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Resumen

Este trabajo considera evidencia empírica para una economía pequeña y abierta, caracterizando e identificando los efectos dinámicos de shocks externos y de política monetaria sobre la economía Chilena. Se utiliza la metodología de VAR estructurales con restricciones contemporáneas no recursivas. Varios resultados interesantes surgen del análisis. En primer lugar, consistente con las predicciones de un modelo estocástico de expectativas racionales, una contracción monetaria interna genera una caída transitoria del producto y de los agregados monetarios. Segundo, no hay evidencia de la presencia de puzzles de precios y de tipo de cambio. Tercero, la fuente de volatilidad del producto, del nivel de precios y del tipo de cambio real en Chile es similar a la identificada en países industrializados: la política monetaria explica una proporción relativamente pequeña de la volatilidad del producto, del nivel de precios y del tipo de cambio real. Finalmente, innovaciones en la política monetaria externa presentan efectos de corta duración sobre las tasas de interés internas y escasa influencia sobre otras variables macroeconómicas de Chile; mientras que cambios inesperados en la prima de riesgo influencian significativamente tanto a la tasa de interés interna como al tipo de cambio real.

Abstract

This paper considers empirical evidence for a small open economy, characterizing and identifying the dynamic effects of both foreign and monetary policy shocks on Chilean macroeconomic variables. A structural VAR approach is used with non-recursive contemporaneous restrictions. Several interesting results appear in the analysis. First, consistent with the predictions of a stochastic rational expectations model, a domestic monetary contraction generates a transitory fall in output and monetary aggregates. Second, there is no evidence of price and exchange rate puzzles. Third, the source of Chilean output, price level, and real exchange rate volatility is similar to that identified in industrial countries: monetary policy explains a relatively small proportion of output, price level, and exchange rate variability. Finally, foreign monetary policy innovations have very short-lived effects on domestic interest rates and have no major influence over other Chilean macroeconomic variables; while risk premium shocks influence significatively both the interest rate and the exchange rate.

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1 Introduction

What are the effects of monetary policy in a small open economy? What are the consequences of changes in international financial conditions in a small open economy? These questions have long held an essential place in monetary economics. Some of the recent literature has focused on these issues for industrial and some emerging economies, studying the impact of monetary and foreign shocks over real and nominal variables. In industrial countries those effects are, in general, consistent and coherent with conventional theory and among different studies.[1] However, in emerging economies, the effects of monetary policy and different external conditions remain very much an open subject. The main reason for this lack of knowledge is the difficulty of identifying exogenous monetary policy actions.

Thus, the main contribution of this paper will be to identify domestic monetary policy and to check whether the short-run dynamic responses of output, exchange rate, and price level are consistent with the predictions of a stochastic, rational expectations version of the Mundell-Fleming model.[2] In particular, a domestic monetary contraction reduces the price level, contracts output and monetary aggregates temporarily, and appreciates the exchange rate on impact; while a foreign innovation, essentially increases domestic interest rates and depreciates the exchange rate.

This paper provides a quantitative analysis of the effects of monetary and foreign shocks on output, prices, interest rates, monetary aggregates, and the exchange rate, confronting the conventional empirical puzzles. These puzzles can be defined along the following lines. *Liquidity puzzle*: positive monetary shocks (identified as innovations in monetary aggregates) are associated with increases (instead of decreases) in nominal interest rates. *Price puzzle*: positive monetary innovations (identified as innovations in interest rates) are related to increases (rather than decreases) in the price level. *Exchange rate puzzle*: positive monetary innovations (identified as innovations in interest rates) are linked with an impact depreciation (rather than appreciation) of the exchange rate.[3]

[1] See Cushman and Zha (1997), Kim (1999), and Kim and Roubini (2000). See Appendix 6.1 for comprehensive summaries of these studies.

[2] See Svensson (2000), Parrado (2001), and Parrado and Velasco (2001), for small open economy theoretical models.

[3] See Sims (1992), Christiano and others (1996), Kim (1999), and Kim and Roubini (2000) for additional details about these empirical puzzles.

Key insights come from imposing some plausible restrictions on contemporaneous relations among variables, employing a structural vector autoregressive (SVAR) approach, and from including variables representing expected inflationary pressures. The latter insight would avoid the fact that interest rate innovations, to a certain extent, would reflect inflationary pressures that result in price increases.

The paper analyzes the effects of both foreign and monetary policy shocks using Chile as a case study.[4] The results of the paper are consistent with the Mundell-Fleming framework. Such results can be summarized as follows. First, a monetary policy tightening has negative effects on output in the presence of flexible exchange rates. In particular, a domestic monetary contraction, for instance, 100 basis points (bps), provokes a persistent increase in the interest rate that lasts eight months, a transitory fall in output (1.3 percent and 1.6 percent in the sixth month and in a year, respectively) and monetary aggregates (3.5 percent and 2.1 percent in the 6th month and in a year, respectively). In contrast with many previous studies that use Chilean data, the results also show the absence of both price and exchange rate puzzles.[5] The contractionary shock appreciates the exchange rate by less than 1 percent on impact, which is lower than one could theoretically expect for a country with flexible exchange rates (no overshooting).

Second, the sources of Chilean output volatility are very similar to the one presented in more developed countries where monetary policy explains a relatively reduced proportion of domestic output variability in the short-run but a larger proportion in the long-run. Monetary policy also accounts for a moderate fraction of the real exchange rate and price level fluctuations, as is often the case in industrial countries.

Third, the effects on domestic variables of positive foreign monetary innovations are very mild, having positive and very short-lived effects on domestic interest rates. Specifically, a policy shock of 100 bps U.S. monetary policy implies an increase in the domestic interest rate of 20 bps on impact and,

[4] Among other studies that consider Chilean data are Rosende and Herrera (1991), Rojas (1993), Valdés (1998), Morandé and Schmidt-Hebbel (1997), Calvo and Mendoza (1998), Cabrera and Lagos (1999), Landerretche, Morandé, and Schmidt-Hebbel (1999), and Chumacero (2000). See Appendix 6.2 for complete summaries of these works.

[5] The liquidity puzzle is solved identifying monetary policy shocks as innovations in interest rates, which is the Central Bank of Chile's main instrument. In this regard, Sims (1992) discusses the benefits of using short-term interest rates (rather than monetary aggregates) as a measure of monetary policy shocks.

more interesting, over 600 bps in the next two periods. There is no significant effect on exchange rates because of the large increase on domestic interest rates. On the other hand, the impact of the risk premium spread, embodied by the EMBI index,[6] of 300 bps leads to a change of 20 bps on domestic interest rates on impact, depreciating the exchange rate 1.4 percent. The maximum impact is reached in the next period: 24 bps in the case of domestic interest rates and 1.9 percent in the case of the real exchange rate.

The case of Chile is considered because it fits the characteristics of a small open economy. In this paper, the rest of the world is represented by the United States. Chilean monetary policy is interesting because it is one of the emerging markets with a strong commitment to fight inflation. As in many developed countries, the main objective of the Central Bank of Chile (CBC) has been to maintain price stability. The current regime of inflation targeting supports this goal with two key aspects. First, the CBC is independent from the government, hence it isolates its actions from the political cycle. Second, by setting the target of inflation for the next year the CBC provides a nominal anchor for private, public, and external sectors. Consequently, the benchmark sample used in this paper extends from the early 1990s to the present, capturing an independent monetary policy and a regime with a clear policy instrument and unambiguous objectives.

The motivation for this work is twofold. First, in recent years a vast empirical literature presents reliable evidence for developed countries. For example, in the case of the U.S. economy, Eichenbaum and Evans (1995) study in which way the exchange rate response to monetary shocks is consistent with liquidity effects. They conclude that monetary expansions, identified as negative innovations to U.S. interest rates, led to an impact appreciation of U.S. dollar. Similarly, Grilli and Roubini (1995) address the same issue empirically in the G7 countries. They argue that a positive shock in U.S. interest rates leads to an impact appreciation of the U.S. dollar, while positive interest rate shocks in most of the other G7 countries result in an impact depreciation of these currencies relative to the U.S. dollar. These results are also consistent with Cushman and Zha (1997), who analyze the Canadian example. In the most recent contribution, Kim and Roubini (2000) conclude that monetary policy shocks on exchange rates, prices, and output are consis-

[6]The J.P. Morgan Emerging Markets Bond Index (EMBI) is a total-return index that tracks the traded market for the U.S. dollar denominated Brady and other similar sovereign restructured bonds. This index would provide a benchmark to measure risk and returns in emerging markets.

tent with conventional theory. Specifically, a monetary contraction reduces the price level, contracts output temporarily, and appreciates the exchange rate on impact.

However, we have little equivalent evidence for countries in earlier stages of development. In order to obtain a complete characterization of monetary policy, it is important to study how domestic monetary shocks, foreign monetary shocks, and risk premium shocks affect emerging markets —in this case the Chilean economy.

Second, the management of exchange rates in developing countries has always been complex, especially in view of the high macroeconomic volatility in Latin America, especially in output and exchange rates.[7] For instance, in the recent Asian crisis, several countries abandoned pegs to the dollar, but then tightened monetary policy in response to both internal and external adverse shocks, and attempted to fight the depreciation of their currencies. Between the end of 1997 and 1998 most Latin American countries, including Chile, also used tight money and high interest rates to sustain their currencies. Gavin and others (1999) and Calvo and Reinhart (2000) have recognized this pattern, in what they call the "fear of floating" puzzle. However, the phenomenon among small industrial economies was not the same: during the Asian crisis, Australia and New Zealand allowed their currencies to depreciate sharply and battered the storm with little cost in terms of domestic output. In light of this contrast, characterizing the effects of monetary policy in open emerging markets seems especially important.

Methodologically, the paper follows Bernanke (1986), Blanchard and Watson (1986), Sims (1986), and more recently Cushman and Zha (1997) and Kim and Roubini (2000) to identify the empirical model. This paper is most closely related to Cushman and Zha (1997) and Kim and Roubini (2000) because their identification schemes yield results that contribute to solving the puzzles on the effects of monetary policy in a small open economy.

Three of the innovative features of the empirical model are the following: First, it makes use of the SVAR methodology to impose a minimum number of restrictions among Chilean macroeconomic variables. In particular, previous work for Chile —with the important exception of Chumacero (2000)— focus on a recursive structure of contemporaneous restrictions. Second, un-

[7]For example, during the 1990s, Chilean nominal exchange rate presented very high volatility (11.4 percent), which contrasts with lower variability registered by industrial countries: Australia (7.9 percent), Canada (8.5 percent), France (6.9 percent), Germany (7.5 percent), New Zealand (9.9 percent), and the U.K. (7.3 percent), among others.

like much work in the literature based on Chilean data, the paper confronts the conventional empirical puzzles, including some variables which represent inflationary pressure such as the world oil price. Finally, it considers changes in international financial conditions represented by foreign interest rate shocks and by risk premium shocks.

The paper is organized as follows: Section 2 describes Chilean monetary and exchange rate policies. Here, the paper outlines the CBC's design and jurisdiction, inflation targeting and exchange rate regimes, operating procedures of the monetary authority, and a narrative description of the CBC policy during the 1990s. Section 3 presents a description of the SVAR framework and methodology, while section 4 analyzes the mentioned issues. The final section summarizes the results and their implications for monetary policy.

2 Chilean monetary and exchange rate policies

Similar to many developed and some emerging countries, the main objective of the Chilean monetary authority is to maintain price stability. The current regime of inflation targeting supports this goal in two main ways. First, the independence of the central bank from the government isolates its actions from the political cycle. Second, each year the CBC sets the target of inflation for the next year, providing a nominal anchor for private, public, and external sectors.

In addition, it is worth noting that the inflation targeting regime in Chile allows for flexibility. In other words, there is no legal mandate to achieve the target each year. For example, the official target for the consumer price index (CPI) inflation was 3.5 percent in 2000. However, given some unexpected events, such as increases in oil prices and sluggish domestic consumption, inflation came in at 4.5 percent with no political or judicial costs.

Now the paper will proceeds to characterize the institutional design of the CBC. Section 2.1 presents the organization and jurisdiction of the central bank. Section 2.2 describes the practice of monetary policy, inflation targeting, and the exchange rate policy. Section 2.3 describes the operating procedures for conducting monetary policy. Finally, section 2.4 presents a narrative description of the CBC policy during the 1990s.

The issue can be addressed by analyzing quantitatively the response of a model economy to domestic and foreign monetary shocks, characterizing the its dynamic effects on output, prices, interest rates, monetary aggregates, and the exchange rate.

2.1 Central bank design and jurisdiction

The aim of having an independent central bank from the government is to isolate monetary and exchange rate policies from any political influence. In this framework, Article 97 of Chapter XII of the Political Constitution (1980) brings constitutional status on the existence of an independent central bank. The Constitutional Act of the CBC empowers the monetary authority to "stabilize the value of the currency and provide normality in the functioning of internal and external payments."

The formal body that sets CBC monetary policy is the Board of Governors, which is in charge of the management and administration of the bank. The Board consists of a president, vicepresident, and three other members. Members of the board and the president of the board are designated by the president of the republic and approved by the senate. Terms are for 10 years, with the possibility of re-election for an equal period, while the post of president of the board lasts five years. Again, long-term positions are justified as a means to shield the governing body from political pressures.

2.2 Inflation targeting and the floating exchange rate

As mentioned earlier, the main objective of the Chilean monetary authorities has been preserving price stability. To meet this goal, the CBC has adopted an inflation targeting regime together with a floating exchange rate regime to keep inflation at a low and stable level.

The central bank has the power to set the framework of exchange rate policy. In the late 1980s and for most of the 1990s, the country adopted a crawling exchange rate band, which went through many modifications in order to accommodate the appreciation of the peso.[8] Since September 2, 1999, the country has embraced a flexible exchange rate regime, with the possibility of the monetary authority intervening in the market only if the

[8] See Morandé (2001b) for details about the evolution of the exchange rate policy in Chile during the 1990s.

exchange rate does not reflect the "real" value of the foreign currency. This regime brings more flexibility to the CBC to use its monetary instruments than in the case of a managed or fixed exchange rate regime. Moreover, the flexible exchange rate regime helped to abandon one of the nominal anchors (the exchange rate target) in the new monetary policy framework, creating some monetary policy dilemmas. The CBC, consistent with empirical research and conventional wisdom, believes that the main benefit of having a flexible exchange rate is that it allows absorbing foreign and real shocks and, consequently, generates lower output and employment volatility.

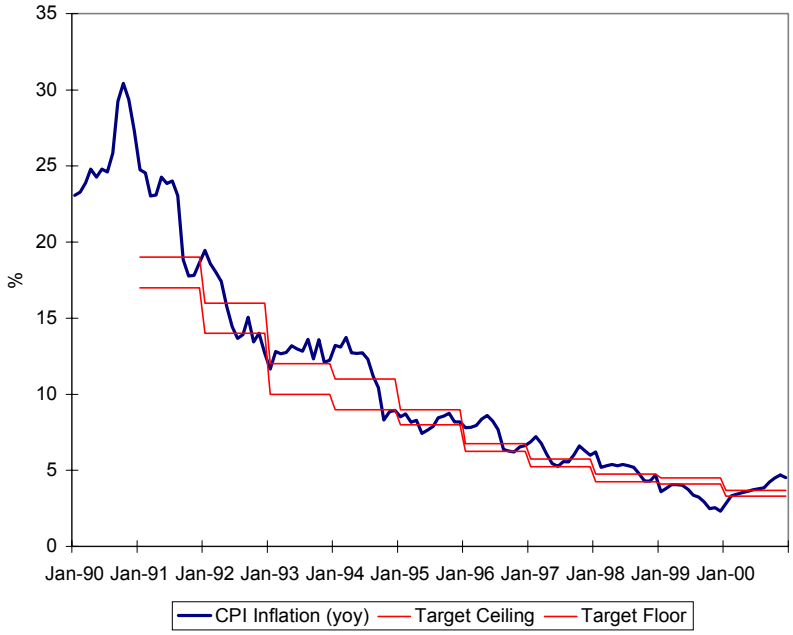
The inflation targeting regime was introduced in 1989, the first year of the CBC independence. Monetary authorities felt the need to maintain some kind of explicit nominal anchor to guide policy in their new autonomous framework. The procedure works as follows: each September the monetary authority sets a CPI inflation target for the next year. With the introduction of this fixed target, the monetary authority influences wage and price adjustments in both the public and the private sector.

The target is defined as a range of 2 percent to 4 percent per year in the medium term (12 to 24 months). The 3 percent central value represents the operational target that guides monetary policy in the medium term. The CBC avoids a 0 percent target because, first, the price index may overstate the true inflation rate since it tends to undercompensate for improvements in the quality of goods or for introduction of new goods. Second, this 2 percent to 4 percent range takes into account some degree of inflationary inertia derived from the extensive use of indexing with respect to past inflation in many markets. Finally, empirical research shows that countries that have grown faster than world average, as in the case of Chile, have higher productivity growth in the tradable sector which is associated with higher inflation.

The operational target is defined in terms of changes in the CPI. However, the CBC prefers to concentrate its attention on the underlying or core-CPI inflation, because it excludes the prices of goods with more volatile behavior (vegetables, fruits, and fuel). In addition, to project the evolution of inflation over the medium term, both indicators are used because they tend to coincide at longer time horizons.

In May 2000, in order to give credibility and transparency to the inflation targeting regime, the CBC began publishing its Monetary Policy Report, which appears every four months (January, May, and September). Its main objectives are: "first, to support the process of monetary policy articulation by the Board of Governors of the central bank with a medium-term frame-

Figure 1: Inflation and Inflation Targets



work; second, to inform and explain to the general public the Board's views on recent and expected inflation figures and its consequences for conducting monetary policy; finally, to orient economic agents' expectations regarding future inflation and output trends."[9]

From the autonomy of the CBC, Chilean monetary policy has been well known for its commitment to fight inflation. Average annual inflation has decreased from 27.3 percent in 1990 to 4.5 percent in 2000 (with a record of 2.3 percent in 1999). The targets were chosen with the purpose of gradually reducing inflation over time. From 1991 to 2000, the record in achieving the targets has been outstanding, with an average difference of -0.2 percent (and standard deviation of 1.2 percent) between actual CPI inflation and selected targets (see Figure 1).

[9]See Banco Central de Chile (2000).

2.3 Operating procedures

The daily management of monetary policy is based on short-term market interest rates. However, the main operative instrument of monetary policy consists in the auction of quotas of its own debt securities that are held on the open market from month to month. In order to stabilize the overnight interbank interest rate around its target (defined as the monetary policy rate), these open market operations increase or decrease liquidity in the interbank market (repo and reverse repo operations).

From 1985 to April 1995, the instrument of monetary policy was short-term interest rates indexed to the monthly change in the CPI through adjustments in the *Unidad de Fomento*[10] (UF). In May 1995 the CBC changed its policy instrument to an overnight interbank interest rate, which is controlled through the management of liquidity.

As Valdés (1998) pointed out, there were two main reasons to use ex-post real interest rates instead of nominal rates. First, the Chilean economy presents a high degree of indexation that suggests the convenience of using real rates. Second, the monetary authority thought that given the characteristics of real rates, they have more credibility. Thus, changes in real rates would not imply double interpretations as in the case of nominal rates.

To address the effects of unexpected changes in the domestic interest rate, this analysis uses an interest rate series that is controlled by the monetary authority. Consequently, innovations in this series will be associated to policy changes. In particular, a hybrid instrument is used combining the short-term interest rates of three-month instruments from January 1991 to April 1995, with the overnight interest rate from May 1995 until 2001:01. In addition, given the use of real interest rates, the model considers the real exchange rate (rather than the nominal exchange rate). The main motivation is that results based on the real uncovered interest parity condition have better interpretations.

[10] The *UF* is used as a unit of account for financial transactions. It is calculated on the 10th day of each month by a linear amount each day. Thus, by the 9th day of the next month it will have increased in value by as much as the CPI had two months before.

2.4 A narrative description of the central bank policy in the 1990s

This section presents a selective review of CBC policy from the early 1990s to the present, showing how the CBC works in practice.

Almost immediately after it was freed from its obligations from the government, the CBC raised short-term interest rates considerably in order to reduce inflation. Real interest rates went up for the 90-day PRBC (readjustable bills) from 6.8 percent to 8.7 percent, and the interest on 10-year notes rose from 6.9 percent to 9.7 percent. As a result of this policy, spending grew at a much slower pace. This was also the result of a new government which had initiated an austere fiscal policy program. In September 1990, the CBC announced a target rate of inflation for 1991 of 17 percent. There were also considerable capital inflows during the year, but the CBC defended the exchange rate band at ± 5 percent. The result was a large accumulation of foreign reserves. The economy did better and actual inflation almost hit the target (18.7 percent).[11]

Inflation continued to fall throughout 1992. This came as a result of higher interest rates[12] and the appreciation of the peso, which even allowed authorities to lower their inflation forecast by mid-year from 15 percent to 13 percent. Except for the month of May, intervention in the foreign exchange market was not required since the exchange rate evolved within the band. Actually, this lack of intervention was really due to the fact that, at the end of 1991, Chile's strong external accounts forced the CBC to lower the referential dollar exchange rate (middle of the band) by 5 percent and to widen the exchange rate band to ± 10 percent. Although this decision was taken to increase the market role in determining the exchange rate, in March it was decided that the central bank should have a dirty floating option to intervene within the band. The combined force of a restrictive monetary policy and the appreciation of the exchange rate helped to achieve the inflation target.

The downward trend in inflation observed since 1991 came to a stop, as prices rose in 1993 only 0.5 percent less than in 1992. This was due in part to

[11] An anti-inflationary policy was complicated by several factors. However, issues such as an increase in VAT (from 16 percent to 18 percent), coupled with important wage increases, a severe drought and a sizable increase in the price of oil, offset the tightening of monetary policy.

[12] Spending began to rise again at the beginning of 1992, forcing the CBC to increase interest rates from 4.7 percent to 6.5 percent.

the steady increase in domestic spending, which fueled non-tradable goods inflation. To keep spending controlled, the CBC raised 90-day PRBC bills in mid-1992, a move that proved successful and timely according to the CBC.

In 1994, inflation finally broke down the one-digit barrier.[13] The sharp slowdown in the growth of nontradable prices played a very important role in this outcome. Up until September, the interest rate on 90-day PRBC notes was maintained at 6.5 percent, a rate that had been in place since November 1992. When inflation was clearly under control, the CBC decided to lower interest rates to 6.1 percent.

The same year, after some months of evolving relatively far from the lower end of the exchange rate band, the exchange rate finally hit it in August, forcing the CBC to intervene. In November, as a way of internalizing the aforesaid structural changes, the referential dollar exchange rate was lowered by almost 10 percent.

During 1995, seasonal factors in a group of foods and a rise in taxes on cigarettes and gasoline prevented inflation from falling even more. As mentioned previously, the CBC decided to introduce an important modification to its monetary operations. It decided to stop offering unlimited amounts of 90-day PRBC notes at a fixed interest rate and instead opted for auctioning the interest rate on those notes twice a week. The CBC turned to the overnight rate as its new main operational instrument. A liquidity deposit account was created where overnight transactions are carried out at a prefixed interest rate —thus putting a lower limit on short-term interest rates. Now the CBC could provide liquidity to the market through liquidity credit lines and purchase of securities with a resale agreement (reverse repos).

For much of the year 1995, the exchange rate evolved in the lower half of the exchange rate band, but further away from the floor than in previous years. The effects of the Mexican crisis did not really affect the exchange rate. The CBC decided to revalue the referential dollar by 2 percent per year.

Inflation fell for the sixth year in a row in 1996.[14] An important feature of the inflation figure for 1996 is the fact that non-tradable inflation was only 7.8 percent (it had been consistently above 10 percent in the previous years). During the first part of the year, the CPI increased by 8.6 percent because

[13] In 1994, the target was a range between 9 percent and 11 percent. The actual inflation was 8.9 percent.

[14] In 1996, the target was a 6.5 percent, while actual inflation was 6.6 percent.

of higher international prices of fuel and wheat. The trend reversal observed toward mid-year was also related to the price behavior of those commodities. Inflation ended at 6.6 percent (the target was set at 6.5 percent).

A real appreciation of the peso was observed during 1996, resulting in a 24.5 percent real appreciation since 1990. The nominal exchange rate stayed close around the lower end of the band, but no modifications were introduced by the end of the year.

The evolution of inflation was very irregular during 1997. The price of perishable products increased dramatically during the third quarter, due to bad weather, but by December the situation had returned to normal. The interbank interest rate was reduced four times (in February, April, June, and September), bringing it down from 7.5 percent to 6.5 percent.

The nominal exchange rate continued to fluctuate around the lower end of the exchange rate band. The exchange rate band was widened to ± 12.5 percent around the central parity, which was lowered by 4 percent. By the end of the year, the Asian crisis had negative effects on Chile's economic forecast and as a result the exchange rate went up by 10 percent.

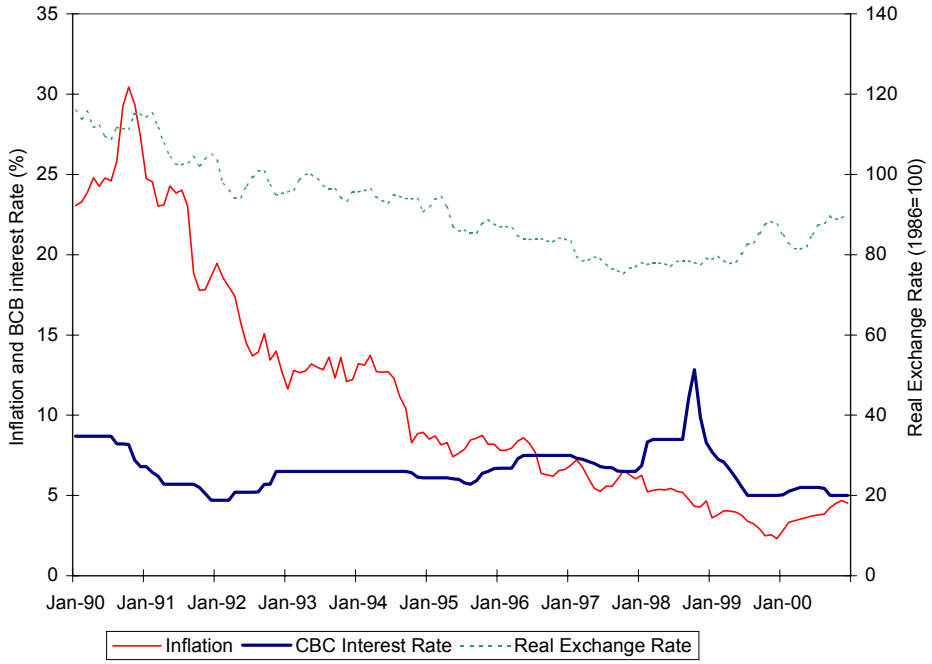
The year 1998 was a troublesome period with strong pressures on inflation arising from the exchange rate depreciation. The CBC responded to this event by raising its interest rate policy from about 6.5 percent in December 1997 to a peak of 12.8 percent in October 1998. In addition, by the end of June, the CBC decided to narrow the exchange rate band from ± 12.5 percent to 5.5 percent (3 percent above the center and 2.5 percent below it). However, this narrow band could not be maintained because of the Russian crisis that hit emerging markets that year. The CBC determined to modify the exchange rate band again to 7 percent, allowing a gradual widening until 10 percent by the end of the year.

After the Asian crisis, the inflation rate reached the lowest point in 1999: 2.3 percent (the target was between 4.5 percent and 4.3 percent). The combination of the Asian crisis and restrictive monetary policy drove the economy into a recession. The downturn induced the CBC to ease interest rates. In particular, it reduced the overnight rate and then kept it at 5 percent through the second part of the year. These circumstances permitted the CBC to decide to abandon the band in September, when there was no pressure in the financial and exchange rate markets.[15]

Inflation rates increased to 4.5 percent in 2000, core inflation stayed be-

[15] See Morandé (2001b) for details.

Figure 2: Inflation, CBC Interest Rate, and Real Exchange Rate

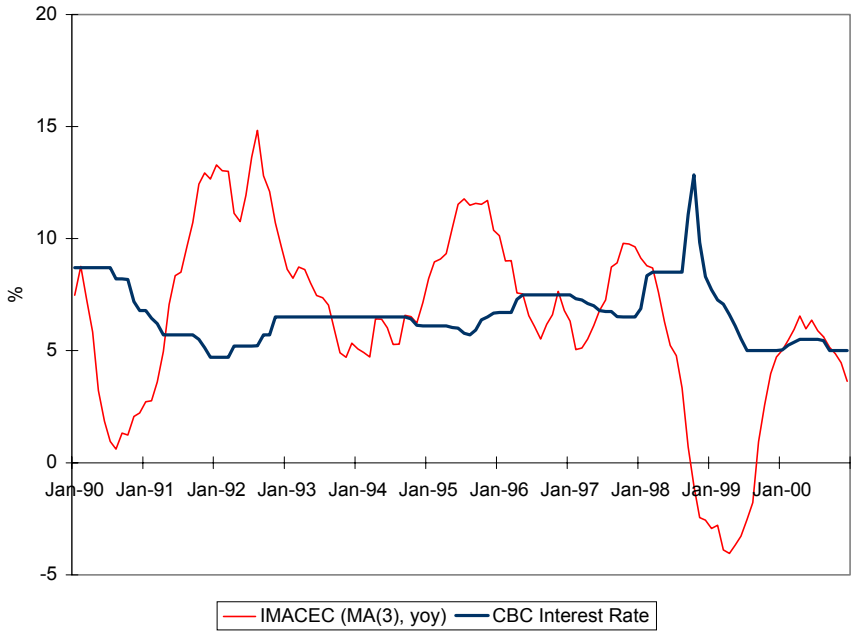


tween 1.4 percent and 3.4 percent. It could be argued that the increase in CPI inflation was produced by a severe increase in the world oil price, rather than by accommodating monetary policy.

In sum, the CBC seems to act aggressively raising its interest rates in response to perceived inflationary pressures. From the narrative approach and from Figures 2 and 3 we could deduct, first, that the CBC has tried to stabilize inflation directly through the inflation target and indirectly through the real exchange rate, and second, that the interest rate managed by the CBC has apparently an important effect over output.[16]

[16] These presumptions are consistent with those derived in theoretical models as in Parrado (2001).

Figure 3: IMACEC and CBC Interest Rate



3 Analytical framework

To determine the effects of domestic monetary policy shocks and foreign innovations (foreign monetary policy and risk premium shocks) on output, price level, interest rate, monetary aggregates, and the exchange rate a structural vector autoregressive (SVAR) approach is used. This methodology relies both on institutional information of interest rates and its timing to identify the dynamic effects of key macroeconomic variables and, by implication, to infer monetary shocks. In particular, the SVAR relates the observed movements in a variable to a set of innovations that have economic interpretation. It is worth noting that SVAR label as monetary policy shocks are not the result of the execution of the monetary rule when reacting to macroeconomic fluctuations. They are, instead, random components that can not be explained by the reaction function.

As stated previously, the main policy instrument used by the Chilean monetary authority is an indexed interest rate that combines the 90-days PRBC (from 1991:01 until 1995:05) with the overnight rate (*tasa de instancia,* from 1995:05 until 2001:01).

3.1 Data

The data used in the model are the following:

y: log of IMACEC,[17]
p: log of consumer price index (CPI),
wop: log of world oil price,
r: domestic interest rate,
r^*: foreign interest rate (U.S. Fed Funds rate),
[ρ: risk premium (EMBI)],
m: log of monetary aggregate, M1A,
rer: log of the real exchange rate.

The model uses seven variables to describe the Chilean economy. Four are nonpolicy variables. Of these, two are meant to characterize the state of the economy: IMACEC (y) and CPI (p). The two others reflect important external factors that influence the Chilean economy: world oil price (wop) and either the U.S. Federal Funds rate (r^*) or the EMBI (ρ). The three policy variables are: the domestic interest rate (r), the real money supply (m), and the real peso-dollar exchange rate (rer).

The sample period is from 1991:01 to 2001:01, allowing one to study the behavior of an independent central bank, which has an unambiguous objective: price stability. Output, money, and the price level present strong seasonality, so seasonally adjusted series are used. The data are from the CBC (y, r, m, rer), National Statistics Bureau (p), IFS (wop), the U.S. Federal Reserve Bank of St. Louis (r^*), and J.P. Morgan (ρ)

Three variables, which are assumed to be exogenous to the Chilean economy, are worth explaining in detail: the world oil price, the U.S. Federal Funds rate, and the EMBI.

The world oil price is included to control for the systematic component of the policy rule in order to identify exogenous monetary policy changes. In

[17] The IMACEC is the monthly indicator of economic activity, which covers over 90 percent of Chilean GDP.

other words, the world price of oil is introduced as a variable that captures negative and inflationary shocks. Including this variable would avoid the presence of the *price puzzle*, in which positive monetary shocks from increases in the interest rate implies a rise in the price level.

The empirical model incorporates separately either the foreign interest rate (U.S. Fed Funds rate) and a measure of risk premium (EMBI) to capture changes in international financial conditions. Such variables are included to control the component of domestic monetary policy that reacts to foreign innovations. A priori, one could say that general effects might be similar; however, specific effects on domestic interest rates and exchange rates could differ. As is pointed out by Borensztein, Zettelmeyer, and Philippon (2001) there are three main reasons to study these shocks separately. First, interruptions of capital inflows would force the central bank to maintain the value of the currency, since depreciations may have perverse effects in that case. Second, depreciation of the exchange rate after a change in international conditions could affect the credibility of the CBC depending on what types of foreign shock hit the economy. In particular, there is the idea that depreciations by risk premium shocks affect credibility more than foreign interest rate shocks because emerging markets risk is attached to the former. Finally, depreciation following either type of shocks could shift the economy from a good equilibrium where foreign debt service obligations are low and expected output is high, to a bad equilibrium with high foreign debt burden and low expected output.

In terms of SVAR estimations, the SVAR is performed with the natural logarithm of variables in levels, except for interest rates. McCallum (1993) argues that the estimation in levels is appropriate if the error term in each VAR equation is stationary and serially uncorrelated. In this case, likelihood ratio tests show that the residuals could be characterized as a vector white noise processes.

However, residuals reveal deviations from normality. Montecarlo methods infer the distribution of the standard errors generating randomly a vector drawn from a normal distribution. It is worth noting that, in general, conclusions of previous empirical research, if they include standard errors, assume that innovations are jointly Gaussian, which in general is not the case. Thus, one could get wrong inferences based on incorrect confidence intervals. This research uses an alternative approach, which is bootstrapping. The idea behind bootstrapping is to obtain an estimate of the small sample distribution of the estimated parameters of the model without assuming that innova-

tions are Gaussian. Thus, inference exercises can be performed with more confidence.

In terms of optimal lags, different tests[18] recommend diverse number of lags. For example, the likelihood ratio test (LRT) suggests the use of five lags. However, the LRT is based on asymptotic theory, which may not be very helpful in this sample. Thus, it is also computed the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC). AIC and SBC tests advise the use of two and one lag, respectively. This model considers two lags because in most of the cases second lags are significant.

One additional important issue is the one related to the inclusion of a determined variable into a VAR. In particular, the addition of the rest-of-the-world variables could result in potential misinterpretations, the reason being that these foreign (exogenous) variables would depend not only on their own lags but also on domestic variables lags. Therefore, the block exogeneity tests[19] are needed in order to check whether the exclusion of a variable (and/or its lags) into a VAR is convenient to get sound statistical inferences. In this case, for 90 percent significance level, the restriction of no domestic variable lags in foreign variables equations can be rejected. In other words, there is no major benefit in getting rid of domestic variable lags in foreign variable equations.

Unit Root Tests and Granger Causality could also be considered for each variable of the system. However, it is worth noting that some authors argue that the integration order is not an issue [Bernanke and Blinder (1992), Gordon and Leeper (1994)]. The reason is that this authors follow a Bayesian inference.

[18] The likelihood ratio test (LRT) is defined by $(T-c)(log|\sum_p| - log|\sum_{p+k}|)$, where $|\sum|$is the determinant of the variance-covariance matriz of the residuals, T is the number of usable observations, c is the number of parameters estimated in each equation of the unrestricted system, and p is the number of lags. The Akaike Information Criterion (AIC) is described by $Tlog|\sum|+2N$, where N is the total number of parameters estimated in all equations. Finally, the Schwartz Bayesian Criterion (SBC) is equal to $Tlog|\sum|+Nlog(T)$.

[19] Block Exogeneity is based on a likelihood ratio test equal to $(T-c)log|\sum_r| - log|\sum_u|\tilde{}\chi^2(nq)$, where n represents the number of restricted equations and q represents the lags excluded from the restricted VAR (r), and c is the number of parameters estimated in each equation of the unrestricted system (u).

3.2 Specification and identification of the SVAR

3.2.1 Specification

It is possible to estimate the following reduced form of a vector autoregressive (omitting constant and deterministic terms) with the following expression

$$y_t = B(L)y_t + u_t, \tag{1}$$

where y_t is an $n \times 1$ vector of observations, $B(L)$ is a matrix polynomial in the lag operator L, and $E[u_t u_t'] = \Sigma$.

However, we are interested in the structural form equations and not in the reduced form equations. Thus, the economy can be described by a structural dynamic system of equations

$$G(L)y_t = e_t, \tag{2}$$

where y_t is an $n \times 1$ vector of observations, $G(L)$ is a matrix polynomial in the lag operator L, and e_t is an $n \times 1$ vector of structural shocks. It is assumed that e_t is serially uncorrelated and $E[e_t e_t'] = \Lambda$, and Λ is a diagonal matrix where the diagonal elements are the structural shocks variances.

There are several ways of recovering the parameters in the structural form equation from the estimated parameters in the reduced form equation. The most traditional and standard factorization method is the Cholesky decomposition which consists of orthogonalize reduced form residuals Σ. However, with this technique we are assuming a recursive structure. In other words, it is important to know the position in which the variable enters in the VAR (*recursive VAR*).

For that reason, the paper follows Bernanke (1986), Blanchard and Watson (1986), Sims (1986), and more recently Cushman and Zha (1997), and Kim and Roubini (2000) to identify the empirical model. They recommend a generalized method in which nonrecursive structures are allowed while only restricting contemporaneous structural parameters (*structural VAR*).

Let G_0 be the contemporaneous coefficient matrix in the structural form, $G(L)$, and let $G_{-0}(L)$ be the coefficient matrix in $G(L)$ without contemporaneous coefficient G_0, that is,

$$G(L) = G_0 + G_{-0}(L). \tag{3}$$

Thus, the structural form equation and the reduced form equation are related by

$$B(L)y_t = -G_0^{-1}G_{-0}(L)y_t,$$
$$u_t = G_0^{-1}e_t.$$

It follows that

$$E[u_t u_t'] = \Sigma = \left(G_0^{-1}\right)\Lambda\left(G^{-1}\right)'. \tag{4}$$

Therefore, we need to minimize over the free parameters in G_0 and Λ through maximum likelihood using the sample covariance matrix estimate of Σ. The right-hand side of equation (4) has $n \times (n+1)$ free parameters to be estimated. G_0 has n^2 free parameters, while Λ has n (diagonal matrix) parameters to be estimated. We need at least $n \times (n+1)/2$ restrictions because Σ contains the same number of parameters. If we normalize each one of the n diagonal elements of G_0 to 1, we require at least $n \times (n-1)/2$ restrictions. With a Cholesky factorization, in which it is assumed that G_0 is lower triangular, we get an exactly identified model. However, if we have enough restrictions ($n \times (n-1)/2$), the Bernanke-Sims structural VAR modeling G_0 can take any structure.

3.2.2 Identifying monetary policy shocks

The data vector of the model is $\{wop,\ y,\ p,\ r^*[\rho],\ r,\ m,\ rer\}$.

Thus, one possible characterization of the model identification is the following:

$$\begin{bmatrix} e_{wop} \\ e_y \\ e_p \\ e_{r^*[\rho]} \\ e_r \\ e_m \\ e_{rer} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \mathrm{a}_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ \mathrm{a}_{31} & \mathrm{a}_{32} & 1 & 0 & 0 & 0 & 0 \\ \mathrm{a}_{41} & 0 & 0 & 1 & 0 & 0 & 0 \\ \mathrm{a}_{51} & 0 & 0 & \mathrm{a}_{54} & 1 & 0 & 0 \\ 0 & \mathrm{a}_{62} & \mathrm{a}_{63} & 0 & \mathrm{a}_{65} & 1 & 0 \\ \mathrm{a}_{71} & \mathrm{a}_{72} & \mathrm{a}_{73} & \mathrm{a}_{74} & \mathrm{a}_{75} & \mathrm{a}_{76} & 1 \end{bmatrix} \begin{bmatrix} u_{wop} \\ u_y \\ u_p \\ u_{r^*[\rho]} \\ u_r \\ u_m \\ u_{rer} \end{bmatrix},$$

where e_{wop}, e_y, e_p, $e_{r^*[\rho]}$, e_r, e_m, and e_{rer} are the structural disturbances,

that is, foreign supply shocks, supply shocks, price shocks, foreign interest rate shocks, money supply shocks, money demand shocks, and exchange rate shocks, while u_{wop}, u_y, u_p, $u_{r^*[\rho]}$, u_r, u_m, and u_{rer} are the residuals shocks.

It is worth mentioning that the system represents only contemporaneous restrictions on the structural parameters. It has not imposed any restriction on the lagged structural parameters.

1. The oil price is the most exogenous variable, and thus, it does not depend on any domestic or foreign variable. For that reason, the world commodity price is first in the system.

2. Output depends only on the oil price contemporaneously. It is assumed that both interest rates, money, and real exchange rate do not affect contemporaneously real activity. The main plausible justification for these assumptions is that firms do not change their output suddenly after changes in monetary policy because of adjustment costs.

3. The price level is affected contemporaneously by the oil price and the level of activity.

4. The measure of foreign international conditions (r^* or ρ) depends only on the oil price. In the case of r^*, the motivation is that the U.S. Federal Reserve will increase interest rates in response to inflationary shocks. Movements in the U.S. Fed Funds rate are unlikely to affect Chilean output and inflation within the period, thus, it seems reasonable to order this variable last among nonpolicy variables. On the other hand, emerging markets have a strong oil dependency, therefore changes in its price would induce one to reconsider the analysis of risk and returns in these economies.

5. The model assumes that the CBC adjusts domestic interest rate to contemporaneous innovations in the oil price and the foreign innovations. The main rationale is information availability. Since information about these two variables become available contemporaneously, innovations in these variables are included to the CBC information set. These variables are included to isolate exogenous monetary policy changes. Since the real exchange rate is considered instead of the nominal exchange

rate,[20] the model also excludes from the monetary reaction function the contemporaneous real exchange rate, which is not available within a month.

6. The model assumes the usual money demand function. The demand for nominal money balances depends on real income, price level, and the interest rate.

7. The model also assumes that all variables have contemporaneous effects on the real exchange rate.

In sum, the structural shocks are composed by three blocks: (1) Money market: money supply and money demand equations, (2) Domestic goods market: output and the price level equations, (3) Exogenous shocks: oil price and foreign financial condition equations, and (4) Arbitrage condition: the real exchange rate equation.

Table 1 shows the estimated contemporaneous coefficients for different structural models and different samples. Table 1 also reports the likelihood ratio test of the over-identifying restrictions. In general, the identifying restrictions are not rejected at any conventional significance level.

[20] I examined an SVAR including the nominal exchange rate instead of the real exchange rate. Depending on different samples, I found that the inclusion of the nominal exchange rate produces either similar impulse responses or awkward dynamic responses. Moreover, likelihood ratio tests of the over-identifying restrictions, including the nominal exchange rate, are rejected at any conventional significance level.

Table 1: Contemporaneous coefficients in selected structural models

	Levels	Levels	Levels	Differences
	(1991:01 - 2001:01)	(1991:01 - 1998:01)	(1989:01 - 2001:01)	(1991:01 - 2001:01)
a21	0.022	-0.005	0.017	0.020
Std. Error	0.011	0.015	0.009	0.011
a31	-0.005	-0.008	-0.012	-0.006
Std. Error	0.005	0.008	0.005	0.005
a32	-0.003	-0.017	0.023	-0.036
Std. Error	0.041	0.056	0.044	0.041
a41	-0.265	-0.183	-0.325	-0.286
Std. Error	0.178	0.261	0.152	0.174
a51	-0.143	-0.385	-0.295	-0.425
Std. Error	0.533	0.303	0.456	0.523
a54	-0.027	-0.084	0.286	0.210
Std. Error	0.270	0.126	0.247	0.271
a62	-0.099	0.078	0.087	-0.205
Std. Error	0.202	0.254	0.185	0.229
a63	1.920	1.631	1.559	1.639
Std. Error	0.453	0.489	0.355	0.511
a65	0.008	0.027	0.007	0.010
Std. Error	0.004	0.013	0.004	0.005
a71	0.018	0.043	-0.016	0.008
Std. Error	0.018	0.025	0.017	0.018
a72	0.223	0.240	0.119	0.082
Std. Error	0.150	0.175	0.155	0.146
a73	0.598	0.320	0.288	0.759
Std. Error	0.355	0.354	0.317	0.340
a74	0.005	0.014	0.005	0.007
Std. Error	0.009	0.010	0.009	0.009
a75	0.004	-0.010	0.002	0.003
Std. Error	0.003	0.009	0.003	0.003
a76	0.133	-0.006	0.135	0.038
Std. Error	0.067	0.074	0.070	0.058
Chi-Square(6)	2.863	7.654	6.228	5.139
Signif. Level	0.826	0.265	0.398	0.526

4 The effects of monetary policy shocks

4.1 Theory

Traditional literature predicts that a monetary contraction would have the following effects:

1. First, the general situation is that in the presence of a domestic monetary contraction, initially interest rates rise and monetary aggregates fall.

2. The price level and the output level declines in the short to medium terms. An increase in interest rates can be interpreted as a sign that the monetary authority believes that the economy is growing more than expected. In other words, current output is greater than potential output, which generates inflationary pressures. Thus, with this theoretical interpretation, one would think that an increase of interest rates would imply a decline in output to the potential output level, reducing the price to its level of full employment. In this case, a monetary contraction affects both the price level and output through two potential channels. First, an increase in the interest rate managed by the CBC would increase the cost of borrowing in the market, a move that could be expected to reduce both consumer spending and investment, and consequently output and prices. Second, the increase in interest rates would provoke lower prices of financial assets, which may negatively affect both expenditure as consumers feel poorer, and investment by increasing the cost of capital.

3. Variations in interest rates caused by monetary policy affect the exchange rate. An unexpected increase in the domestic policy rate would lead to a rise in the peso against the dollar on impact. The appreciation is due to the fact that higher domestic interest rates causes peso assets to become more attractive to local and foreign investors. Then, the exchange rate moves to a level at which agents expect a future depreciation in the peso. Thus, it will reduce the attractiveness of peso-denominated assets.

4. Analogously, for the same reasons as domestic interest rate effects, an unexpected hike of both the foreign interest rate and the risk premium

would imply a depreciation of the exchange rate. A contractionary foreign monetary policy that increases the domestic interest rate for a given expected inflation rate would lead to a persistent nominal and real depreciation of the exchange rate. However, the real depreciation would be short-lived after prices have adjusted to their pre-shock levels.

4.2 Empirical evidence

This section is divided in three subsections. Section 4.2.1 presents the effects of a domestic monetary contraction, analyzing the variables responses to a one standard structural deviation shock. Section 4.2.2 shows the results of the variance decomposition analysis to determine what fraction of the variance of each series is attributable to each shock. Finally, Section 4.2.3 shows the responses of Chilean macroeconomic variables to a foreign monetary innovation.

Figures 4 and 5 exhibit impulse responses to a one-standard domestic interest rate innovation over output, price level, real ex-post interest rates, monetary aggregates, and the real exchange rate, while Figures 6 and 7 report impulse responses to a one-standard structural shock in the foreign interest rate and in the risk premium over the same variables. The horizon is 36 months. In each graph, the solid line path corresponds to the impulse responses of the variables, while the dashed lines describes the error bands generated from 1000 draws by bootstrapping integration.

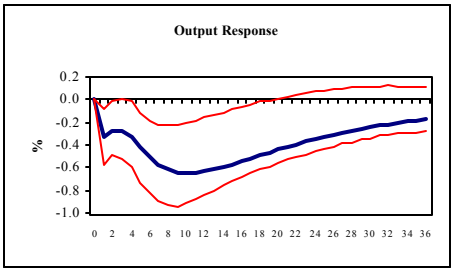
4.2.1 Effects of a domestic monetary contraction

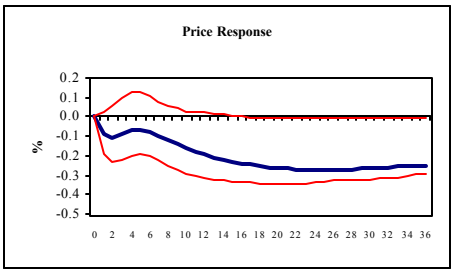
Figure 4 presents the impulse responses to a one-standard domestic interest rate shock considering two types of foreign shocks. The first column shows the impulse responses of the SVAR that includes the U.S. Fed Funds rate (FFR), while the second column displays the same exercise with a measure of emerging markets risk premium (EMBI).

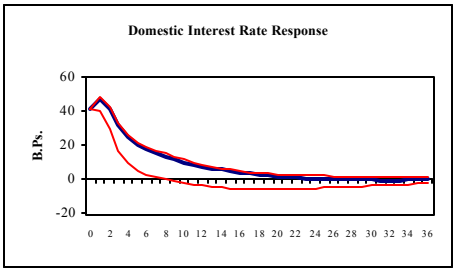
The impulse response functions in both cases appear to be consistent with conventional wisdom. Specifically, several interesting results emerge.

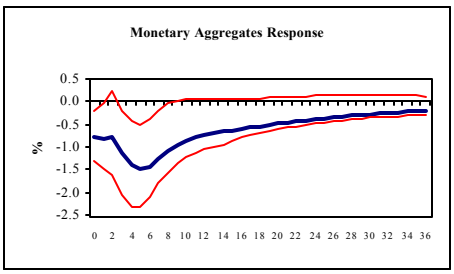
Figure 4: Dynamic Responses to Domestic Interest Rate Innovations

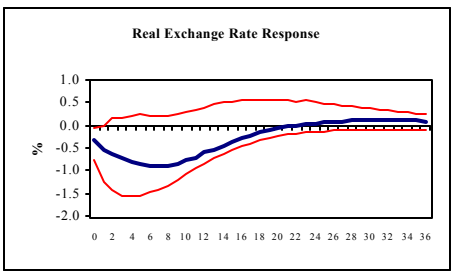
SVAR including FFR (41 bps)



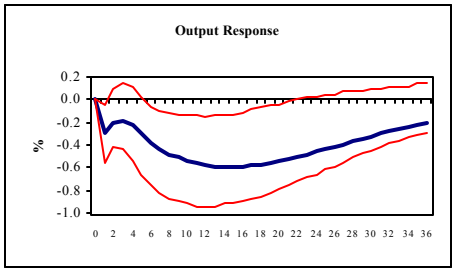


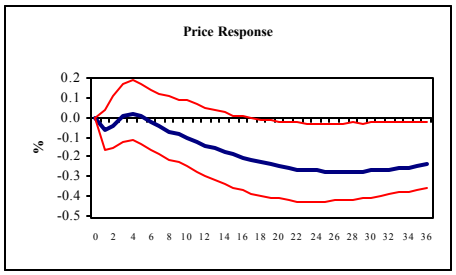


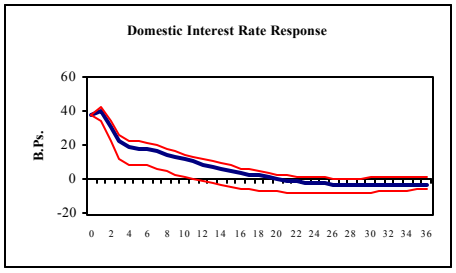


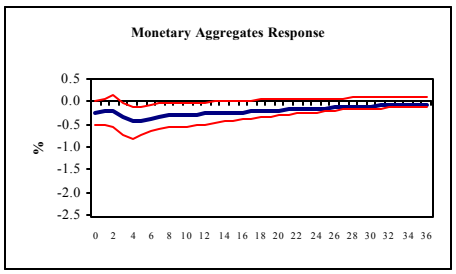


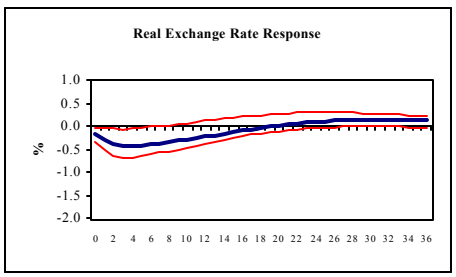
SVAR including EMBI (38 bps)











First, output appears to be significatively lower from the fifth month on, with a lasting effect of at least one year. In particular, an increase of domestic interest rates of about 100 bps[21] causes a decline in output of 1.0 – 1.3 percent in the sixth month and 1.4 – 1.6 percent in one year. This result is consistent with the Mundell-Fleming framework, in which monetary shocks have large effects in output in the presence of (relatively) flexible exchange rates.

Second, in response to the money supply, interest rate rises and the money supply falls 2.7 – 3.5 percent in the sixth month and 1.7 – 2.1 percent in one year, while the increase in interest rates tends to be similar in terms of persistence (almost 8 months), than the decline in monetary aggregates.

Third, the price level tends to fall over the entire horizon following the monetary contraction. However, given the wide confidence interval bands, monetary innovations take some time, 15 months, to unfold a significant effect over the price level. Moreover, there is no evidence of a price puzzle as it is found in many previous studies. For example, Calvo and Mendoza (1998), using a monthly sample from 1987:01 to 1997:05, conclude that the Chilean price level increases (however, this result is statistically significant only in one case of four) before a one percent shock to the policy innovation (given by a 90-day indexed lending rate). Morandé and Schmidt-Hebbel (1997), Valdés (1998), and Chumacero (2000) show no clear conclusions regarding inflation (not the price level). However, the former two conclude that innovations in the domestic interest rate show evidence of reducing the inflation gap (difference between actual core inflation and the inflation target of the period). In our case, the baseline SVAR has not considered directly the inflation gap because all the variables which the CBC conditions its inflation target are already included in the system. Moreover, the introduction of a measure of the inflation gap into the SVAR model would imply theoretical difficulties in explaining the systematic link between that variable and its impact over the other variables of the system.

Finally, the effects of monetary policy shocks on the level of the exchange rate are considered. The impact effect of a monetary contraction of 100 bps is a statistically significant real exchange rate appreciation of almost one percent (0.83 – 0.95 percent). Later, in accordance with the uncovered interest parity condition (UIPC), the real exchange rate reverts its tendency given

[21] A one-standard deviation of domestic monetary innovations corresponds to 41 bps or 38 bps depending if the SVAR includes the FFR or the EMBI, respectively. See third row of Figure 4. The size of the shock appears to be similar to the one presented in U.S. (approximately 50 bps), but small to some European countries (up to a 100 bps in Italy).

by the expected depreciation produced by the initial appreciation. These effects are lower than one could theoretically expect for a country with flexible exchange rates. For example, Zettelmeyer (2000), using an empirical methodology different from VARs, finds that on average, a 100 bps points contractionary shock appreciates the exchange rate by 2 to 3 percent in Australia, Canada, and New Zealand.

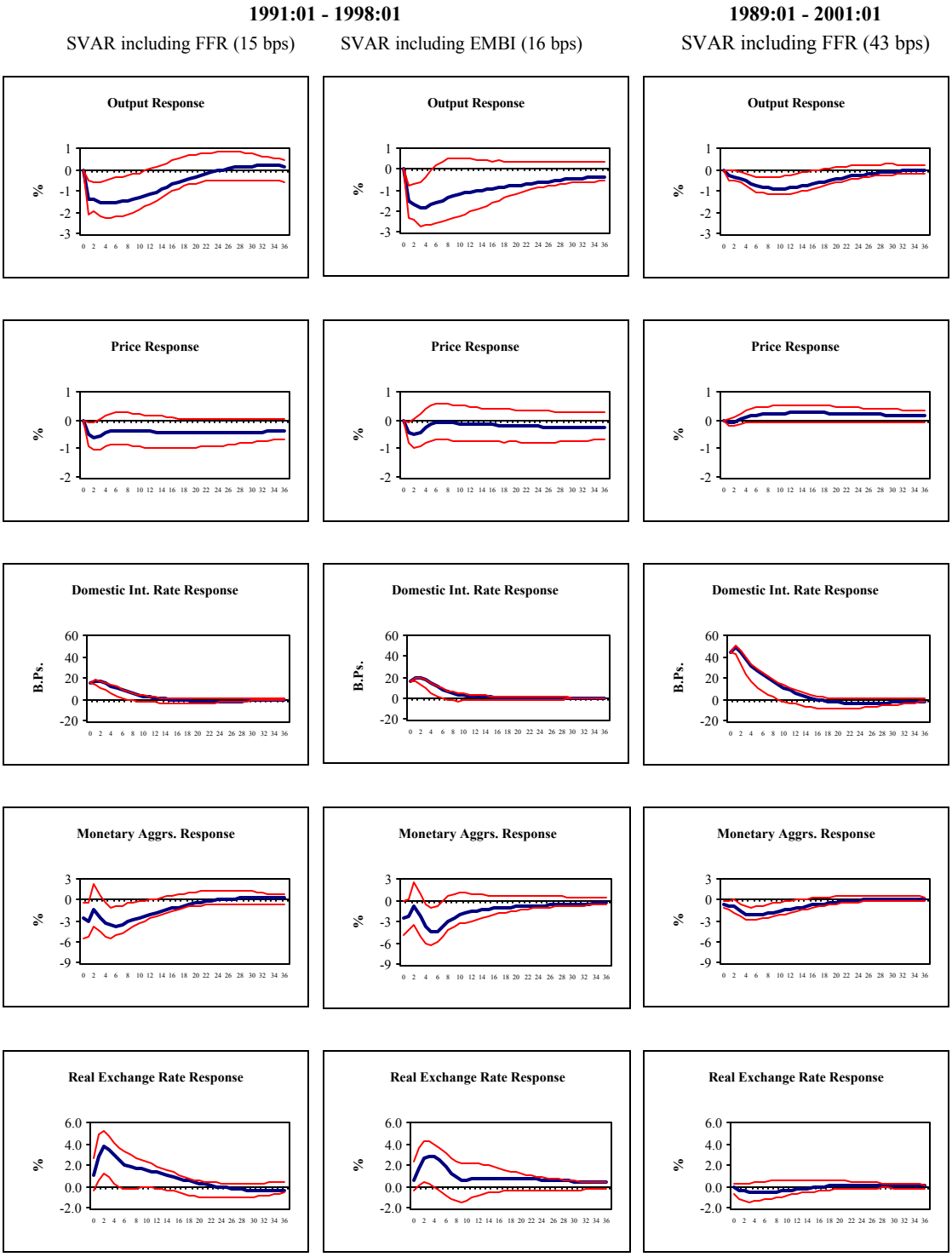
Robustness of these results are examined experimenting with different samples, different structural models (SVAR in differences), and different variables within the baseline SVAR. In Figure 5 we can observe some exercises with different samples, including a pre-East Asian crisis sample period. In general, the results are consistent with the benchmark case: 1991:01 – 2001:01 for all variables. The only exception is the presence of the exchange rate puzzle in the 1991:01 – 1998:01. This puzzling implication of the data can be explained by two factors inherent to that particular sample period, for instance, the taxation of capital inflows and a managed exchange rate regime.

Table 2: Selected SVAR exercises (1991:01 – 2001:01)

SVAR model	r-shock	Comments
$\{wop,\ y,\ p,\ r^*[\rho],\ r,\ m,\ rer\}$	✓	Consistent with theory
$\{wop,\ y,\ \mathbf{cp},\ r^*,\ r,\ m,\ rer\}$	✓	Price puzzle (not significant)
$\{wop,\ y,\ p,\ r^*,\ r,\ m,\ \mathbf{ner}\}$	✓	Consistent with theory
$\{\mathbf{wcp},\ y,\ p,\ r^*,\ r,\ m,\ rer\}$	✓	Consistent with theory
$\{\Delta wop, \Delta y,\ \Delta p,\ r^*,\ r,\ \Delta m,\ \Delta rer\}$	✓	Consistent with theory

Table 2 also shows some robustness exercises that considers changes in the baseline model with different variables (one by one): core price level (cp), nominal exchange rate (ner), world commodity prices (wcp). The check mark stands for similar effects than baseline SVAR. In general, the results do not change significantly in comparison to the main SVAR; in only one case does the price puzzle appear; however, this effect is not significant. The main results also hold if an SVAR in differences is used.

Figure 5: Dynamic Responses to Domestic Interest Rate Innovations. Selected Samples



4.2.2 Sources of output, price level, and real exchange rate fluctuations

This section presents the variance decomposition analysis to determine what fraction of the variance of each series is attributable to each shock. Tables 3 to 5 show the sources of output, the price level, and the real exchange rate variations, respectively. The top of the table shows the source of fluctuation, while the first column displays the horizon at which forecast errors were calculated.

Output variance decomposition: In this case, the results can be summarized as follows (see Table 3): first, foreign shocks have a substantial effect on output volatility, especially real exchange rate shocks has been the dominant source of domestic output fluctuations. At a six-month horizon, the real exchange rate shock explains 15.5 percent of output fluctuations, while in the first year is almost 20 percent, reaching 15.7 percent in the second year. The world oil price and the foreign rate shocks explain over 10 percent in the sixth month, reaching almost 15 percent in the second year. This seems plausible considering the fact that Chile is a small economy and very sensitive to a variety of foreign shocks, terms of trade shocks, in addition to the country's dependence of natural resources, both in exports (e.g., copper, fresh fruits, and the like) and imports (e.g., oil). Third, the monetary policy shock has relatively little impact on domestic output in the initial months, becoming more influential after a year. This result is consistent with many other authors like Kim (1999) and Kim and Roubini (2000) in which monetary policy shocks are not major sources of output volatility in G-7 countries.

Table 3: Output Variance Decomposition

Horizon	Std. Error	*wop*	*y*	*p*	r^*	*r*	*m*	*rer*
1	0.008	3.41	96.59	0.00	0.00	0.00	0.00	0.00
6	0.015	9.88	55.94	1.74	0.75	5.60	10.60	15.49
12	0.019	11.47	38.17	1.46	1.44	14.06	13.70	19.70
18	0.021	11.36	32.28	4.01	3.07	18.74	13.33	17.21
24	0.023	10.50	29.65	8.21	4.28	19.71	11.98	15.67
30	0.024	9.58	28.19	12.22	4.56	19.04	10.73	15.70
36	0.025	8.93	27.16	15.25	4.37	18.16	9.87	16.27

Price variance decomposition: Table 4 shows the fraction of the forecasting error variance of the price level. Of all the shocks, the domestic interest rate plays the most important role in explaining price level fluctuations in the medium-term, although, it only explains 10 percent of the price level fluctuation in the second year. In shorter periods, the dominant source of variations comes from monetary aggregates.

Table 4: Price Variance Decomposition

Horizon	Std. Error	wop	y	p	r^*	r	m	rer
0	0.004	0.80	0.01	99.14	0.00	0.00	0.00	0.00
6	0.008	0.34	0.22	90.98	0.70	1.15	4.42	2.20
12	0.010	1.69	0.30	84.78	0.52	3.33	6.61	2.78
18	0.011	3.58	0.24	78.83	0.41	6.87	7.51	2.56
24	0.012	5.07	0.26	74.24	0.36	9.98	7.54	2.55
30	0.014	6.06	0.43	71.03	0.35	12.16	7.18	2.79
36	0.015	6.66	0.70	68.82	0.36	13.54	6.73	3.19

Real exchange rate variance decomposition: Finally, in Table 5 we can observe that monetary policy shocks have a relatively weak effect over the real exchange rate variability, especially in the short run. Kim and Roubini (2000) find a similar effect in some of the G-7 countries: Canada and Italy, where domestic monetary policy explains between 4 percent (6 months) and 6 percent (24 months).

Table 5: Real Exchange Rate Variance Decomposition

Horizon	Std. Error	wop	y	p	r^*	r	m	rer
0	0.014	0.65	1.91	0.81	0.29	0.99	3.08	92.27
6	0.039	4.17	11.42	3.38	0.05	3.90	9.43	67.64
12	0.044	5.55	16.65	4.80	0.43	6.27	8.64	57.66
18	0.047	5.18	18.23	5.42	1.17	6.17	8.87	54.97
24	0.048	4.97	18.35	5.48	2.05	5.89	9.15	54.12
30	0.048	4.89	18.12	5.40	2.97	5.82	9.26	53.54
36	0.049	4.85	17.96	5.42	3.71	5.81	9.24	53.02

In sum, the source of Chilean output, price level, and the real exchange rate volatility is similar to the one presented in some industrial countries, where monetary policy explains a relatively reduced proportion of output, price level, and real exchange rate fluctuations. These results should not suggest that monetary policy has been unimportant during the 1990s. There are two main reasons. First, it could be possible that systematic monetary policy (rather than unanticipated) decreases the variance of output and inflation. Second, in contrast with impulse response functions, variance decomposition exercises do not tell us anything about the potential effects of monetary policy surprises; they only bring information about the combination of the potential effect with the actual monetary policy shocks for particular samples.

4.2.3 Effects of foreign interest rate shocks

This subsection reports the effects of a positive foreign interest rate shock (U.S. Federal Funds rate innovation) to Chilean macroeconomic variables. The impulse responses are presented in Figure 6.

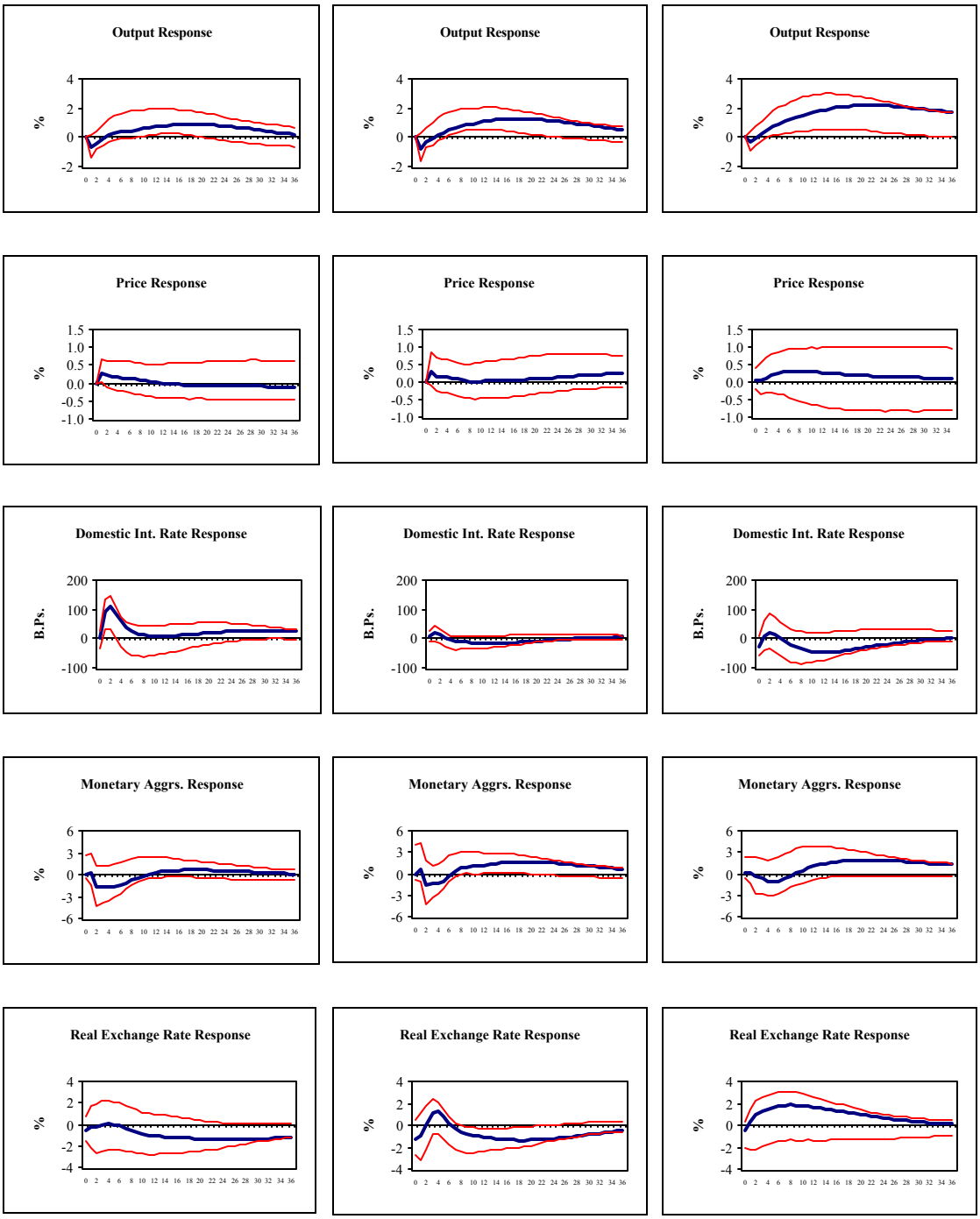
First, a positive innovation of 100 bps[22] in the foreign interest rate implies a domestic interest rate increase of 20 bps on impact; while after that, only two periods present statistically significant expansions of over 600 bps. There are two possible reasons. First, since the Unites States is a large economy, Chilean interest rates tend to follow hikes of U.S. interest rates. In the Chilean case, this phenomenon can be explained by the fact that the monetary authority has a very strong commitment to maintain stability of prices through the inflation targeting regime. Therefore, under the UIPC, a rise in foreign interest rates would be associated with a depreciation and consequently it would create some pressures on the consumer price index through the price of tradable goods. It is also worth noting that this effect has a very short persistence of two months.

Second, because of the first result, there are no significant effects over the price level and the real exchange rate. This lack of flexibility could be an argument in favor of the "fear of floating" literature; however, the causes for this behavior result, instead, by the "fear of inflation" that comes from the inflation targeting regime rather than the direct concern of exchange rate fluctuations.

[22] A one-standard deviation in foreign interest rates corresponds to 14 bps.

Figure 6: Dynamic Responses to Foreign Interest Rate Innovations. Selected Samples

1991:01 - 2001:01	**1991:01 - 1998:01**	**1989:01 - 2001:01**
Foreign interest rate shock (14 bps)	Foreign interest rate shock (13 bps)	Foreign interest rate shock (15 bps)



Third, a positive innovation in foreign interest rates involves an initial decline in domestic monetary aggregates. However, the dynamic response is not statistically significant. The reason is that the foreign innovation implies an increase in the domestic interest rate and consequently monetary aggregates tend to decrease.

Finally, output has both positive and negative responses. Initially, output decreases on impact because of higher interest rates. However, in the medium term output increases because lower interest rates boost aggregate demand, tending to increase activity.

In most cases (see also Figure 7), the effects of foreign monetary policy innovations have very short-lived significant effects on domestic interest rates. However, the dynamic responses of the other Chilean macroeconomic variables are not statistically significant after a foreign monetary contraction.

4.2.4 Effects of risk premium shocks

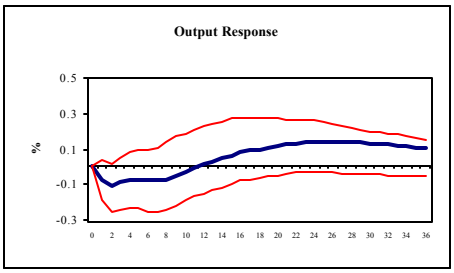
The effects of risk premium shocks are similar (see Figure 7), as one could have expected, to the ones presented for foreign interest rate shocks. The main difference is that the effect of risk premium innovations produces significant effects, not only over the domestic interest rate, but also over monetary aggregates and exchange rates. In particular, the impact of an increase in the risk premium index, for example, 300 bps[23] in the EMBI index, leads to a positive change of 20 bps on domestic interest rates on impact, depreciating the exchange rate 1.4 percent. The maximum impact is reached in the next period with an increase of 24 bps in the case of domestic interest rates and a depreciation of the exchange rate of 1.9 percent.

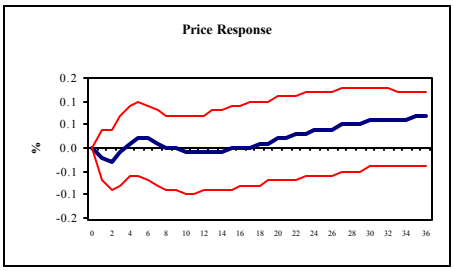
The risk premium shock, in terms of effects over Chilean variables, is stronger than foreign interest rate shocks. The impact over the domestic interest rate is almost double, consequently, the impact over monetary aggregates and the real exchange rate is also larger. This result could suggest that the Chilean economy is more sensitive to changes in international conditions through variations in emerging markets risks rather than fluctuations in foreign interest rates.

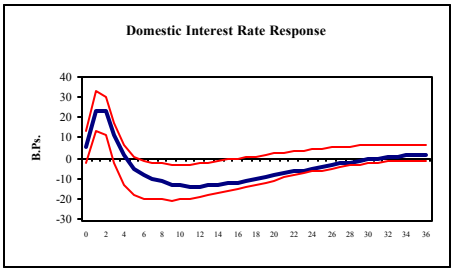
[23] A one-standard deviation in the risk premium corresponds to 89 bps.

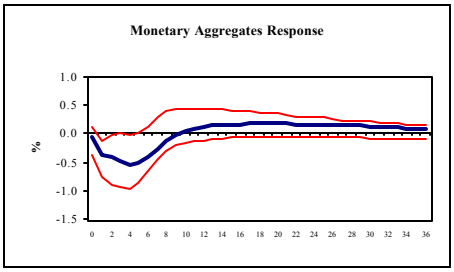
Figure 7: Dynamic Responses to Risk Premium Innovations. Selected samples

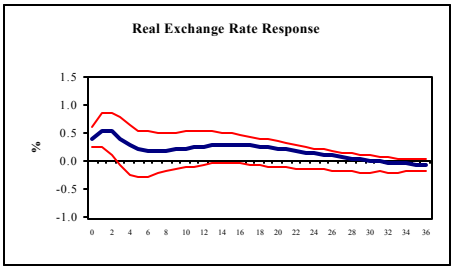
1991:01 - 2001:01
Risk premium shock (89 bps)



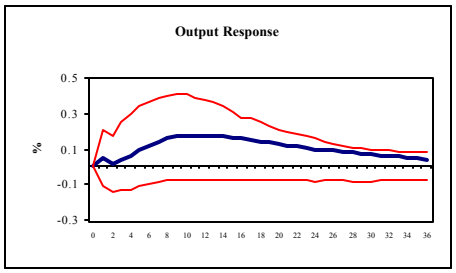


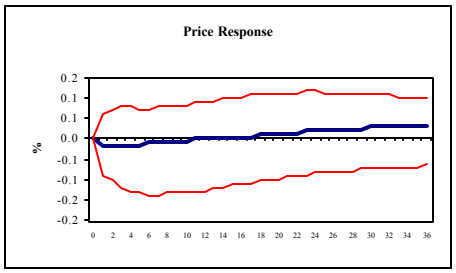


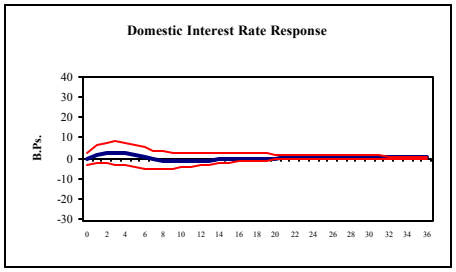


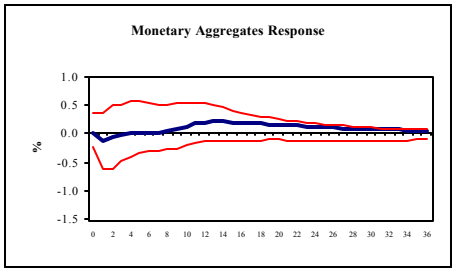


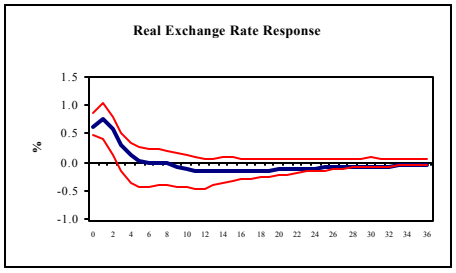
1991:01 - 1998:01
Risk premium shock (83 bps)











These previous results would suggest that the CBC is reluctant to let the exchange adjust in response to a foreign interest rate shock but it is not the case for risk premium shocks.[24] Thus, there is combined (partial) evidence that the flexible exchange rate regime has helped to insulate Chile from risk premium shocks, and therefore an argument contrary to the fear of floating argument.

5 Concluding remarks

This paper has developed a structural vector autoregressive model of the Chilean economy based on Cushman and Zha (1997) and Kim and Roubini (2000), in which their identification design permits solving conventional empirical puzzles. In particular, the results show no evidence of both price and exchange rate puzzles.

Key insights which differentiate this work from previous studies come from imposing some reasonable restrictions on contemporaneous relations among Chilean macroeconomic variables and from including variables representing expected inflationary pressures. These features would help to avoid, to a certain extent, potential empirical puzzles.

In general, the results are consistent with traditional theory. First, domestic monetary innovation generates an increase in the interest rate, a transitory fall in output and in monetary aggregates, a decline in the price level, and an appreciation of the exchange rate. Second, the source of domestic volatility is very similar to the one presented in some industrial countries, where monetary policy explains a relatively reduced proportion of output, price level, and the real exchange rate variability. Third, the effects of foreign monetary policy innovations have very short-lived effects on domestic interest rates and have no major influence over other Chilean macroeconomic variables. Finally, in contrast to the foreign interest rate, risk premium innovations have significant effects over domestic interest rates and the real exchange rate.

In terms of current CBC monetary policy, the model can yield some rec-

[24] Similar results hold with daily VARs that consider the variables of the uncovered interest parity condition: domestic and foreign interest rates, risk premium, and the exchange rate. In the baseline SVAR, both the risk premium and the foreign interest rate could have been added simultaneously; however, to save degrees of freedom the model includes these shocks separately.

ommendations. First, as long as the CBC follows its systematic rule and minimizes erratic behavior of interest rates, it would be convenient to give greater flexibility to the exchange rate because of the positive effects over real activity. However, we would additional years of data to capture a clearer illustration of the exchange rate flexibility during the inflation targeting regime.

A natural next step for this research project would be to extend the analysis to the systematic component of monetary policy to analyze how the CBC works in practice.

Appendix 6.1 Empirical studies (VAR) on monetary policy in developed countries

Author (year)	Country/ Frequency	Model/Method of estimation	Variables used	Main findings (Impulse-response)	Main findings (Variance decomposition)
Cushman and Zha (1997)	Canada, monthly data 1974-1993.	10-variable SVAR (Exc, M1, R, P, y, Tx, Tm, y*, P*, R*, Wxp*). 12 lags.	• Exchange rate, Exc, dollar price of Canadian currency • Money, M1, Canadian M1 • Domestic interest rate, R, Canadian 3-month Treasury bill rate • Nominal prices, P, Canadian CPI • Output, y, Canadian industrial production • Exports, Tx; • Imports, Tm • Foreign output, y*, US industrial production • Foreign prices, p*, US CPI • Foreign interest rate, R*, US federal funds rate • Foreign export prices, Wxp*, world total exports commodity price index in US$.	• **Domestic monetary shock** (interest rate): Output: -(mo:1-6) Prices: +(mo:2), -(mo: 13, 20--33) Nominal exchange rate: +(mo: 13) Real exchange rate: +(mo: 2-3) • **Foreign monetary shock:** not analyzed • **Risk premium shock:** not analyzed.	**V.D. of ouput** Production: 17%-100% Foreign: 0%-79% Money demand: 0%-1% Money supply: 0%-3% Information: 0%-4%.
Kim (1999)	U.S., Germany, Japan, U.K., France, Italy, Canada. Monthly data 1965.03 - 1997.05.	5-variable SVAR (CR, M, CPI, IP, CMPW). 14 lags.	• Domestic interest rate, CR, call money rate • Money, M, M1 or M2 • Nominal prices, CPI • Output, IP, industrial production • Foreign export prices, CMPW, world export commodity price index.	• **Domestic monetary shock** (interest rate): Output: -(mo: 2-24) Prices: -(mo: 3-48) All the results differ among countries. • **Foreign monetary shock:** not analyzed • **Risk premium shock:** not analyzed.	**V.D. of ouput** Money: 0%-38% All the results differ among countries.
Kim and Roubini (2000)	Germany, Japan, U.K., France, Italy, Canada. Monthly data 1974.07-1999.12.	(i) 7-variable SVAR (R, M, CPI, IP, OPW, FFR, E(/$)). (ii) Model (a) with RE(/$) instead of E(/$). 6 lags.	• Domestic interest rate, R, short-term rate • Money, M, M0 or M1 • Nominal prices, CPI • Output, IP, industrial production • Foreign prices, OPW, US$ world price of oil • Foreign interest rate, FFR, U.S. Fed Funds rate • Exchange rate, E(/$), foreign currency/ US dollar. • Real exchange rate, RE(/$).	• **Domestic monetary shock** (interest rate): Models (a) and (b) Output: -(mo: 4-24) Prices: -(mo: 3-48) Nominal exchange rate: -(mo: 1-40) Real exchange rate: -(mo: 1-24). • **Foreign monetary shock:** (interest rate): Output: +(mo: 1-6) and -(mo: 12-24) Prices: +(mo: 2-24) Nominal exchange rate: +(mo: 1-3) All the results differ among countries. **Risk premium shock:** not analyzed.	**V.D. of ouput** Money: 1%-25% Foreign prices: 1%-28% Foreign interest rate: 1%-36% Exchange rate: 0%-30% All the results differ among countries.

NOTE: +( ) : represents a positive significant effect; the number in parenthesis indicates the month(s) in which the effect is significant
-( ) : represents a negative significant effect; the number in parenthesis indicates the month(s) in which the effect is significant.

Appendix 6.2 Empirical studies (VAR) on monetary policy in Chile

Author (year)	Data frequency	Model/Method of estimation	Variables used	Main findings (Impulse-response)	Main findings (Variance decomposition)
Rosende and Herrera (1991)	Quarterly data 1978.01-1990.02.	Standard 5-variable VAR (r, h, p, m, y). Two models: monetarist (variable order: h, m, r, p, y) and non-monetarist (h, r, m, p, y). 3 lags.	• Real interest rate, r (90-365-day indexed deposit rate) • Real exchange rate, h • Nominal prices, p (CPI) • Money, m (M1A) • Output, y, (GNP).	• **Domestic monetary shock** (interest rate): Output: +(qu:1-8), cyclically disappears (qu:30). Prices: -(qu: 1-3), cyclically disappears qu:36). Price puzzle not found. Domestic interest rate: not reported. Real money balances: +(qu:1-4). Real exchange rate: not reported. NOTE: confidence intervals are not reported. • **Foreign monetary shock:** not analyzed • **Risk premium shock:** not analyzed.	• **V.D. of prices** Output: 0%-2%; Prices: 38%-50% Domestic interest rate: 11%-23% Money: 1%-5% Real exchange rate: 25%-47% • **V.D. of ouput** Output: 15%-73% Prices: 9%-18% Domestic interest rate: 1%-14% Real money balances: 16%-25% Real exchange rate: 2% - 45%.
Rojas (1993)	Quarterly data 1978.01-1991.02.	(i) Standard 2-variable VAR (money and PGB). (ii) Model (i) and TIN (iii) Model (i) and TIR (iv) Model (iii) and bank loans (v) Model (iii) , G and TCR.	• Nominal interest rate, TIN, (30-89-day not-indexed deposit rate) • Real interest rate, TIR, (30 to 89-day indexed deposit rate) • Nominal prices (CPI) • Money, (base money, M1, M1A) • Output, PGB (GNP) • Real exchange rate, TCR • Public expenditure, G.	· **Domestic monetary shock,** nominal interest rate, model (ii): Output: -(mo: 1-oo). · **Domestic monetary shock,** nominal interest rate, model (iii): Output: -(mo: 1-11, 18-24), +(mo: 12-17). NOTE: confidence intervals and number of lags not reported. Models (iv) and (v) are not reported. Price puzzle not analyzed. · **Foreign monetary shock**: not analyzed. · **Risk premium shock:** not analyzed.	**VD of output**: · Model (i) and (ii) Output: 22%-69% Prices: 1%-24% Nominal interest rate: 0%-8% Money: 31%-48% · Model (iii), (iv) and (v): Output: 22%-75% Prices: 0%-13% Real interest rate: 0%-40% Money: 11%-30% Bank loans: 5%-39%.
Valdés (1997)	Monthly data 1985.01-1996.08.	(i) 6-variable VAR (policy rate, underlying inflation, output growth, money growth, real exchange rate growth, terms of trade growth. (ii) Model (i) with expenditure growth (iii) Model (i) with inflation gap. (iv) Model (i) with expenditure growth and inflation gap. 3 lags.	· Policy rate: 90-day indexed interest rate PRBC (1985-95) and interbank rate (1995-96). · Underlying inflation · Output growth, IMACEC · Money growth (M1A) · Real exchange rate growth · Terms of trade (some commodities and US WPI) · Inflation gap (between underlying and target inflation).	• **Domestic monetary shock (policy rate):** Models (i), (ii) and (iv): Output: -(mo: 7-15) Inflation gap: -(mo: 5-14) Underlying inflation: +0(oo). Price puzzle found (not significant). Money: -(mo: 3-7) Real exchange rate: +0 Underlying inflation: +0 Policy rate: +(mo: 1-14) Model (c*)*: similar results except · **Foreign monetary shock**: not analyzed · **Risk premium shock:** not analyzed.	**V.D. of inflation**: · Model (iv): Output: 1%-24% Inflation gap: 1%-21% Policy rate: 64%-100% Money: 1%-18% Real exchange rate: 1%-3% · Models (i), (ii) and (iii) are not reported.

Author (year)	Data frequency	Model/Method of estimation	Variables used	Main findings (Impulse-response)	Main findings (Variance decomposition)
Morandé and Schmidt-Hebbel (1997)	Monthly data 1983.01-1997.03.	(i) 8-variable relatively unrestricted VAR (exogenous: FINF, RIR, TARG; endogenous: MG,NERG, NWG, ROG, INF) (ii) Model (i) with FINF and TARG exogenous. (iii) Model (i) with FINF exogenous. (iv) Model (i) without RIR, TARG, MG, ROG. 3 lags.	· Foreign inflation, FINF · Money growth, MG: M1. · Nominal exchange rate growth, NERG · Nominal wage growth, NWG: index of national wages and salaries. · Real output growth · ROG: IMACEC · Inflation target, TARG: official targets (Central Bank of Chile). · Real interest rate, RIR: 90-365-day UF-indexed rate. · Inflation rate, INF: CPI.	· **Domestic monetary shock** (interest rate): Model (ii) (w/o inflation target): Inflation: +(mo: 1-2, 5-12); +(mo: 2-23). Price puzzle found (significant). Model (iii) (w/o inflation target): Inflation: 0 • **Domestic monetary shock** (inflation target): Model (iii) (w/o inflation target): inflation: +(mo:2); +(mo: 1,4, 10-14). Model (iv) (w/o inflation target): inflation: -(mo:2); +(mo: 1,12-22). • **Foreign monetary shock**: not analyzed • **Risk premium shock:** not analyzed.	**V.D. of inflation** • Model (ii) without inflation target: Output: 0%-1% Inflation: 37%-91% Money: 1%-16% Real interest rate: 0%-1% Nominal exchange rate: 6%-34% • Model (iii) with inflation target: Output: 0%-2% Inflation: 30%-89% Inflation target: 7%-18% Money: 0%-3% Real interest rate: 0%-5% Nominal exchange rate: 1%-9%.
Calvo and Mendoza (1998)	Monthly data 1986.01-1997.05.	(i) Recursively-identified-8-variable VAR (R90, LP, LRER, LY, LM1A, LNIR and TOT). Contemporaneous effect: to R90 shock: LM1A, LNIR. (ii) Standard 8-variable VAR: and copper price. 6 lags.	• Interest rate, R90, 90-day indexed lending rate • Prices, LP, CPI • Real exchange rate, RER, IMF´s measure • Output, LY, IMACEC • Money, LM1A, M1A • Net international reserves, LNIR.	· **Domestic monetary shock,** R90, model (i); (ii): Output: +0-; +(mo: 9-14) Prices: +0 (oo); +(mo: 1-4, 10-18). Price puzzle found (significant). Interest rate: +(mo:1-2); similar results Real exchange rate: 0; similar results Money: 0; -(mo: 1,2,4) Net international reserves: 0; -(mo:1) • **Foreign monetary shock**: not analyzed. • **Risk premium shock:** not analyzed.	Variance decomposition is not reported.
Cabrera and Lagos (1999)	Monthly data 1986.01-1997.12	(i) 7-variable SVAR (BRECHA, LIPCNT, LTCN, LTCRINE, LTTUC, TASABC and TBE). (ii) Model (i) and money, loans, underlying prices. (iii) Model (ii) and stock exchange index (without bank loans) (iv) Model (iii) and output gap (without money and stock exchange index) (v) Model (i) and Libor rate (without BRECHA, LTTUC and TBE). 3 to 6 lags.	· Output-expenditure gap, BRECHA · Prices, LIPCNT (non tradable goods) · Nominal exchange rate, LTCN · Real exchange rate, LTCRINE · Terms of trade, LTTUC · Real interest rate, TASABC, 90-day indexed rate (PRBC) and, TASABC, (8-year PRC).	· **Domestic monetary shock,** interest rate Models (i); (ii); (iii); (iv): Output-expenditure: -0; -0; -(mo: 15-18); 0 Real exchange rate: +0. Models (i); (ii); (iii): Prices: - (mo: 13-21); +0(oo); +0(oo). Price puzzle not found (significance depends on model). Models (i); (iv); (v): Inflation: +0(oo); 0; +(mo: 6-11,14-15). Price puzzle found (significance depends on model). • **Foreign monetary shock**: not analyzed. • **Risk premium shock:** not analyzed.	Variance decomposition is not reported.

Author (year)	Data frequency	Model/Method of estimation	Variables used	Main findings (Impulse-response)	Main findings (Variance decomposition)
Landerretche, Morandé and Schmidt-Hebbel (1999)	Monthly data 1983-1998.	Restricted 8-variable VAR (IMACEC, IPCEXT, TCN, IPC, MONEY, WAGES, TASA and TTRADE). Time trend included.	· Endogenous: real output growth (IMACEC), nominal exchange rate growth (TCN), CPI inflation (IPC), nominal wage growth (WAGES), nominal money growth (MONEY), 90-365 day financial-system indexed interest rate (TASA). · Exogenous: foreign inflation (IPCEXT), rate of change of terms of trade (TTRADE).	Inflation forecasts are typically higher than both target and actual inflation rates. Price puzzle not analyzed. NOTE: confidence intervals are not reported. Impulse-response functions are not reported.	Variance decomposition is not reported.
Chumacero (2000)	Monthly data 1985.01-2000.05.	7-variable SVAR (y*, y, e, P, M, r^e, i). 2 lags.	· Foreign output, industrial production index, y* · Output, y, (IMACEC) · Real exchange rate, e · Prices, P, CPI · Money, M, M1 · Real interest rate, r^e, 90-day UF-indexed rate (PRBC). · Nominal interest rate, i, 90-day non indexed rate (PDBC).	• **Domestic monetary shock** (real interest rate): Output: -(mo:1, 5-9). Prices: -(mo:1). Price puzzle found (not significant). Real exchange rate: 0. • **Domestic monetary shock** (nominal interest rate): Output: 0 Prices: +0(oo). Price puzzle found (not significant). Real exchange rate: +(mo:1) • **Foreign monetary shock:** not analyzed • **Risk premium shock:** not analyzed.	Variance decomposition is not reported.

NOTE:
- 0 : represents a non significant effect
- +0 : represents a positive effect that is not significant
- -0 : represents a negative effect that is not significant
- +0(oo) : represents a permanent positive effect that is not significant
- +( ) : represents a positive significant effect; the number in parenthesis indicates the quarter(s)/month(s) in which the effect is significant
- -( ) : represents a negative significant effect; the number in parenthesis indicates the quarter(s)/month(s) in which the effect is significant
- -(1-oo) : represents a negative significant effect; the symbol in parenthesis indicates a permanent effect.
- qu : quarter(s)
- mo : month(s)
- w, w/o : with and without, respectively.

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