.291} CREDCON + \underset{(2.22)}{0.135} CEMENTO + \underset{(0.96)}{0.072} HORMIGON$$
$$+ \underset{(3.42)}{0.180} PSFF + \underset{(1.94)}{0.124} HIDROELEC - \underset{(-2.67)}{0.153} VCONSTSFF - \underset{(-1.95)}{0.142} MATERIALES + \underset{(4.87)}{0.297} (MBF - MICF)$$
$$- \underset{(-0.99)}{0.035} AUTOS + \underset{(3.28)}{0.331} AR(1)$$

In brackets, corrected t statistics (Newey-West)
Corrected R2 = 0.93
Residual standard deviation = 25.1%
LM test for serial correlation (4 lags): F = 1.23 (p-value 0.31)
Jarque-Bera normality test: $c^2 = 0.95$ (p-value 0.62)
White heteroscedasticity test: $N \cdot R^2 = 84.90$ (p-value 0.25)
Estimation period: 1995:1 2003:6

Model 4

$$IMACEC = \underset{(-1.57)}{-0.068} + \underset{(8.00)}{0.300} M6 + \underset{(4.28)}{0.127} IVCHINE + \underset{(1.89)}{0.116} CREDCON + \underset{(2.12)}{0.147} CEMENTO + \underset{(0.46)}{0.039} HORMIGON$$
$$+ \underset{(4.11)}{0.190} PSFF + \underset{(4.02)}{0.174} HIDRORATIO - \underset{(-3.05)}{0.152} VCONSTSFF - \underset{(-2.32)}{0.119} MATERIALES + \underset{(5.95)}{0.297} (MBF - MICF)$$
$$+ \underset{(1.40)}{0.115} AR(1)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.94$
Residual standard deviation = 23.9%
LM test for serial correlation (4 lags): F = 1.00 (p-value 0.41)
Jarque-Bera normality test: $c^2 = 0.19$ (p-value 0.91)
White heteroscedasticity test: $N \cdot R^2 = 81.79$ (p-value 0.33)
Estimation period: 1995:1 2003:6

Indicators' Behavior in the Past Cycle

Since 1998, different indicators have proven very precise in predicting a phase change in the economic cycle, especially at times when activity was lowest. Changes in the Imacec, average leading and coincident indicators are presented below (figure 3.2).

In general, these indicators average a one-quarter lead. It should be noted that during an expansive stage, after the drop in output in 1999, these continued to adjust to the change of phase, but with magnitudes different from the Imacec. A plausible explanation for the leading indicator's over-estimation compared to the Imacec is that the Chilean economy was going through a low-growth period, making it difficult to reproduce past figures used to estimate this indicator.

Figure 3.2
Changes in the Imacec, Leading and Coincident Indicators
(moving quarterly averages, percent)

3.3 Short-Term Models

This section presents model selection criteria and short-term projections for some variables that play a significant role in explaining the change in output and monthly domestic demand. It describes how projection models are obtained and implemented for total cif imports, total fob exports, manufacturing sales and production.

Methodology

The "theoretical relationships" between variables can be structured differently when carrying out projections. For example, variables can be expressed as logarithms, as first differences with the immediately previous period or with its equivalent in the past (for example, January-January or first week-first week), by applying the ARIMA-X12[51] method or using dummies for seasonal adjustments, different estimation methods, etc. As a result, there are many models that can be used to project. There are at least two strategies for choosing between these models: a weighted version of them (Clements and Hendry, 1998), or the selection of the best ("surviving model") based on an evaluation of prediction error. The Central Bank's experience indicates that the weighting method generally provides rather imprecise estimates for the respective weights, reflecting a pronounced multi-collinearity that arises because the projections obtained by each model separately ended up being very similar or when they shared the same exogenous variables.

51 This method is the one used regularly by the Central Bank to seasonally adjust economic series. For details, see Bravo et. al. (2002).

Of all the criteria using prediction error, we chose the one defined by *Theil* (Pindyck and Rubinfeld, 1991), which is based on an index that measures prediction capability in an out-of-sample exercise for a given projection horizon. Its interpretation is similar to mean square error (ECM) and it can be broken down in three parts: bias (*Theil-mean*), volatility (*Theil*-var) and randomness (*Theil-cov*). These components must always add up to 1, so they can be interpreted as the total percentage of prediction error that can be explained by each of them. For example, a projection will be perfectly unbiased compared to the original series if the *Theil-mean* is zero, that is, if 0% of the error can be explained by a misadjustment to the mean. Similarly, a model will adjust perfectly to the volatility of the original series if the *Theil-var* is also zero. Thus, a good projection model must have the lowest possible *U-Theil* index and every error must be justified by randomness, which is reflected in the value closest to 1 in the *U-cov* index.

Formally, the *U-Theil* index and its components are defined as:

$$U-Theil=\sqrt{\frac{\frac{1}{K}\sum_{1}^{K}\left(\tilde{y}_k-y_k\right)^2}{\frac{1}{K}\sum_{1}^{K}y_k^{\,2}}} \qquad (3.1)$$

$$U-media=\frac{\left(\frac{1}{K}\sum_{1}^{K}\tilde{y}_k-\frac{1}{K}\sum_{1}^{K}y_k\right)^2}{\frac{1}{K}\sum_{1}^{K}\left(\tilde{y}_k-y_k\right)^2} \qquad (3.2)$$

$$U-\mathrm{var}=\frac{\left(\sigma_{\tilde{y}}-\sigma_y\right)^2}{\frac{1}{K}\sum_{1}^{K}\left(\tilde{y}_k-y_k\right)^2} \qquad (3.3)$$

$$U-\mathrm{cov}=\frac{2\left(1-\rho_{\tilde{y}y}\right)\sigma_{\tilde{y}}\sigma_y}{\frac{1}{K}\sum_{1}^{K}\left(\tilde{y}_k-y_k\right)^2} \qquad (3.4)$$

The selection criterion, in general terms, was the following: first, the best model was selected from a set of alternatives, according to which had the lowest projection error, measured by the *U-Theil*, then unbiasing properties throughout the period, and finally for its adjustment to variance. If no model is obtained that prevails over the rest, then the one showing the best projections for the next period is chosen from among the “survivors”. The reason for this second criterion is that it is assumed that the main objective sought is to maximize the short-term projection capacity.

Once the short-term projection model has been selected, the predictive properties for the different horizons are analyzed. This way, how reliable projections are for which period can be determined.

Balance of Trade Projections

Projection of the balance of trade is done by separating fob export and cif import model projections, applying a factor that approximates the latter to their fob equivalent. The data available is weekly[52] and comes from the National Customs Service report, with approximately a one week lag.[53]

52 The month is distributed in four fixed weeks, which in general do not coincide with the weeks of the calendar month. Respectively, the first to the fourth week run from the 1st to the 7th, the 8th to the 15th, the 16th to the 23rd, and the 24th to the 31st of each month.

53 The methodology for calculating this data changed in May 2002, with corrected data constructed backward to January 1996, on a monthly basis only. To fit with the weekly series, consistent data was generated, with the monthly difference between the data calculated using old and new methodologies assigned uniformly to all weeks. This procedure was used from the start of each sample until the last week of April 2002.

The seasonality cannot be modeled using ARIMA-X12 because this method can only be applied to monthly series. The exogenous variables used are as follows:

The Customs dollar (TCNAD), which is used by the National Customs Service in its calculations as the reference dollar value, is monthly, and reflects the dollar price on the second last working day of the previous month.

The dollar (TCN), which represents the average weekly price from daily data, maintaining the last available data for the remaining weeks in the month, unless some other *ad hoc* assumption is used.

The average weekly oil price (for imports, POIL) and copper price (for exports, PCU), which are calculated and applied in the same way as the TCNAD.

Each model projects the remaining weeks in the month to obtain monthly data. For example, if there is data through the first week of May, then the next three weeks are projected to obtain the May prediction; if data is available through the fourth week of May, then the next four weeks are projected to obtain the prediction for June.

The best model obtained by applying this selection method was in the case of both imports and exports, the one differentiating over the previous week. To visualize how prediction error and its properties evolved, an out-of-sample exercise was used for February 2001 to January 2003. An average error for the period was calculated, and projected with a set of data that systematically moved away from this period by up to eight months. Exogenous variables were assumed to take on their true value during the projection exercise.

Cif Import Projections

Oil and non-oil components of imports are projected separately for the current month. The available sample runs from the first week of January 1997 to the present. Dependent variables include oil and non-oil imports (MPF and MNPF respectively), with those obtained from total cif imports.

For non-oil imports, based on the methodology explained above, the model selected uses some variables that can be defined as follows:

$$AMNPFi_t = \frac{\sum_{s=1}^{i} MNPF_{t-4+s}}{\sum_{s=1}^{i} días_{t-4+s}}$$

Thus, AMNPFi can be interpreted as average daily non-oil imports obtained during the last i weeks. In this model, the dependent variable is the average daily non-oil imports from the previous month (AMNPF4) and the exogenous variables are the daily average for the two weeks previous to the current period (AMNPF2); the daily average during the week previous to the last three weeks (AMNPF1); the number of working days in the fixed week (DÍAS); the Customs dollar, TCNAD; the dollar, TCN; dummies for months and for weeks s_i (corresponding to the i-nth, are four fixed weeks), and AR components. The results are as follows:

$$\Delta LAMNPF4 = \underset{(5.23)}{0.061} + \underset{(6.90)}{0.132}\,\Delta LAMNPF2_t + \underset{(13.14)}{0.125}\,\Delta LAMNPF1_t - \underset{(-5.93)}{0.013}\,\Delta DIAS_t \tag{3.5}$$

$$+ \underset{(5.01)}{0.002}\,s4(LTCNAD_t - LTCNAD_{t-4}) - \underset{(-11.19)}{0.001}(LTCNAD_t - LTCNAD_{t-4})$$

$$- \underset{(-10.63)}{0.003}\,s4(LTCNAD_t - LTCN_t) + \underset{(9.20)}{0.049}\,s4_t - \underset{(-4.31)}{0.025}\,FEBRERO - \underset{(-2.79)}{0.014}\,JUNIO$$

$$- \underset{(-1.45)}{0.001}\,NOVIEMBRE - \underset{(-5.67)}{0.032}\,DICIEMBRE - \underset{(-2.16)}{0.111}\,AR(2) - \underset{(-4.89)}{0.301}\,AR(3)$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.68
Residual standard deviation = 2.8%
LM test for serial correlation (4 lags): F = 3.68 (p-value 0.006)
Jarque-Bera normality test: c^2 = 16.95 (p-value 0.000)
White heteroscedasticity test: N·R^2 = 28.45 (p-value 00367)
Estimation period: 1995:1:1 2003:7:2

Several observations can be made about the non-oil import model. A rise in the Customs dollar over the previous month implies, as would be expected, a decline in import levels. However, the exchange rate effect on imports is also influenced by the behavior imposed by the Customs dollar on importers' expectations. For example, in the fourth week, importers know ahead of time that a new dollar will be set for the following month. This means that a TCN dollar that during the fourth week is higher than the Customs dollar currently in effect will push the import-relevant dollar upward in the next month, with a further positive effect on imports in the fourth week, due to the rise expected in import costs.

Finally, seasonal factors also exist. On average, the fourth week of each month has a positive impact, which can be explained by the same arguments mentioned above. At the same time, December of each year has a negative effect, due to the (3.6) policy of scaling down tariffs, which is applied at the beginning of each year, leading to imports to be postponed until the next month. February also posts a significant negative impact.

The oil model is much simpler: the logarithm for the weekly data is regressed against the average price for the current week, along with seasonal dummies for weeks and months and AR components. The regression thus obtained is:

$$LMPF = \underset{(46.27)}{1.019}\,LPOIL_t + \underset{(1.40)}{0.2}\,s4_t - \underset{(1.41)}{0.135}\,MARZO_t + \underset{(1.64)}{0.171}\,OCTUBRE_t - \underset{(-3.24)}{0.17}\,AR(1) + \underset{(2.22)}{0.17}\,AR(4) \tag{3.6}$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.22
Residual standard deviation = 0.81%
LM test for serial correlation (4 lags): F = 0.368 (p-value 0.832)
Jarque-Bera normality test: c^2 = 4757.1 (p-value 0.000)
White heteroscedasticity test: N·R^2 = 15.99 (p-value 0.007)
Estimation period: 1995:1:1 2003:7:2

The adjustment to the data is rather low. The average for the current week's oil price is significant and there is evidence that the import is on average higher in the second week of each month and throughout the month of August. In March a negative effect is observed.

Errors in the projection and its properties are presented in figure 3.3. Panel A in figure 3.3 presents the results of the non-oil import model for different horizons. In the figure, each additional week indicates that there is less information to complete the month. For example, week one indicates that there is just one week missing to complete the month, so as we move away from this first week, that is, as the projection horizon increases, projection errors should rise. As is apparent, error does rise, from 3% on average to approximately 6% in the fourth week. After this, the error stabilizes since actual values, valid on a monthly basis, are used, to complete imports in the coming months.

In terms of unbiasing properties, these are rather good, with a maximum 3% error (that is, total error of 0.009%) due to this component. Considering these small magnitudes, we end up with the *Theil-mean* posting the worst index to one week, which then steadily improves to three weeks, before worsening and then improving again. On variance, the model also provides a good replica for every horizon, although in the fifth and sixth it shows an exponential increase, but one that does not reach 2% error. Overall, looking at the *U-cov* it can be concluded that projection error is highly explained by randomness.

The oil import model projection error is notoriously higher and, as with the previous one, rises from 10% to 23% as the number of weeks being projected increases until the fourth, before stabilizing (panel B, figure 3.3). From this, the proportion that can be assigned to bias rises with horizon length and, surprisingly, the component assignable to volatility falls. In general, error attributable to a random factor remains constant and at a comparatively unsatisfactory level. This model behavior is in part expected, due to: (i) the volatility of the dependent variable; (ii) the model's simplicity, as it is unable to foresee correlations with other variables; (iii) as is usual in projection models, the error increases as the horizon does, and (iv) the index evaluates monthly error, so more weekly information within the month significantly reduces the projection error.

The properties of the sum of both, total imports, are summarized in Panel C of figure 3.3. Given that the oil component accounts for about 10% of total imports, in the aggregate sphere the conclusions obtained for the non-oil component tend to be repeated.

Fob Export Projections

While the original information is broken down between copper and the rest, this model could only be implemented for the total, with data available from the first week of January 1995. The exogenous variables used are the copper price, the TCN and Customs TCNAD dollars, seasonal variables for weeks and months, working days and ARMA components. The Customs dollar is included because while it is less relevant than before, it is used to evaluate payments for the port and storage rights. As with the specification for the non-oil imports model, the dependent and some exogenous variables represent the daily average calculated from the aggregation of a certain number of weeks, in the same way and using the same nomenclature. In this case, these variables are called AEXi. For example, AEX4 represents average daily exports during the last month, AEX3 the daily average for the three weeks previous to the current one, and AEX2 to the fortnight prior to the current fortnight. Thus, the "surviving" equation is:

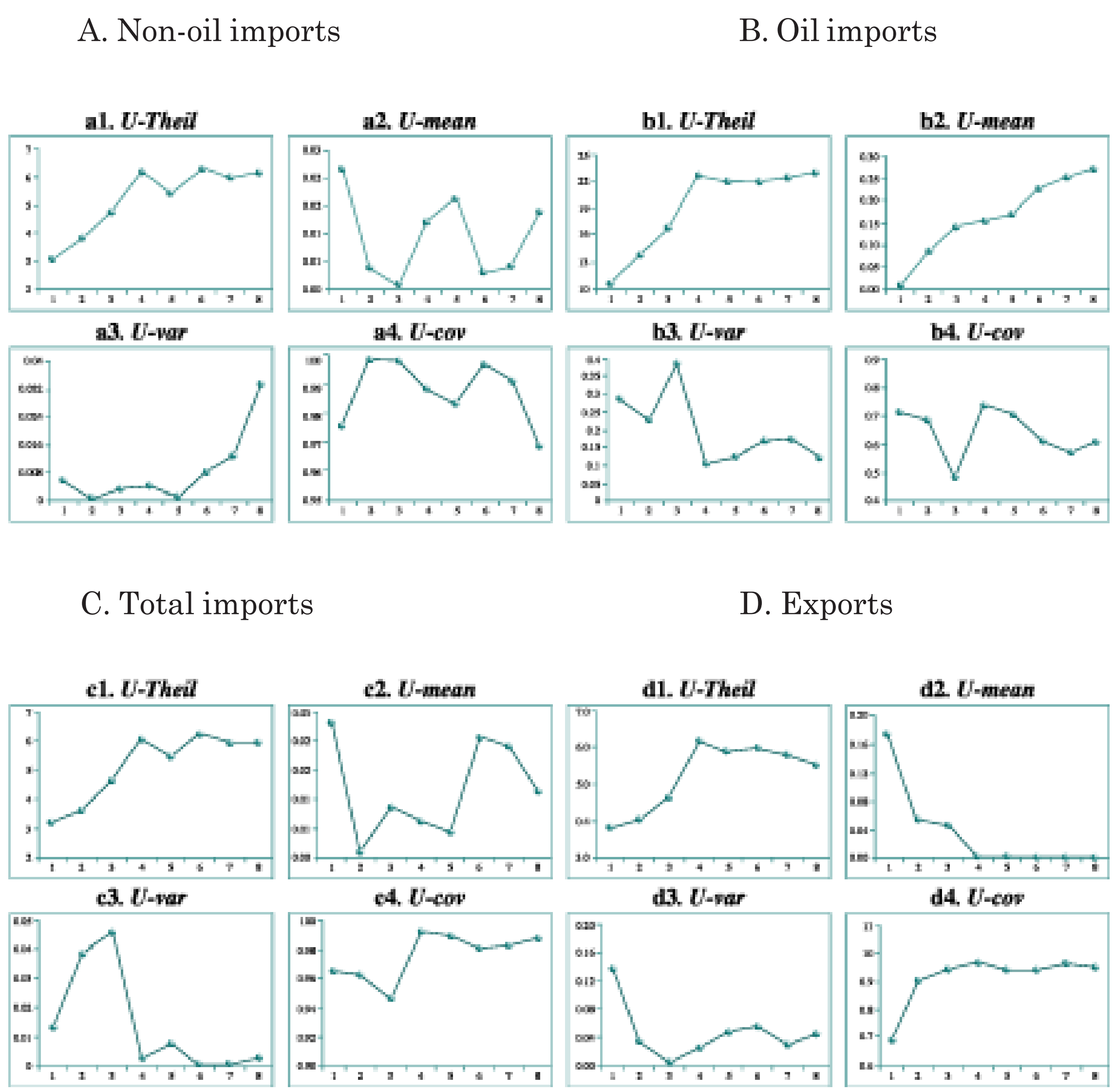
$$
\begin{aligned}
\Delta LAEX4 = {} & \underset{(10.22)}{0.045} + \underset{(7.87)}{0.443}\,\Delta LAEX3_t + \underset{(5.21)}{0.259}\,\Delta LAEX2_t - \underset{(-3.62)}{0.018}\,\Delta DIAS_t \\
& - \underset{(-5.17)}{0.016}\,\Delta DIAS_{t-1} + \underset{(-5.59)}{0.089}\,\Delta LPCU_{t-1} + \underset{(2.74)}{0.012}\,\Delta LTCN_{t-2} \\
& - \underset{(1.58)}{0.0001}(LTCNAD_t - LTCNAD_{t-4}) - \underset{(-1.41)}{0.0001}\,s4(LTCNAD_t - LTCN_t) - \underset{(-7.06)}{0.069}\,s2_t - \underset{(-9.44)}{0.098}\,s3_t \\
& + \underset{(-4.13)}{0.006}\,MARZO - \underset{(-5.82)}{0.012}\,ABRIL - \underset{(-3.99)}{0.014}\,MAYO + \underset{(2.17)}{0.007}\,OCTUBRE - \underset{(-3.57)}{0.008}\,NOVIEMBRE \\
& - \underset{(-4.47)}{0.502}\,AR(2) - \underset{(-2.05)}{0.187}\,AR(4) - \underset{(-7.76)}{0.677}\,MA(1) - \underset{(-3.56)}{0.44}\,MA(3) + \underset{(2.50)}{0.262}\,MA(4)
\end{aligned}
\tag{3.7}
$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.57$
Residual standard deviation = 3.7%
LM test for serial correlation (4 lags): F = 2.887 (p-value 0.025)
Jarque-Bera normality test: $c^2 = 1.695$ (p-value 0.428)
White heteroscedasticity test: $N \cdot R^2 = 23.06$ (p-value 0.574)
Estimation period: 1995:1:1 2003:7:2

The results expected include the positive effect of the copper price. There is weak evidence on the positive effect of dollar quotes and the Customs dollar, which is key to shipping costs, has a negative effect, which rises in the fourth week, for the same reasons provided for imports, although on a much smaller scale. Shipments sent in March and October are higher than average, while those for April, June and November are lower. The corrected R2 shows a medium to high adjustment.

The prediction is slightly worse than that obtained for imports, with average error ranging from 4% to 7%, depending on the horizon considered, with the same rising trend apparent until the fourth week, which later stabilizes (panel D, figure 3.3). Clearly, for the projection to one week error due to bias is greater, reaching 0.8% projection error, although it falls considerably over longer horizons. However, due to the low magnitudes involved in errors, the rise in bias is not worrisome. In the case of adjusting the model to volatility, something similar occurs, with total error reaching 0.06% when projected to one week. As is to be expected, for this horizon, 70% of total error is attributable to randomness, which increases to over 90% when projected to more weeks.

Figure 3.3
Exports and Imports, Out-of-sample Error: 2001:M2-2003:M1
(Y-axis: percentage of ECM; X-axis: *i-nth* quarter projected forward)



Manufacturing Sector Projections

Unlike the balance of trade, variables from the manufacturing sector are monthly in frequency, with data from December 1990 to date, all expressed in logarithms. Independent variables are: M1A; a quantum measure for imports, MQPEXT (value of total imports deflated by the external price index, PEXT); the policy rate, MPR; the real exchange rate, TCR; a *proxy* to measure inventories (moving averaged lagged for the difference between production and sales); working days, DIAS; and ARMA components. The INE production and sales dependents (PINE and VINE, respectively) are estimated and projected in separate models, even though the sales projection is used as an input for production, assuming that a sales shock, whether positive or negative, will affect future production decisions, but not the opposite.

Later these results are turned into their equivalent within the CCNN weighting, based on the conversion models explained above. The "surviving" model from this out-of-sample exercise corresponds in both cases to one of those expressed with 12-month difference.

Production Projections

The "surviving" model includes several sales lags, M1A, MQPEXT and the difference in working days, AR(1) and MA(12), commonly significant in regressions using the 12-month change. The estimation obtained through December 2002 is the following:

$$\begin{aligned}\Delta_{12}LPINE_t = &-\underset{(-2.32)}{0.023}\Delta_{12}LPINE_{t-3} + \underset{(4.74)}{0.333}\Delta_{12}LVINE_t + \underset{(1.58)}{0.144}\Delta_{12}LVINE_{t-3} \\ &+ \underset{(2.07)}{0.083}\Delta_{12}LM1A_{t-1} + \underset{(2.30)}{0.083}\Delta_{12}LM1A_{t-3} + \underset{(3.45)}{0.028}\Delta_{12}LMQPEXT_{t-1} \\ &+ \underset{(6.90)}{0.011}\Delta_{12}DIAS_t + \underset{(3.89)}{0.394}AR(1) - \underset{(-40.50)}{0.885}MA(12)\end{aligned} \tag{3.8}$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.88$
Residual standard deviation = 1.73%
LM test for serial correlation (4 lags): F = 0.403 (p-value 0.806)
Jarque-Bera normality test: $c^2 = 1.674$ (p-value 0.432)
White heteroscedasticity test: $N{\cdot}R^2 = 14.407$ (p-value 0.4199)
Estimation period: 1990:12 2003:5

The parameters found have the expected magnitudes and signs. Sales (VINE) have a contemporaneous effect on production (PINE), which grows stronger with lags. Money (M1A) also has a positive effect, which also grows stronger with lags. Imports (MQPEXT) and working days have a similar effect. It should be noted that about 1% of production growth could be explained by the presence of one additional working day, compared to the same month of previous year. The adjustment is high, reaching 88%.

In terms of the prediction, it is clear from panel A, figure 3.4, that the error rises moderately to between 1.5% and 1.6%, depending on the projection horizon. These results are also considerably lower than those obtained using balance models. The *U-mean* index reveals that of this error, from 10% to 30% reflects the model's inability to reproduce the mean. Thus, unbiasing is quickly lost until projections reach three months, then become stable for longer horizons. In any case, it should again be noted that although this component's share is relatively high, the low general error implies that a discrepancy of just 0.03% appears between the projection and the original series for this reason.

In terms of how the model reproduces volatility, no more than 1% of the error is explained by this component (figure 3.4). In this sense, the model's performance is notoriously improved when it is projected to one month, becoming stable for the other horizons. Finally, randomness causes from 90% to 65% of total error, and falls as the unbiasing property weakens.

Sales Projections

As mentioned, this model does not include manufacturing production as an exogenous variable. Empirically, however, money (M1A) is significant, as the *proxy* for import quantums (MQPEXT) and working days. Moreover, other variables that *a* *priori* may have affected sales levels, such as the monetary policy rate or the real exchange rate, were not significant in the surviving model. Estimation to December 2002 provides the following results:

$$\Delta_{12}LVINE_t = \underset{(2.11)}{0.128}\Delta_{12}LVINE_{t-3} + \underset{(1.63)}{0.152}\Delta_{12}LM1A_t + \underset{(4.17)}{0.153}\Delta_{12}LM1A_{t-3} + \underset{(2.55)}{0.046}\Delta_{12}LMQPEXT_{t-3} + \underset{(6.74)}{0.017}\Delta_{12}DIAS_t + \underset{(4.15)}{0.363}AR(1) - \underset{(-34.77)}{0.895}MA(12) \quad (3.9)$$

In brackets, corrected t statistics (Newey-West)
Corrected $R^2 = 0.76$
Residual standard deviation = 2.56%
LM test for serial correlation (4 lags): F = 2.057 (p-value 0.022)
Jarque-Bera normality test: $c^2 = 0.367$ (p-value 0.832)
White heteroscedasticity test: $N{\cdot}R^2 = 7.544$ (p-value 0.673)
Estimation period: 1990:12 2003:5

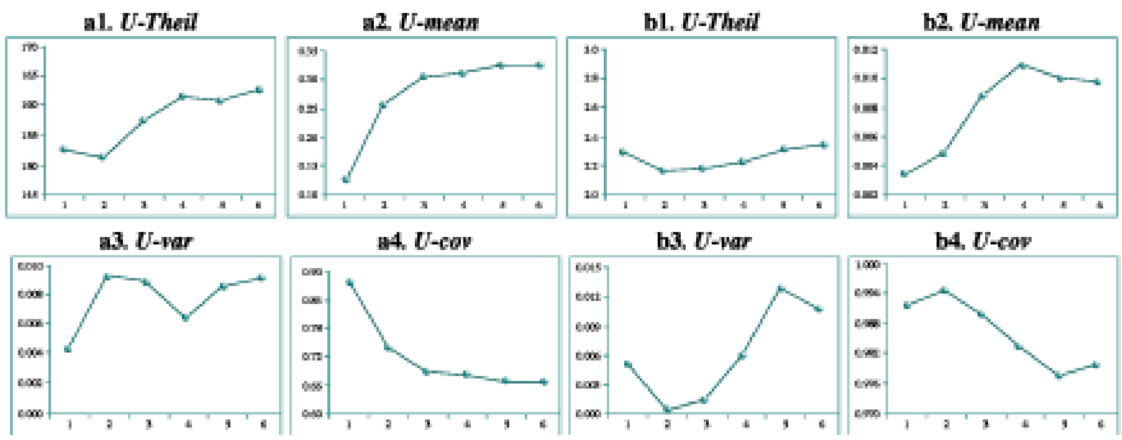
The positive effect of the lag in sales themselves reflects some persistence of this variable. Similarly, M1A also has positive contemporaneous effects as do lags, in the same way as MQPEXT. It should be noted that, on average, an additional working day over the same month of the previous year pushes it up by 1.7%. The adjustment, although less than for production, is also high, although this difference is reflected in prediction errors.

On this point, figure 3.4 presents the *U-Theil* index and its components. As a first observation, the average error is stable between projection horizons, hovering around 2.2%. Of this, a maximum of 0.1% is due to adjusting projections to the mean, remaining notoriously lower when these are projected for less than three months (although it rises between them). Over the longer term, the error arising from this source stabilizes.

Something similar occurs with the model's ability to reproduce the original series' volatility, with total error remaining below 1.5%. When projected to one month, this component's incidence is 0.6%, falling to almost 0% when the projection is prepared using information from two months earlier, and rising progressively over longer horizons. In short, strictly random error is by far the main component of the total, although it decreases as projections extend over more months, but always accounts for more than 97.5% of total error.

Figure 3.4
Manufacturing, Out-of-Sample Error
2002:M12-2002:M11
(Y-axis: percentage of ECM; X-axis: quarter *i-nth* projected forward)

A. Production (INE) B. Sales (INE)



INE - CCNN Conversion Models

The purpose of these models is to use the above projections for production and sales from the CCNN, which can then be used to calculate variables such as the Imacec. These models have a simple structure, considering the corresponding contemporaneous series according to the INE, work days, seasonal dummies for months, and some ARMA components. These models, estimated through December 2002, follow:

Production:

$$LPCCNN_t = \underset{(124.16)}{0.942}\,LPINE_t + \underset{(1.98)}{0.001}\,DIAS_t + \underset{(4.92)}{0.004}\,MARZO + \underset{(5.08)}{0.008}\,ABRIL + \underset{(6.33)}{0.008}\,MAYO + \underset{(4.27)}{0.006}\,JUNIO$$
$$+ \underset{(4.57)}{0.007}\,JULIO + \underset{(4.12)}{0.009}\,AGOSTO + \underset{(3.09)}{0.006}\,SEPTIEMBRE + \underset{(7.57)}{0.582}\,AR(1) + \underset{(4.28)}{0.374}\,AR(2) \qquad (3.10)$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.99
Residual standard deviation = 0.45%
LM test for serial correlation (4 lags): F = 2.887 (p-value 0.025)
Jarque-Bera normality test: c^2 = 19.526 (p-value 0.000)
White heteroscedasticity test: $N{\cdot}R^2$ = 63.01 (p-value 0.000)
Estimation period: 1990:12 2003:5

Sales:

$$LVCCNN_t = \underset{(3.91)}{0.352} + \underset{(12.25)}{0.735}\,VINE_t + \underset{(8.93)}{0.694}\,AR(1) - \underset{(-1.52)}{0.164}\,MA(1) + \underset{(2.01)}{0.191}\,MA(3) \qquad (3.11)$$

In brackets, corrected t statistics (Newey-West)
Corrected R^2 = 0.97
Residual standard deviation = 0.34%
LM test for serial correlation (4 lags): F = 1.425 (p-value 0.228)
Jarque-Bera normality test: c^2 = 594.8 (p-value 0.000)
White heteroscedasticity test: $N{\cdot}R^2$ = 0.007 (p-value 0.983)
Estimation period: 1990:12 2003:5

Both models adjust well to data, although production achieves closer conversions. According to this model, the manufacturing production series from CCNN (PCCNN) behaves almost identically to the INE series (PINE), although working days are weighted slightly more and it is somewhat higher, on average, between March and September. On the sales side (VCCNN), the seasonal factor is not relevant to determining the differences between both series, given a constant and a lower than production factor for the INE series (VINE). Finally, it must be noted that the monthly difference and 12-month models differ from those presented, yielding less favorable results.

3.4 Macroeconomic Consistency Model

The Central Bank's MACRO model is based on the main identities of national accounts. Given a set of exogenous variables, identities are used to obtain the rest of the model's variables residually. The MACRO constitutes a projection consistency tool applied to different economic sectors, as well as an instrument for checking the implications of variables determined residually. In this sense, the MACRO is not a projection model in itself, but rather verifies the consistency of projections carried out using other models and their implications for variables projected in a residual manner. In the case of the Central Bank's MACRO, the main exogenous variables are the components of external accounts, GDP, consumption and investment. The main variables determined residually are domestic demand and inventory change.

Variables and Identities Covered by the MACRO

The MACRO contemplates variables related to GDP expenditure and income, investment and gross saving, components of the real exchange rate, the main deflators, external accounts in dollars and changes in export and import goods prices and quantities.

The MACRO shows real annual changes in the main Gross Domestic Product (PIB) components, in terms of domestic demand (DI), exports (X) and imports (M):

$$PIB = DI + X - M \tag{3.12}$$

It not only allows for growth in real domestic demand but also the breakdown for consumption (C) and investment (I).

$$DI = C + I = CP + CG + FBK + IEX \tag{3.13}$$

The real annual change in total consumption breaks down into private (CP) and public (CG) consumption. Investment, meanwhile, includes gross fixed capital formation (FBK) and investment in inventories (IEX). Exports (X) and imports (M) break down into goods (XB) and service (XS) exports, and goods (MB) and service (MS) imports. All these figures are fob.

The MACRO also calculates gross national disposable income, which is obtained by subtracting from GDP real payments abroad net of factors or net income (REN) and adding real net transfers from abroad (TN). This figure also considers the effect on domestic income of changes in the terms of trade.

$$INBD = PIB - REN + TN + \text{ajuste por TDI} \tag{3.14}$$

The MACRO also generates a breakdown on the saving and investment side. Total investment is divided into general government's contribution (IG) and that of the rest of the economy (non-financial companies, financial companies, households and non-profit institutions, IP). Meanwhile, total saving consists of general government saving (SG, the difference between income and expenditure on consumption), external saving (SEXT, the negative of the current account balance in pesos) and the rest of the economy (SP, income minus private consumption). It should be noted that total saving and total investment must be equivalent.

$$\frac{I}{PIB} = \frac{IG}{PIB} + \frac{IP}{PIB} = \frac{SG}{PIB} + \frac{SP}{PIB} + \frac{SEXT}{PIB} = \frac{S}{PIB} \tag{3.15}$$

The main deflators are also calculated or estimated by the MACRO. The GDP deflator is calculated as:

$$P = \frac{PIBN}{PIB} = \frac{PCP \cdot CP + PCG \cdot CG + PFBK \cdot FBK + PIEX \cdot IEX + PX \cdot X - PM \cdot M}{CP + G + FBK + IEX + X - M} \tag{3.16}$$

where P denotes the deflator for GDP, GDPN over GDP in current pesos and PCP, PCG, PFBK, PIEX, PX and PM are the deflators for private consumption, government consumption, gross fixed capital formation, investment in inventory, exports and imports, respectively. The terms of trade (TDI) are calculated as a change in the ratio between the export deflator and the import deflator:

$$TDI = \frac{PX}{PM} \tag{3.17}$$

For external accounts, the MACRO calculates the balance in dollars of the current account (CCF), along with the ratio between this balance and GDP, measured in current dollars. Similarly, this model includes dollar balances for the main current account components:

$$CCF = XBF + XSF - MBF - MSF - RENF + TRANF \tag{3.18}$$

where F indicates figures are measured in dollars.

Dollar balances for goods exports and imports are constructed using changes in prices and quantities for each component of cif imports and fob exports.

MACRO Functioning

The MACRO is merely a set of macroeconomic identities. The MACRO treats several variables as exogenous, to calculate the rest in a residual manner. Which variable is exogenous and which residual is immaterial, since this reflects the projection process for each variable as well as possible. In this case, the exogenous variables chosen are as follows:

GDP: Real GDP growth.
- Real annual change in private consumption.
- Real annual change in government expenditure on consumption.
- Real annual change in gross fixed capital formation.
- Average nominal exchange rate.

- Average annual CPI inflation.
- Average annual relevant external inflation.
- Credits and debits of the balance of services in dollars.
- Income account balance, in dollars.
- Net transfers, in dollars.
- Change in the quantity and price of each fob export and cif import component, except the copper export and copper import price.
- Copper and oil price.

Using these exogenous data, the MACRO then calculates:

GDP expenditure and income:
- Total domestic expenditure is obtained from the difference between total GDP and the balance of goods and services; total exports are subtracted from GDP and total imports added.
- Total consumption is the sum of private and government consumption.
- Investment in inventories is obtained from the residue and is calculated as the difference between domestic demand expenditure on consumption and gross fixed capital formation.
- Total investment is the sum of investment in inventory and gross fixed capital formation.
- The real change in goods exports and imports is calculated by applying the change in quantity to figures in 1996 pesos.
- To calculate the real change in service exports and imports an assumption is made about change in the deflator. In the case of exports, it is assumed that the deflator changes according to domestic inflation, while for imports it is assumed that it changes according to external inflation measured in pesos. With these deflators, real changes in dollar figures and the exchange rate are calculated.
- To obtain real national disposable income, figures on income sent abroad and transfers from abroad are necessary. To achieve this, net figures are divided into credits and debits to reflect the composition of recent years, with the export deflator applied to credits and the import deflator to debits (these deflators are presented below). Domestic income is then obtained by subtracting from GDP real net income and adding real net transfers. The terms of trade adjustment captures the effect of external price changes on our income. A rise in the terms of trade increases our domestic income and vice versa.

Saving and investment:

- Nominal investment is obtained by inflating real investment with its deflator (shown below). The breakdown of investment into general government and the rest of the economy is done using assumptions about change in government investment.
- National saving is the sum of government saving and that of the rest of the economy, while total saving is obtained by adding external saving to national saving.
- The nominal income of the rest of the economy is obtained by subtracting from nominal GDP the government's income and net income from abroad (rents plus transfers). Moreover capital transfers that the general government makes to the rest of the economy (a rather small amount, which is projected using the government budget or another *ad hoc* assumption for more distant horizons) is added. Nominal private consumption is obtained by inflating private consumption using its deflator. Saving of the rest of the economy is the difference between income and consumption of this sector.

- While nominal government consumption is obtained from the real figure, inflated using the corresponding deflator, government saving is obtained from the government's budget or by applying the structural deficit rule if the horizon is more distant. Government income results from adding up saving and consumption.
- Nominal external saving is the (negative of) the past current account deficit in pesos, using the nominal exchange rate. This deficit breaks down into the balance of goods and services (net expenditure on goods abroad) and the sum of the balance of income and transfers (net income or expenditure to or from abroad).

Deflators:
- The private consumption and government consumption deflator is obtained by applying the change in the CPI.
- The deflator of gross fixed capital formation is obtained from applying weights for the change in the CPI (30%) and the deflator of imports (70%).
- The export and import deflator is obtained from changes in imputed prices. Change in the ratio of these deflators provides the change in the terms of trade index.
- The deflator for change in inventory is assumed to be the same as that for GDP. Using other deflators GDP minus investment in inventory can be calculated in nominal terms. This term can also be calculated in real terms. The ratio between these two figures provides the GDP deflator and that for investment in inventory.

Foreign trade and trade in goods:
- Using the copper price and the oil price, changes in the indices of mining export and fuel import prices are calculated.
- Based on assumptions about each component, the total change in prices and quantities of cif goods imports and fob exports are calculated.

Current account:
- Using the result from the previous point, fob exports and cif imports are calculated in dollars for each component and for totals, anchored in values for the previous year. To calculate fob goods imports, a factor is applied that reflects past differences between cif and fob. These figures moreover are complemented by a memorandum that shows the implications of goods exports and imports for the projected monthly average.
- The current account balance in dollars results from subtracting fob goods exports from fob goods imports and adding the balances outstanding from the surplus (deficit) of services, income and transfers. The ratio of the current account to nominal GDP is calculated by converting GDP to current dollars using the GDP deflator and the nominal exchange rate.

4. Applications

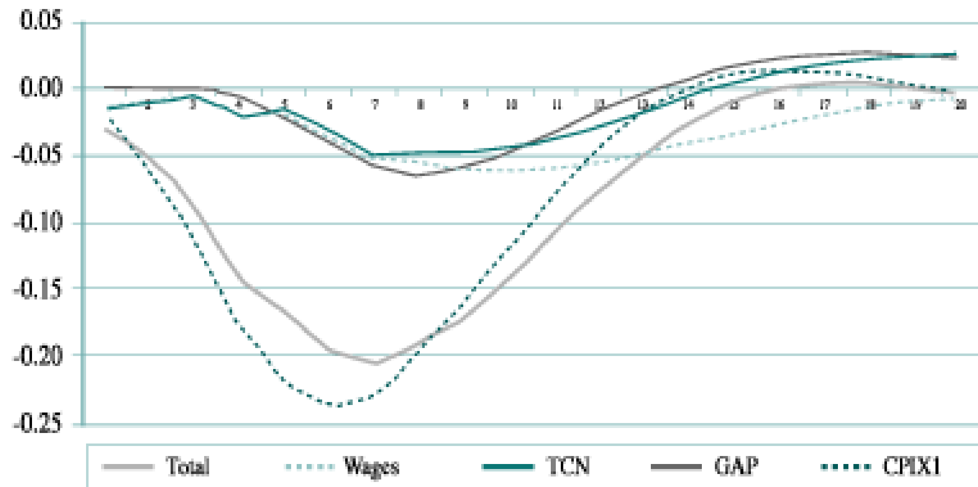
This chapter presents applications of the different models presented in this volume, paying special attention to the MEP. These applications are exercises to develop information for the usual debates about monetary policy, and serve to quantify the relationships between the different macroeconomic variables.

4.1 Response to Changes in the Monetary Policy Rate (MPR)

Monetary Policy's Impact According to the MEP

To analyze the impact of monetary policy according to the MEP an exercise has been carried out that involves raising the monetary policy rate (MPR) for one quarter by 100 points. After this increase, the monetary policy rate (MPR) continues its course within the corresponding equations in the model. The response of total inflation, as figure 4.1 reveals, peaks at eight quarters after the change in the monetary policy rate (MPR) and with a decline in inflation of almost 20 points.[54] The impact is rather moderate, which underlines the lags in monetary policy taking effect. After 12 quarters, there is still an effect of five points.

Figure 4.1
Effects of a 100-point Rise in the Monetary Policy Rate (MPR) on Inflation According to the MEP
(Percent)



The effect of the change in the MPR on inflation can be broken down. The line labeled "GAP" in figure 4.1 shows the effect solely through the output gap, maintaining the nominal exchange rate, wages and expectations constant at their level prior to the disturbance (target level). A moderate effect is apparent, with a maximum decline in inflation of six points. This varies minimally if the nominal exchange rate is allowed to fluctuate, thus confirming that aggregate demand and not the exchange rate is the

54 For this exercise, the effect of the IPCSF has been excluded to capture the most fundamental effects of the MPR and filter out of the direct effect on financial services.

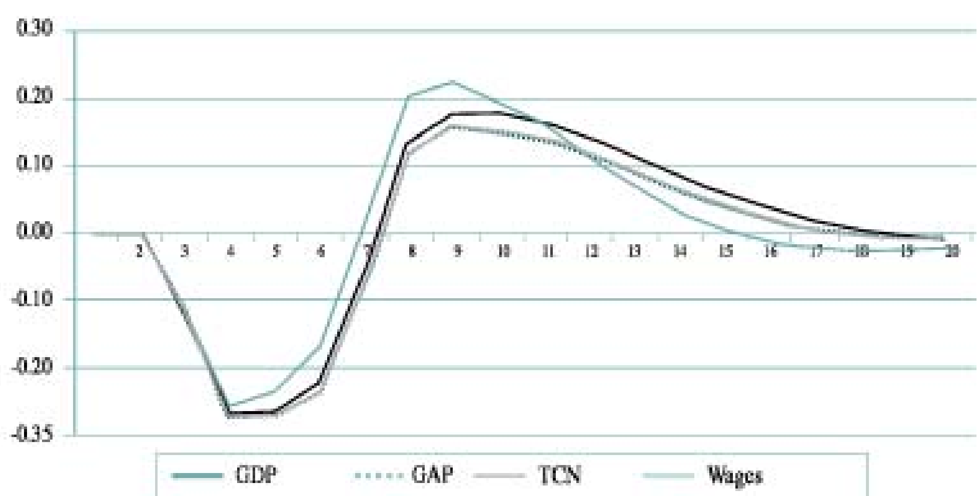
main transmission mechanism in the MEP. By permitting that, along with the gap and the nominal exchange rate, wages also respond, the effects are more persistent, with significant differences after the tenth quarter. Finally, by comparing this curve with the total effect confirms the important role that expectations play in the MEP. By allowing agents to be rational and forecast future inflation, the effects are considerably greater. The figure also shows the effect on core inflation (IPCX1), which behaves somewhat differently from total CPI, underlining the role that other prices play.

In terms of the effect that a change in the monetary policy rate (MPR) has on output (figure 4.2), this peaks at the end of four quarters. The response according to the MEP is a maximum decline of just under thirty points. There is a period of increased growth after the seventh quarter. It should be remembered that the MEP requires that GDP move toward its potential level, reflecting the neutrality of monetary policy in the long term. The positive growth apparent between quarters seven and 17, after the change in the monetary policy rate (MPR) responds to this situation. Different exercises produce a similar output reaction, with the exchange rate and wages acting in the MEP through channels other than those determining GDP.

Figure 4.2

Effects of a 100-point Rise in the Monetary Policy Rate (MPR) on Output According to the MEP

(Percent)



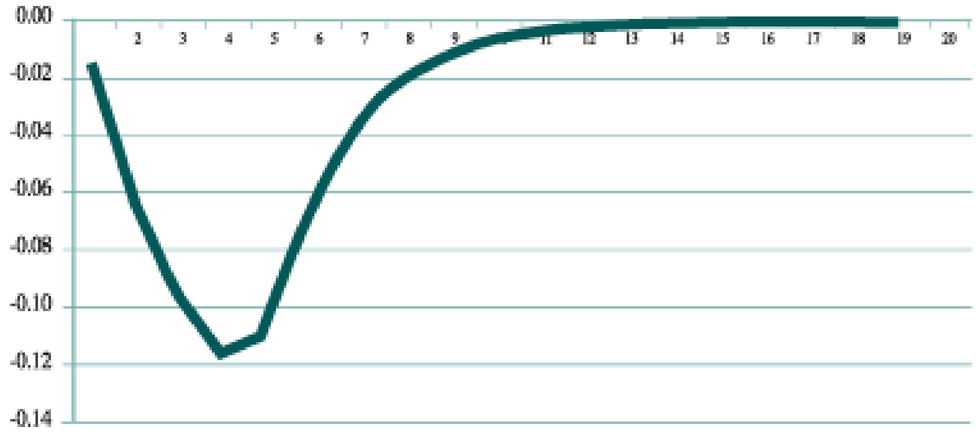
Monetary Policy Impact According to VAR

We carried out an exercise similar to the previous one using a VAR model. Inflation's response is presented in figure 4.3. The maximum response according to the VAR is a little more than ten points less inflation and occurs two to four quarters after the rise in the monetary policy rate (MPR). By the end of six quarters, a five point effect remains, while at the end of two years the impact is almost zero. As can be seen, in the case of the MEP, inflation's response is somewhat tardier than with the VAR. Moreover, the effect of the monetary policy rate (MPR) lasts longer to the MEP than it does with the VAR.

Figure 4.3

Effects of a 100-point Rise in the Monetary Policy Rate (MPR) on Inflation According to VAR

(percent)

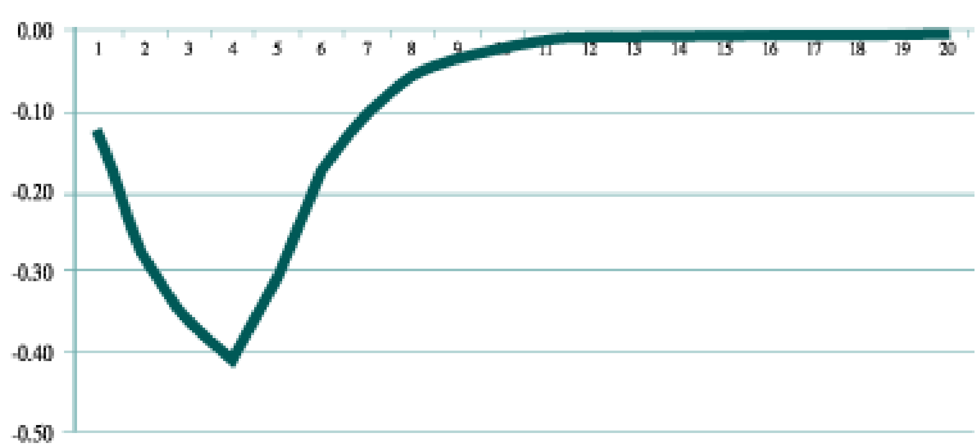


In terms of the effect of a change in the monetary policy rate (MPR) on output, the results from both the MEP and the VAR are similar. In both cases, the maximum effect occurs four quarters after the change in the monetary policy rate (MPR). The response according to the VAR is a maximum decline of forty points. In the case of the MEP, a period of increased growth occurs after the ninth quarters, which is not apparent in the VAR, for the reasons explained above.

Figure 4.4

Effects of a 100-point Rise in the Monetary Policy Rate (MPR) on Output According to the VAR

(percent)



Results of Previous Studies

One of the first studies that estimated a monetary VAR for the Chilean economy was by Herrera and Rosende (1991). They used quarterly data and standard variables used in a monetary VAR (table 7.1 of the appendix). The results thus obtained were those expected: an increase in the real interest rate reduced the price and output gap during the first two years, with these effects then fading over time. In terms of the lags involved, the impact of the 1.2% rise in the interest rate on prices peaked after just two quarters (-0.8%), then faded out in the next year and a half. The impact on output followed a similar trajectory, bottoming out in the fourth quarter (-1.0%) and then recovering quickly. A second study was prepared by Rojas (1993), who focused on the relationship between money and economic activity. The response patterns exhibited by the models in this study were more persistent than those found by Herrera and Rosende; output's response to a real interest rate shock was negative, peaking as well in the fourth quarter and lasting some five years. These initial results point to rapid monetary passthrough; in particular, they indicate that price declines precede those in output.

A second generation of models was estimated, starting in the second half of the 1990s. For example, Cabrera and Thegos (2000) reviewed VAR models estimated for Chile in the period from 1986-1997, concluding that in some specifications the inflation response to an increase in the policy rate is positive.[55] This price puzzle has become the main problem confronting researchers when they try to estimate VAR in the Chilean economy.[56] In this sense, García (2001)[57] shows a solution to this problem that consists of incorporating the inflation target directly into the VAR as an endogenous variable. Another example in this direction was Valdés (1997),[58] who estimated a semistructural VAR,[59] in which the gap between inflation and the target was included as an endogenous variable.[60] In this case, a rise in the interest rate of about 0.3% reduced both the inflationary gap and the Imacec. As can be deduced from this study's results, monetary policy lags remain short but, unlike Herrera and Rosende (1991), the maximum impact of reducing the inflationary gap (-0.4%) coincides with the impact on output (-0.5%) during the eighth month.

Another important effort was that of Parrado (2001),[61] whose work presents a complete specification for the Chilean economy in terms of contemporaneous relationships between the variables used. The author estimated different levels and first difference models without inflation targets. Results were different from those described above, mainly in terms of the impact of monetary policy on price levels, which occurred substantially later than the impact on output. An interest rate shock of 0.4% significantly affected the price level after the first year, peaking at two years (-0.3%). Output also fell more slowly, bottoming out in the tenth month (-0.6%). In this sense, by adjusting the monetary policy rate (MPR) for liquidity, Bravo and García (2002) found that the effects reported by Parrado (2001) overestimated the impact of

55 Other more recent studies using the VAR with the price puzzle problem are Duncan (2002) and Chumacero (2002).
56 See Bravo and García (2002).
57 The author uses the identification scheme described by Christiano, Eichenbaum and Evans (1999).
58 This author uses the identification scheme proposed by Bernanke and Blinder (1992).
59 Bernanke and Mihov (1998) define a semi-structural VAR as when only part of the VAR structure is identified.
60 Another interesting characteristic of this model is that it was estimated for 12-month changes, which generally show more systematic and less erratic patterns for level or first difference variables. Another study using annual change variables is by Caputo and Herrera (1997).
61 The author uses the identification system developed by Kim and Roubini (2000).

the monetary policy rate (MPR). But they did confirm that the monetary policy rate (MPR) would affect output first (one year) and then prices (a year and a half).[62]

International Evidence

It is interesting to compare the reaction of inflation and GDP to changes in monetary policy according to Central Bank models and those reported by other countries. Table 4.1 provides the results from a survey conducted by Fuentes et al. (2003) and compares them to results for Chile reported in this document. As can be seen, results for Chile are not significantly different from those reported by other countries.

Table 4.1

Effects of Monetary Policy on Output and Inflation

(response to a 100 basis point increase in the policy rate)

	Maximum decline in output %	Quarter in which 50% of the maximum effect is achieved	Maximum decline in annual inflation %	Quarter in which 50% of the maximum effect is achieved
Australia	0.15	2	0.10	8
Canada	0.15	2	0.06	3
Colombia	0.14	2	0.14	5
Czech Republic	0.28	2	0.20	4
Iceland	0.50	1.5	0.30	3.5
Mexico	0.50	1	1.00	2
New Zealand	0.20	2	0.10	3
Norway	0.75 a 1	2 a 3	0.3 a 0.4	4 a 5
Poland	0.19	3.5	0.04	6.5
South Africa	0.30	3	0.20	4 a 6
Sweden	0.50	4	0.13	2
United Kingdom	0.25	2	0.30	6
Average (*)	0.27	2.2	0.21	4.4
Mean (*)	0.25	2.0	0.14	3.5
Maximum(*)	0.50	4.0	1.00	8.0
Minimum(*)	0.09	1.0	0.04	2.0
Standar deviation (*)	0.14	1.0	0.23	2.2
Chile MEP	0.30	2	0.15	5
Chile VAR	0.41	2	0.12	2

(*) Excludes Norway and includes other countries that did not authorize reporting of individual results.

62 One estimation that challenges the results obtained previously was that of Calvo and Mendoza (1998). They found that the main variable in reducing inflation during the 1990s was exchange rate appreciation due to positive external shocks and not stabilization policies. A shock of about 0.3% in the interest rate had no defined effect on prices; in one of the specifications the effect was not statistically significant and in the other model reported prices rose instead of falling.

4.2 Sacrifice Ratio

Usually the relationship between change in inflation and change in GDP is summarized in the sacrifice coefficient. This coefficient measures what percentage of output must be sacrificed to reduce inflation by one percentage point. A higher sacrifice coefficient implies greater efforts, in terms of output, to reduce inflation. This section estimates Chile's sacrifice ratio using the MEP, and compares it with results from other countries' studies. This coefficient can be calculated through a specific econometric model or historic events. In the first case, the exercise involves reducing the inflation target by one point and calculating the accumulated losses in output. The second calculates the reduced level of activity during deflationary periods. This study concludes that the sacrifice ratio in Chile is similar to that obtained for other countries, standing on average at 1.9. That is, two points of GDP must be sacrificed to reduce inflation by one percentage point.

The Ball Exercise

Ball (1994) suggests calculating the sacrifice ratio by taking specific moments of reductions in the inflation rate. The denominator of the sacrifice coefficient is the change in inflation from the start of the chosen period to the end. The numerator is given by the sum of losses in output (as a percentage) compared to the trend level or "full employment". This exercise assumes the absence of supply shocks, attributing all changes in inflation to shifts in aggregate demand. Similarly, the exercise assumes that the trend output, against which actual GDP is compared, is not affected by the inflation reducing process. Upon carrying out this exercise for 28 episodes from 1960-1991 (quarterly data) and nine developed countries, Ball (1994) found that the average sacrifice coefficient was 1.4, with values ranging from 0.0 to a maximum of 3.6.

In Chile's case, Magendzo (2003) has chosen a period of falling inflation that ran from the fourth quarter of 1998 to the fourth quarter of 1999. During this period, core inflation (IPCX1) fell from 6.8% to 2.8% (figure 1).[63] During the period chosen, the decline in inflation was associated mainly with contracting demand. To calculate output losses, Magendzo (2003) used several methods. The sacrifice coefficient for Chile is between 1.3 and 2.7, depending on the methodology used. This means that at least for the experience studied, each point of reduced inflation came with or required the sacrifice of 1.3% to 2.7% of annual GDP, with an average for the three methodologies of 2.0%. According to table 4.2, this figure is in line with Ball's results (1994) for developed countries, although somewhat higher than average.

The MEP and the Sacrifice Coefficient

An alternative for calculating the sacrifice coefficient is by using some version of the Phillips curve. This is probably the most common approach. Its advantages lie in the possibility of controlling the movement of other variables and the correlations between variables such as the exchange rate, the gap and inflation. The most important limitation on this approach is that it assumes that the sacrifice coefficient remains the same at all times, without distinguishing episodes in which inflation is falling from those in which it is rising, among other things (there is evidence of asymmetries in this sense).

63 This period was chosen because it is associated with a low-growth period with a rather stable nominal exchange rate, unlike the first half of the 1990s, in which inflation fell at the same time as the country posted high growth rates and an appreciating exchange rate.

The exercise consists of changing the inflation target by one percentage point (for example, from 3% to 2%) and comparing the change in the GDP projected by the model. Then, as in the previous point, the loss to GDP is measured as a percentage of annual GDP. The MEP is used to reach a sacrifice coefficient of 0.98. This figure is lower than that obtained by Magendzo (2003) with Ball-type exercises; however it is in line with results for other countries, as table 4.2 shows.

Change in GDP growth in response to the reduction in the target appears in figure 4.5. As can be seen, the reduction in the target requires lower GDP growth during the first ten quarters. The maximum effect on GDP is growth that is 40 points lower at the end of six quarters. The positive effect observed after the tenth quarter reflects that in a stationary state the MEP requires that the GDP move toward its potential level, that is, the decline in inflation has no effect on long-term GDP. Because of this, after peaking at 1.39 in the 20th quarter, the sacrifice ratio falls to 0.98.

Figure 4.5

Effects of a 100-point Change in Long-term Inflation on GDP Growth

(percent)

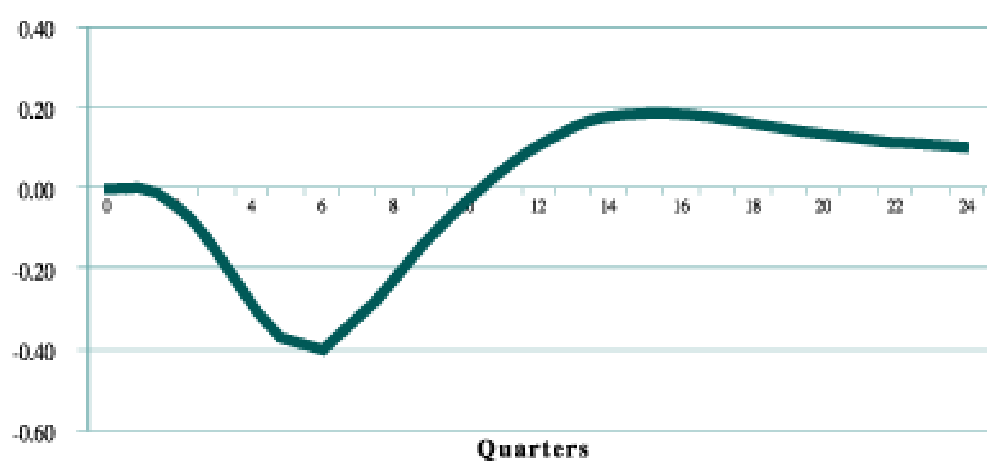


Table 4.2
Sacrifice Ratio for Chile and Other Countries
(quarterly data)

Episode	Sacrifice Ratio
Australia	
74:2-78:1	0.72
82:1-84:1	1.28
Canada	
74:2-76:4	0.63
81:2-85:2	2.37
France	
74:2-76:4	0.91
81:1-86:4	0.60
Germany	
65:4-67:3	2.56
73:1-77:3	2.64
80:1-86:3	3.56
Italy	
63:3-67:4	2.65
77:1-78:2	0.98
80:1-87:2	1.60
Japan	
62:3-63:1	0.53
65:1-67:2	1.66
70:3-71:2	1.27
74:1-78:3	0.61
80:2-83:4	0.02
84:2-87:1	1.48
Switzerland	
73:4-77:4	1.85
81:3-93:4	1.29
United Kingdom	
61:2-63:3	1.91
65:2-66:3	-0.01
75:1-78:2	0.87
80:2-83:3	0.29
84:2-86:3	0.87
United States	
69:4-71:4	2.94
74:1-76:4	2.39
80:1-83:4	1.83
AVERAGE	1.44
Chile 98:3-99:4	
Potential GDP Contreras and García	1.97
Potential GDP C&G corrected	2.73
Ball-type trend	1.26
MEP	**0.98**

4.3 Foreign Exchange Rate Passthrough to Prices

Previous Results

A first calculation of the passthrough coefficient is to be found in Calvo and Mendoza (1998); there, a 1.5% increase in the real exchange rate affects prices after one year (-0.4%), bringing the passthrough to almost 25%, assuming constant international inflation. Using recursive regressions, more recent studies, such as García and Restrepo (2001) show a decline in this coefficient from 40% in the mid-1990s to 15% in 2000. Morandé and Tapia (2002) updated this calculation, finding a similar level for 2002 (14%). In addition, García and Restrepo (2001) demonstrate that when modeling inflation using a Phillips curve, the passthrough depends on factors such as the degree of wage indexing and the output gap. Thus, a more negative output gap reduces the passthrough coefficient; in contrast, more wage indexation makes this coefficient rise.

Upon analyzing international evidence on the passthrough coefficient, the panel data study by Goldfajn and Werlang (2000), which groups by geographic region, finds that the region with the lowest coefficient is Oceania, 19% at the end of a year and a half. Europe follows, with a coefficient of 36%, then America, including Latin America, with a coefficient of 124%. In this study, the passthrough coefficient is determined by the initial level of inflation, the economy's level of openness, the magnitude of the output gap and an overvalued currency. For example, an economy in which the activity level is above potential, inflation high and external imbalances significant will also face a high coefficient. From this perspective, countries that have managed to stabilize their economies will also have low passthrough coefficients. This hypothesis is also apparent in results reported by Hausmann et al. (2000), who find for a horizon of one year a low passthrough coefficient for countries such as Australia (21%), Canada (7%%) and Sweden (14%). In contrast, economies such as Colombia (38%), Mexico (58%), Paraguay (59%) and Poland (62%) post high passthrough coefficients.[64]

Passthrough According to the MEP

In the MEP, the nominal exchange rate is an endogenous variable, so an exogenous shock cannot be directly applied. In contrast, the real long-term exchange rate is exogenous. To analyze the passthrough of the exchange rate to prices a permanent shock to the real, long-term exchange rate has been implemented. Given the US CPI, this shock leads to a rise in the real and nominal exchange rates. However, the increase in the nominal exchange rate leads to a rise in the CPI through regulated prices, pressures on margins, and more imported inflation. Passthrough of the nominal exchange rate to prices measures the change in the CPI as a percentage of the change in the nominal exchange rate. The result is presented in figure 4.6. Both the nominal exchange rate and the consumer price index rise after the shock, but as the figure indicates, four quarters later, the rise in the CPI represents about 20% of the rise in the nominal exchange rate. At the end of 13 quarters this figure has risen 30%, before falling back in the long term to about 25%.

Table 4.3 shows the passthrough coefficient for a number of geographic regions, according to Goldfajn and Werlang (2000). The figure obtained for Chile using the MEP is also provided. As can be seen, Chile's results are similar to those reported for Oceania.

64 For one group of countries, De Gregorio (2002) finds that low inflation, credible monetary policy and a flexible exchange rate are factors that help to explain the decline in the passthrough in countries over time.

Figure 4.6

Passthrough of the Nominal Exchange Rate to CPI

(percent)

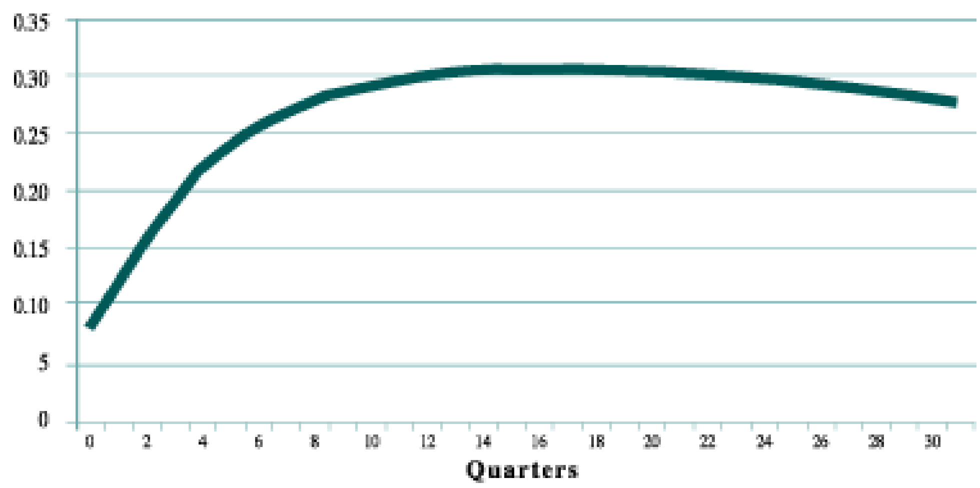


Table 4.3

Foreign Exchange Rate Passthrough to Prices for World Regions and Chile

Quarter	Total	Europe	Africa	America	Oceania	Asia	Chile (MEP)
1	0.169	0.116	0.159	0.199	0.051	0.166	0.077
2	0.426	0.211	0.343	0.539	0.092	0.367	0.122
4	0.732	0.360	0.643	0.692	0.158	0.712	0.219
6	0.701	0.460	0.520	1.240	0.193	0.841	0.256

4.4 Response to External Shocks

As the equation indicates, in the MEP, external factors play an important role in determining output. This equation includes measures of external interest rates, the terms of trade, growth of trading partners, and a measure for external capital flow amounts. While the last two variables affect the model only through output growth, the first two have additional effects. External interest rates are relevant to determining the real and nominal exchange rates given that these affect the parity equation . Changes in the terms of trade, meanwhile, will affect imported inflation if these reflect changes in IVUMs, or the price of fuels and bus fares, if these are caused by a change in the oil price.

Table 4.4
Effects of External Shocks According to the MEP(*)
(Response to a positive shock of one standard deviation for one quarter)

Inflation	Year 1	Year 2	Year 3
DLYEXT	0.00	0.03	0.04
FKYEXT	0.03	0.15	0.14
LIBORR	0.01	-0.10	-0.11
LTDI	0.03	0.14	0.13
LIVUM	0.00	-0.14	-0.16
LPOIL	0.50	0.38	0.25
GDP Growth	Year 1	Year 2	Year 3
DLYEXT	0.01	0.05	-0.04
FKYEXT	0.20	-0.10	-0.25
LIBORR	-0.03	-0.10	0.18
LTDI	0.18	-0.09	-0.23
LIVUM	-0.22	0.11	0.29
LPOIL	-0.08	-0.37	-0.16
GDP Gap	Year 1	Year 2	Year 3
DLYEXT	0.01	0.06	0.01
FKYEXT	0.20	0.10	-0.06
LIBORR	-0.03	-0.14	0.01
LTDI	0.18	0.09	-0.06
LIVUM	-0.22	-0.11	0.07
LPOIL	-0.08	-0.44	-0.52

(*) Standard deviation for variables is 0.07 for *DLYEXT*, 8.01 for *LTDI*, 1.54 for *LIBORR*, 69.16 for *FKYEXT*, 23.52 for *LPOIL* and 9.57 for *LIVUM.* These standard deviations have been calculated for the logarithm representing variables' deviation from their long-term value.

Table 4.4 reports the effect of shocks involving a standard deviation of the most relevant external variables on inflation, growth and gaps, keeping all other variables constant. Although this exercise does not consider important degrees of correlation between external variables, it does make it possible to note the sensitivity of the model's main variables to these changes This sensibility depends not only on the parameters accompanying the disturbed variables in the respective equations, but also the response of all model variables to the disturbance, including the monetary policy rule.

In the case of the first four shocks shown in table 4.4, the effect is similar. A rise in GDP growth and the productivity gap is apparent (a fall in the case of the LIBORR), which tends to revert, while inflation rises both in the second and third years (falling in the case of the LIBORR). Lags vary as do shock magnitudes. In the case of the LIBORR there is an additional effect on the real and nominal exchange rates. This effect explains the small inflationary outbreak apparent during the first year after the shock.

The shock presented for the terms of trade keeps the IVUMs constant, so involves an export price shock. Table 4.4 also shows what happens if the import price rises, with the subsequent decline in the terms of trade. While the rise in IVUMs involves higher imported costs and inflation, the decline in the terms of trade negatively affects the gap, having a deflationary impact. During the first year, these effects cancel each other out, with inflation not responding to the shock, but during the next two years the deflationary effect prevails.

A similar exercise occurs if the oil price is disturbed. This shock translates into a rise in IVUMs and a fall in the terms of trade. Moreover, the oil price affects fuel prices directly, the price of bus fares indirectly, and to a lesser degree public utility rates, as , and show. Unlike the IVUMs, for the oil price the inflationary effects last for the three years shown, with the negative effect expected on growth and the gap. It is important to note that for this exercise, as for all the others, the policy rule proposed operates in the equation . However, this rule does not distinguish between permanent and temporary disturbances, so it is reasonable to think that the monetary policy rate (MPR) will overreact in this model to temporary shocks such as the oil price. This underlines the role of judgment in using the model to carry out projections or policy exercises.

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Glossary of Variables

In the text, in general the letter L before a variable's name indicates its natural logarithm (except for LIBOR, LIBORR and LIBORRE, see below). The symbol Δ_l^k indicates the k-nth difference using l lags. For example $\Delta^2 X_t$ is equal to $\Delta X_t - \Delta X_{t-1}$ and the symbol $\Delta_l X_t$ is equal to $X_t - X_{t-l}$. The letter F at the end of a variable generally indicates that the variable is measured in current dollars; an N at the end of a variable generally indicates that the variable is measured in current pesos and a Q at the end of the variable indicates that it is measured in constant 1996 dollars. Real figures are measured in constant 1996 pesos.

Dummy variables for a specific period are indicated using DYYT, where T represents the quarter and YY the year. For example, D012 is a variable worth one during the second quarter of 2001 and zero in all other periods.

AMNPF	: Weekly average, non-oil imports in dollars, Central Bank of Chile.
AUTOS	: Sales of new cars, ANAC.
BCU5	: The interest rate on indexed Central Bank bonds maturing in five years is the interest rate on the PRC8 until August 2002 and the BCU5 from then on, Central Bank of Chile.
BCU5E	: The equilibrium real interest rate on Central Bank UF-indexed five-year bonds, Central Bank of Chile.
BRECHA	: Output (GDP) gap, represents the percentage difference between output and its potential level, Central Bank of Chile.
BSFIF	: Balance of financial services in the current account in dollars, Central Bank of Chile.
CAPN	: The nominal (unindexed) 30- to 90-day deposit interest rate, Central Bank of Chile.
CCF	: Current account of the balance of payments measured in dollars, Central Bank of Chile.
CD	: Private purchases of durable goods in real terms, Central Bank of Chile.
CG	: Government's expenditure on final consumption in real terms, Central Bank of Chile.
CH	: Private consumption of non-durable goods in real terms, Central Bank of Chile.
CKC	: Cost of construction capital use, Central Bank of Chile, percent.
CKD	: Cost of durable goods use, Central Bank of Chile, percent.
CKM	: Cost of capital in machinery use, Central Bank of Chile, percent.
CLU	: Index of unit labor costs, Central Bank of Chile.
CMON	: Index of total nominal labor costs, National Statistics Bureau, INE, April 1993 = 100.
CMOPRN	: Index of private nominal labor cost, National Statistics Bureau, INE-MINDHA-Central Bank of Chile, April 1993 = 100.
CMOPUN	: Index of public utility labor costs, National Statistics Bureau, INE-MINDHA-Central Bank of Chile, April 1993 = 100.
CP	: Real private total consumption, Central Bank of Chile.
CREDCON	: Consumer credits, Superintendence of Banks and Financial Institutions, SBIF.
DA	: Real aggregate demand, Central Bank of Chile.
DEPC	: Depreciation rate for capital in construction, Central Bank of Chile.
DEPD	: Depreciation rate for durable goods, Central Bank of Chile.
DEPM	: Depreciation rate for capital in machinery, Central Bank of Chile.
DI	: Domestic demand in real terms, Central Bank of Chile.
DIAS	: Number of working days, Central Bank of Chile.
EMP	: Employment without employment programs, National Statitics Bureau, INE-MINDHA.
EMPA	: Employment of formally employed workers, National Statitics Bureau, INE.
EMPC	: Employment of self-employed workers, National Statitics Bureau, INE.
FAIC	: Adjustment factor for construction tax, Central Bank of Chile.
FAIM	: Adjustment factor for machinery tax, Central Bank of Chile.
FBC	: Gross formation of real construction, Central Bank of Chile.
FBK	: Real total gross capital formation, Central Bank of Chile.

FBM : Real gross fixed capital formation in machinery, Central Bank of Chile.
FKYEXT : Availability of external financing, which is the sum of the surplus in the current account of industrialized countries divided by the sum of the GDP, Central Bank of Chile.
FKYEXTE : Equilibrium availability of external financing, Central Bank of Chile.
FT : Labor force, National Statitics Bureau, INE.
HIDROELÉC : Hydro-electric power generation, National Statitics Bureau, INE.
HIP : The interest rate for mortgages, Central Bank of Chile.
I : Real total investment, Central Bank of Chile.
IEX : Changes in inventory or real investment in inventory, Central Bank of Chile.
IG : General government investment in real terms, Central Bank of Chile.
INBD : Real disposable gross domestic income, Central Bank of Chile.
IP : Investment in the rest of the economy in real terms, Central Bank of Chile.
IPC : Consumer Price Index, National Statitics Bureau, INE, December 1998=100.
IPCCOM : Fuel price index, National Statitics Bureau, INE, December 1998=100.
IPCCP : Meat and fish price index, National Statitics Bureau, INE, December 1998=100.
IPCD : Durable goods price index, National Statitics Bureau, INE-Central Bank of Chile, December 1998=100.
IPCFV : Non-durable goods price index, National Statitics Bureau, INE, December 1998=100.
IPCH : Non-durable consumption goods price index, National Statitics Bureau, INE-Central Bank of Chile, December 1998=100.
IPCINX : Indexed price index, National Statitics Bureau, INE-Central Bank of Chile, December 1998=100.
IPCSF : Financial service price index, National Statitics Bureau, INE-Central Bank of Chile, December 1998=100.
IPCSP : Public utility price index, National Statitics Bureau, INE-Central Bank of Chile, December 1998=100.
IPCX1 : Core price index, National Statitics Bureau, INE-Central Bank of Chile, December 1998=100.
IVA : Rate of the value added tax (VAT), Internal Revenue Service, SII.
IVCHINE : Index of non-durable consumption goods sales, National Statitics Bureau, INE.
IVUM : Index of imported goods value, Central Bank of Chile, 1996=100.
IVUMC : Index of imported consumer goods value, Central Bank of Chile, 1996=1.
IVUME : Equilibrium index of imported goods value, Central Bank of Chile, 1996=1.
IVUMIC : Index of intermediate fuel imported goods value, Central Bank of Chile, 1996=1.
IVUMIR : Index of the rest of intermediate imported goods value, Central Bank of Chile, 1996=1.
IVUMK : Index of imported capital goods value, Central Bank of Chile, 1996=1.
IVUMO : Index of other imported goods value, Central Bank of Chile, 1996=1.
IVUX : Index of exported goods value, Central Bank of Chile, 1996=1.
IVUXA : Index of exported agricultural goods value, Central Bank of Chile, 1996=1.
IVUXI : Index of manufactured exported goods value, Central Bank of Chile, 1996=1.
IVUXM : Index of exported mining goods value, Central Bank of Chile, 1996=1.
IVUXO : Index of other exported goods value, Central Bank of Chile, 1996=1.
KC : Capital stock in construction in real terms, Central Bank of Chile.
KD : Capital stock in durable goods in real terms, Central Bank of Chile.
KM : Capital stock in machinery in real terms, Central Bank of Chile.
LIBOR : The nominal external interest rate, which is 180-day LIBOR in dollars, Bloomberg and Reuters.
LIBORR : The real external interest rate, constructed using LIBOR and PUS, Central Bank of Chile.
LIBORRE : The equilibrium real external interest rate, Central Bank of Chile.
M : Real imports of non-financial services and goods, Central Bank of Chile.
M1A : Currency plus deposits in the non-financial private sector checking accounts, net of float, plus time deposits other than current accounts, plus demand savings deposits, Central Bank of Chile.
M6 : M1A plus private sector time deposits, plus savings time deposits including those for housing, plus documents of the Central Bank and the National Treasury in the hands of the public, plus bills of credit in the public's hands.
MB : Real total goods imports, Central Bank of Chile.

MBF : Total goods imports dollars, Central Bank of Chile.
MBF-MICF : Non-fuel imports, Central Bank of Chile.
MBQ : Real total goods imports, Central Bank of Chile, in 1996 dollars.
MCF : Consumer imports, Central Bank of Chile.
MCQ : Real consumer goods imports, Central Bank of Chile, in 1996 dollars.
TARGET : Target inflation rate, Central Bank of Chile.
MICQ : Real fuel intermediate goods imports, Central Bank of Chile, in 1996 dollars.
MIQ : Real intermediate goods imports, Central Bank of Chile, in 1996 dollars.
MIRQ : Real other intermediate goods imports, Central Bank of Chile, in 1996 dollars.
MKQ : Real capital goods imports, Central Bank of Chile, in 1996 dollars.
MKUP : Percentages for retail margins, Central Bank of Chile.
MKUPE : Equilibrium percentages for retail margins, Central Bank of Chile.
MNPF : Non-oil imports in dollars, Central Bank of Chile.
MOQ : Real other imports, Central Bank of Chile, in 1996 dollars.
MPF : Oil imports in dollars, Central Bank of Chile.
MQPEXT : Real imports deflated by the external price index, Central Bank of Chile.
MS : Real non-financial service imports, Central Bank of Chile.
MSF : Non-financial service imports in dollars, Central Bank of Chile.
P : GDP deflator, Central Bank of Chile.
PC : Consumption deflator, Central Bank of Chile.
PCCNN : Manufacturing production index, Central Bank of Chile.
PCG : Government consumption expenditure deflator, Central Bank of Chile.
PCP : Private consumption deflator, Central Bank of Chile.
PCU : Copper price, Chilean copper corporation (Codelco), cents per pound.
PDI : Price of diesel, National Customs Service, Servicio Nacional de Aduanas, in dollars per cubic meter.
PE : Equilibrium GDP deflator, Central Bank of Chile.
PEXT : Index of external prices relevant to Chile, Central Bank of Chile.
PFBC : Deflator of capital in construction, Central Bank of Chile.
PFBM : Deflator of capital in machinery, Central Bank of Chile.
PG93 : Price of 93 octane gasoline, Chilean Energy Commission, CNE, pesos per liter.
PGLI : Price of liquefied gas, Santiago Gas Company, GASCO, pesos per cubic meter.
PI : Deflator for investment, Central Bank of Chile.
PIB : Gross Domestic Product, Central Bank of Chile.
PIEX : Deflator of investment in inventory, Central Bank of Chile.
PIMP : Imported component of costs, Central Bank of Chile.
PINE : Manufacturing production index, National Statitics Bureau, INE, average 1989=100.
PKER : Price of kerosene, Chilean Energy Commission, CNE, pesos per liter.
PM : Deflator of total imports, Central Bank of Chile.
PMB : Deflator of goods imports, Central Bank of Chile.
PMS : Deflator of non-financial services and imports, Central Bank of Chile.
POIL : Oil price, Chilean Energy Commission CNE, dollars per cubic meter.
PUS : US Consumer Price Index, Bloomberg and Reuters.
PUSE : Equilibrium US Consumer Price Index, Central Bank of Chile.
PX : Deflator of total exports, Central Bank of Chile.
PXB : Deflator of goods exports, Central Bank of Chile.
PXS : Deflator of non-financial service exports, Central Bank of Chile.
PY : Nominal GDP, Central Bank of Chile.
QE : Equilibrium labor productivity, Central Bank of Chile.
REN : Real net factor payments abroad or net income in real terms, Central Bank of Chile.
RENF : Real net factor payments or net income in dollars, Central Bank of Chile.
SEXT : External saving in real terms, Central Bank of Chile.
SG : General government saving in real terms, Central Bank of Chile.
SP : The rest of the economy's saving in real terms, Central Bank of Chile.
SPOT : Exchange rate prior to setting the Customs dollar, Central Bank of Chile.
SPREAD : Surcharge on external financing, Bloomberg and Reuters, in percentage points.
SPREADE : Equilibrium surcharge on external financing, Central Bank of Chile, in percentage points.
STOCKS : Number of months of housing stock, Chilean Chamber of Builders, CChC.

TCN : Nominal exchange rate, Central Bank of Chile.
TCN96 : Average nominal exchange rate 1996, Central Bank of Chile
TCNAD : Customs dollar, National Customs Service, Servicio Nacional de Aduanas.
TCR : Real exchange rate against the United States, Central Bank of Chile, April 1993=100.
TCR5 : Real exchange rate against industrialized countries, Central Bank of Chile, 1986=100.
TCRE : Equilibrium real exchange rate index with the United States, Central Bank of Chile.
TCRM : Real multilateral exchange rate index, Central Bank of Chile, 1996=100.
TDI : Terms of trade index, Central Bank of Chile, 1996=100.
TDIE : Equilibrium terms of trade index, Central Bank of Chile.
TM : Average customs tariff. National Customs Service, Servicio Nacional de Aduanas.
TN : Real net transfers from abroad, Central Bank of Chile.
TNF : Net transfers from abroad in dollars, Central Bank of Chile.
MPR : The monetary policy interest rate in real terms, Central Bank of Chile.
MPRE : The equilibrium real monetary policy interest rate, Central Bank of Chile.
MPRN : The nominal monetary policy interest rate, Central Bank of Chile.
TUT : Tax on corporate profits, Central Bank of Chile.
U : Unemployment rate, National Statitics Bureau, INE.
UN : Equilibrium unemployment rate, Central Bank of Chile.
VCCNN : Manufacturing sales index, Central Bank of Chile.
VCONSTSFF: Intermediate construction consumption sales, Manufacturing Development Association, Sofofa.
VINE : Manufacturing sales index, National Statistics Bureau, INE, average year 1989=100.
X : Real non-financial service and goods exports, Central Bank of Chile.
XAQ : Real agricultural exports, Central Bank of Chile, in 1996 dollars.
XB : Real goods exports, Central Bank of Chile.
XBF : Total goods exports in dollars, Central Bank of Chile.
XBQ : Real total goods exports, Central Bank of Chile, in 1996 dollars.
XIQ : Manufactured exports, Central Bank of Chile, in 1996 dollars.
XMQ : Mining exports, Central Bank of Chile, in 1996 dollars.
XOQ : Other exports, Central Bank of Chile, in 1996 dollars.
XS : Real service exports, Central Bank of Chile.
XSF : Non-financial service exports in dollars, Central Bank of Chile.
Y : Real Gross Domestic Product, Central Bank of Chile.
YE : Equilibrium real Gross Domestic Product, Central Bank of Chile.
YEXT : External or world output index, Central Bank of Chile, first quarter 1985=100.
YEXTE : Equilibrium external or world output index, Central Bank of Chile.
YPD : Real disposable private income, Central Bank of Chile.
YRA : Rest of GDP, that is, GDP without natural resources but including agriculture, that is, total GDP minus mining, extractive fishing, energy, gas and water, Central Bank of Chile.
YRAE : Equilibrium real GDP in real terms, Central Bank of Chile.
YRN : Real natural resource GDP, that is GDP for mining, extractive fishing, energy, gas and water, Central Bank of Chile.

NOTES

D1 The variable was seasonally adjusted using the US Census Bureau X-12-ARIMA program.
D2 The variable was seasonally adjusted using the US Census Bureau X-12-ARIMA program, with the restriction that the sum of seasonally adjusted quarters had to equal the year.
D3 The variable was seasonally adjusted using the US Census Bureau X-12-ARIMA program using working days.
D4 The variable was seasonally adjusted using the US Census Bureau X-12-ARIMA program with the restriction that the sum of seasonally adjusted quarters had to equal the year and using an additive model.