The "great moderation" and the monetary transmission mechanism in Chile[1]

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I. Introduction

Chile has undergone important changes to its macroeconomic framework within the last twenty years, in particular since the recovery from the debt crisis of 1982. These changes include the granting of independence to the central bank in 1989, among others. In late 1999, after years of managed exchange rates and capital controls, and after inflation had been sharply reduced and stabilized at low levels, Chile announced the adoption of an inflation targeting regime to be put in place by 2001, the removal of capital controls, and the implementation of a flexible exchange rate regime in which official intervention is regarded as an exceptional occurrence. Finally, in August 2001 monetary policy was "nominalized": whereas previously the rate on the monetary policy instrument had been set on the basis of an ex post interest rate on inflation-indexed bonds, a nominal rate is now used instead.[3] On the fiscal front, Chile has had persistent surpluses since the mid-1980s, except during the period immediately surrounding the recession of 1999, and in 2001 a policy of achieving a structural fiscal surplus of 1 percent of GDP was implemented.

Over the same period, the Chilean economy has gone through several important structural changes. The financial sector has deepened, and the degree of openness to external economic influences has increased, with unilateral tariff reductions and the signing of many free trade agreements, most notably with the United States and the European Union. The 1990s proved to be the Chilean economy's best decade for growth in its history. Although growth has moderated in the present decade, it is still very high from both a historical and a regional perspective. Inflation has declined to levels comparable to those in the industrial economies, and the volatility of both output and inflation has fallen significantly.

With these achievements, Chile can be considered a good example of what has been called the "great moderation", a phenomenon seen in many countries in recent decades in which not only the level of inflation but also the volatility of both inflation and output have declined sharply. But whereas in many industrialized countries this phenomenon had started already in the 1980s, in Chile it began in the 1990s and has been consolidated only in recent years.

This paper examines how the macroeconomic framework developed in Chile since the early 1990s has affected the monetary transmission mechanism and economic performance, in particular regarding the volatility of some important variables. The paper looks at various performance measures, including changes in the volatility of output growth and inflation, focusing on the effects of monetary policy. The paper also reports estimates of a reduced-form vector autoregression (VAR) model to assess whether the transmission mechanism has changed over the period 1990–2006. The results suggest that changes in the transmission mechanism play an important role in explaining Chile's "great moderation". Moreover, these

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[1] This paper was prepared for the Bank for International Settlements meeting on "Transmission Mechanisms for Monetary Policy in Emerging Market Economies: What Is New?" Basel, December 2006. The views expressed in this paper are those of the authors and do not necessarily reflect the opinions of the Central Bank of Chile.

[2] Central Bank of Chile.

[3] Bonds were indexed to inflation using the unidad de fomento (UF), an indexed unit of account.

changes in the propagation of shocks are related to a large extent to the improvements in macroeconomic policies.

The paper is organized as follows. Section II describes the framework of macroeconomic policy in Chile and presents some stylized facts concerning the first two moments of inflation and output growth. It tries to explain those facts in light of the changes in policies experienced by the Chilean economy during that period. Section III addresses some preliminary background issues concerning the monetary transmission mechanism, and section IV presents the VAR model. Section V concludes.

II. The Chilean macroeconomic framework and the reduction of output and inflation volatility

The Chilean macroeconomic framework has undergone several changes in fiscal, monetary, and exchange rate policies since the beginning of the 1990s, which in turn have determined certain characteristics of the economy, especially concerning output and inflation. In this section we document some basic stylized facts of these two variables and review them in the light of recent experience.[4]

Two basic facts underlie this discussion. The first is that inflation fell persistently from the 1990s until 2000, when the full inflation targeting regime was implemented. The second is that the volatility of both output growth and inflation has declined in recent years. These facts are consistent with a "great moderation" in Chile, characterized by sharp declines in the volatility of output and inflation and in the level of inflation. A large body of research documents this "great moderation" across a number of countries and considers possible explanations.[5] In the case of Chile, some important changes in policies can be identified as having contributed to these achievements.

After a long history of high inflation, Chile experienced a downward trend in inflation during the 1980s. During the 1990s annual inflation continued to decline gradually and persistently from 27 percent in 1990 to 2.3 percent in 1999 (figures are as of December in each year). The granting of independence to the Central Bank of Chile in 1989 supported this important achievement. During 1991–99 the central bank for the first time defined an explicit target for inflation based on yearly objectives and forecasts. The first target range for inflation, announced in September 1990, was set at 15 to 20 percent for December 1991. This short-term inflation target embodied Chile's commitment to reducing inflation and reflected the need to generate credibility for the new regime in a country used to high inflation. Although the economy remained highly indexed, and monetary policy continued to seek other objectives such as real exchange rate targets within a band, a high rate of productivity growth kept wage indexation from binding and allowed the real exchange rate to strengthen, placing downward pressure on inflation (De Gregorio (2004)).

During the current period, exchange rate policies have continued to evolve: from a currency band with discrete adjustments allowed when pressures were excessive, Chile has moved to a freely floating system since late 1999. This, in turn, reduced incentives for capital inflows, which in previous years exacerbated the business cycle.[6] It is worth noting that the band was

[4] We do not perform formal tests to discriminate among them because of lack of data, but the VAR estimation later in the paper helps to highlight the effects of macroeconomic policy.

[5] See, for example, Blanchard and Simon (2001), Stock and Watson (2003), Cecchetti, Flores-Lagunes, and Krause (2005) and Kent, Smith, and Holloway (2005). For a discussion on global disinflation see Rogoff (2004).

[6] See De Gregorio (2006).

established in the context of a gradual real appreciation, following the massive inflow of foreign capital that began in 1990. Consequently, implicit targets were set for the current account, and regulations on capital account transactions, including the famous non-remunerated reserve requirement for capital inflows (encaje), were imposed as well.

Fiscal policy has been solid since the mid-1980s, but during the 1990s it became more stringent, with the objective of keeping the rate of growth of current government expenditure below that of GDP. Because such a policy involves some degree of procyclicality, since 2001 fiscal policy has been based on a rule of achieving a structural surplus of 1 percent of GDP. In computing the structural surplus, adjustments are made on the revenue side only. Tax revenue is computed on the basis of a zero output gap, and revenue from copper, Chile's most important export, is computed using an estimation of its long-run price. As a consequence, given recent high copper prices, government saving has been high. Although few studies of the international business cycle have looked kindly on the hypothesis that improved fiscal policy can reduce the volatility of output growth, in Chile it has probably been a very important factor.[7]

Figure 1 traces output growth and its volatility in terms of quarterly, seasonally adjusted GDP, using five-year rolling windows (where period t refers to the window starting in quarter $t - 19$ and ending in t).[8] Homogeneous data on GDP are available only since the first quarter of 1986, and hence the first window for output growth is that for the second quarter of 1991. The standard deviation of output growth declined gradually during the early 1990s and then rose for the next couple of years. The reason for this rise in volatility was the recession of 1999, which started with a decline in output in the third quarter of 1998. Volatility has declined steadily since then. After several years of rapid growth following the recession of 1999, the average rate of growth in five-year windows declined until 2004.

The experience with strong monetary tightening in the late 1990s, together with continuing exchange rate rigidities, led the monetary policy authorities to embark on a substantial improvement of the macroeconomic framework. In 2001 the central bank implemented a full-fledged inflation targeting regime in which control of inflation is the central policy objective, with no other explicit targets. Currently, annual inflation is expected to be around 3% most of the time, with a tolerance range of ±1 percent, and a policy horizon around 2 years.[9] The move toward such a regime was seen as the natural step after reaching a low steady-state level of inflation and establishing sufficient monetary policy credibility.[10] To control for the persistent decline in inflation, each window of Figure 2 shows the variance in detrended inflation. The figure shows that inflation itself as well as its volatility declined all through the 1990s and then stabilized.

Other policies adopted during that period were a free-floating exchange rate regime, nominalization of the monetary policy instrument, deepening of the foreign exchange derivatives market, and a much more open capital account. Since then important efforts have been made to improve transparency and enhance credibility.

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[7] See Medina and Soto (2006), who simulate the impact of the fiscal rule in a dynamic general equilibrium model.

[8] The results are presented as annualized rates. The seasonal adjustment is done using X12-ARIMA.

[9] See details in Banco Central de Chile (2006).

[10] Strictly speaking, this is a flexible inflation target, since it allows the central bank time to adjust to deviations of inflation from the target range. This, in turn, is done because the definition of the objective implicitly weights the deviations of inflation from the target and output fluctuations. We refer to a full-fledged inflation target to indicate that this is also accompanied by all the communications requirements, and no other explicit objectives.

An alternative measure of volatility can be gauged from output gap measures. This allows us to check the robustness of the finding that the reduced volatility of output is not due to a decline in average growth. Figure 3 presents the output gap and its volatility, using a Hodrick-Prescott filter to estimate trend output. The results are similar to those in Figure 1, since volatility has declined, although in this case it has remained relatively stable since 2003.

Some other hypotheses that might explain the decline in output and inflation volatility are important to consider. For example, improved inventory management, resulting from advances in information technologies, has received support in international studies as a cause of declining volatility. Chile, however, lacks a good long-term data series on inventories that would allow us to verify this hypothesis. Chile has also gone through a process of financial deepening, which has likewise been hypothesized to reduce volatility, as consumers as well as firms have greater opportunity to smooth consumption and production when facing adverse shocks.[11]

Recent work by Kent, Smith, and Holloway (2005) emphasizes the role of structural reform in reducing output volatility. Here the most important development in the Chilean economy has been the increase in trade and financial openness, which, by allowing greater geographical diversification of trade and increased portfolio diversification, may have helped to reduce volatility.

Finally, yet another possible explanation for the decline in volatility is that the recent shocks to the economy may have been smaller than in previous periods (Stock and Watson, 2003). If this were so, it would imply that a renewed increase in the magnitude of shocks could once again increase volatility. In fact, Chile's experience in recent years has not been free of large shocks. One particularly important positive shock has been the surge in copper prices: from very low levels at the beginning of this decade, copper prices have increased to unprecedented heights, yet have not resulted in a large expansion of economic activity. Nor, for that matter, did the low copper prices of the early 2000s result in a recession, as had happened before when copper prices were low. Indeed, the years 2000–02 witnessed the lowest real copper prices since the Great Depression, and Chile did not have the recession that many could have predicted. Hence it is difficult to argue that the reduction in volatility has been the result of good luck in the external environment. However, as we report later on, there has been some reduction in the volatility of external shocks, but not enough to explain the significant reduction in volatility. Section IV will return to this issue, to investigate whether the reduction in volatility is attributable to changes in the transmission mechanism associated with macroeconomic policy developments.

III. The monetary transmission mechanism

Here we discuss various aspects of the monetary policy transmission mechanism in the Chilean economy and how they might have changed in recent years, given the new setting described in the previous section. In a context of inflation targeting, an examination of the transmission mechanism is crucial, since monetary policy decisions are based to a large extent on formal estimates and forecasts of the impact of policy on inflation.

[11] During the large expansion of consumer credit of the 1990s, and the subsequent slow growth in consumption, it is possible that an excessive debt burden, due probably to optimistic expectations about the long-term prospects of the Chilean economy by the mid-1990s, contributed to the slow recovery from the recession. But even if this behavior did retard the recovery, it is not obvious that it could have increased volatility.

Monetary policy in Chile has traditionally worked via the interest rate-aggregate demand channel, influencing market interest rates indirectly through short-term instruments, with a special focus on the overnight rate. The central bank also has a large stock of medium- and longer-term debt. This debt is auctioned in fixed amounts, so that the market determines the yield curve. The interest rates thus determined, both nominal and real, affect consumer and investment spending, aggregate demand, and output (Mishkin, 1996).

Other channels of monetary transmission have been identified, such as the exchange rate channel, the asset prices channel, the credit channel, and the expectations channel,[12] but only the first of these has figured importantly in the monetary policy debate in Chile. During most of the 1990s, with monetary policy based on annual inflation targets, changes in interest rates had little impact on current-year inflation, so that pressures were felt on the exchange rate instead. These pressures collided with the objective of maintaining export competitiveness, and this led to the implementation of capital controls and the policy of allowing the peso to appreciate gradually by adjusting the exchange rate band.

Monetary policy can also affect aggregate demand through the wealth effect derived from the asset price channel. In Chile the private pension system has an important influence on stock market prices, through which it can affect agents' wealth and, in turn, aggregate demand (Eyzaguirre (1998)). Although the asset price channel does not seem to be an important channel of transmission of monetary policy in Chile, in fact its importance depends upon the concentration of particular assets in agents' portfolios and the impact of market fluctuations on those assets. Therefore this channel is also worth analyzing in the Chilean context.

Also worthy of comment are the credit channel and its role in the evolution of monetary policy transmission over the last decade. The Chilean financial sector has evolved into a relatively free and sophisticated system, with deep markets. Chile's capital market is mostly based on banks, which have been allowed to expand their activities and invest overseas, following the improvement of supervision and prudential regulation and the introduction of capital adequacy requirements in line with Basel standards. These improvements, together with the development of private pension funds, have increased the supply of long-term funding. In fact, banks and firms have developed new forms of financing such as bond financing.[13]

Although consensus is lacking, the literature seems to support the hypothesis that the development of Chile's financial sector has diluted the effects of monetary policy on output: firms today are less dependent on banks, whose capital costs rise directly in response to monetary policy tightening. Additionally, the credit channel is an alternative monetary transmission mechanism to the aggregate demand channel that could give rise to a financial accelerator (Bernanke, Gertler, and Gilchrist (1996)), which could increase the persistence of the business cycle. Firms that are credit constrained will be affected by the availability of lending and changes in the cost of borrowing, while firms that are unconstrained will be affected only by the latter. Therefore, as credit restrictions diminish, one could expect that investment becomes less sensitive to overall financial conditions. On the other hand, as argued by Roldós (2006), the responsiveness of aggregate demand to changes in monetary policy could rise with the increase in disintermediation, due to the fact that bank lending could become less sensitive to interest rates than market financing, because the long-term relationship with firms would make them avoid the transfer of short-run changes in the monetary policy rate to customers.

As Alfaro et al (2003) have argued, the credit channel had a significant impact on macroeconomic activity in Chile during the 1990s, through the bank lending channel.

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[12] See Mies, Morandé, and Tapia (2002).

[13] See details in Betancour, De Gregorio, and Jara (2006).

Focusing on the ratio of low- to high-quality lending (specifically, the ratio of consumer credit to large corporate credit), they analyze how banks respond to increases in their capital costs. However, given financial development and firms' expanding options for financing after 2000, there seems to be no evidence of a flight to quality, and consequently the volatility of credit has diminished. In fact, the issuance of bonds by banks and firms has risen, giving them more financing opportunities. As a result, the volatility of output growth has also diminished, as documented above. Thus, with the development of the financial sector, firms have become less dependent on bank financing, and this has contributed to the reduction in output volatility.

In 2001 the Central Bank of Chile replaced its monetary policy instrument, shifting from a real interest rate to a nominal rate. This change provided a better nominal anchor for the economy, thus expanding the options for monetary policy. Nominalization also resulted in a deepening in nominal financial asset markets, helping to reduce the volatility of monetary aggregates and nominal interest rates.

Understanding the dynamics of inflation is a fundamental step to analyze the transmission mechanisms. In Chile, inflation has historically displayed a significant degree of persistence. Related to this was the poor performance of inflation until the end of the 1980s that promoted a widespread indexation and high inflation expectations. The independence granted to the central bank together with the consequent inflation targeting framework implemented in Chile, achieved a gradual reduction of inflation during the 1990s and the transition to full-fledged inflation targeting has produced stable and low inflation since 2000. These developments have affected the dynamics of inflation. For instance, the perceived increase in the credibility of monetary policy in its commitment to price stability has made inflation expectations more anchored. Thus, exploring whether the persistence and inertia of inflation have changed helps us to understand the role of monetary policy in shaping the dynamics of inflation and how these modifications feed back into the policy decisions of the monetary authority.

The Phillips curve has provided a route to comprehend the behavior of inflation and its connection with real activity. New Keynesian models have introduced a Phillips curve where the nominal rigidities are controlled by parameters that determine the fraction of firms (or workers) that are able to adjust prices (or wages) optimally every period. In order to generate the observed inertia of the inflation, the New Keynesian Phillips curve has been modified to allow for a lagged inflation term. This term may be obtained if a fraction of firms (or workers) follow a passive rule that adjusts prices (or wages) automatically based on a weighted average between past inflation and the inflation target. The higher the weight on past inflation, the more persistent the inflation will be. Along these lines, Céspedes and Soto (2006) estimate the structural parameters of a New Keynesian Phillips curve for Chile using a GMM methodology. They find a structural break of the parameters of the Phillips curve around 2001. Moreover, they show that the point estimates indicate that the fraction of firms not optimally adjusting prices together with the weight of the inflation target in automatic price adjustments have both increased over time since 1997. Caputo, Medina and Soto (2006) complement this evidence estimating the structural parameters in a full New Keynesian general equilibrium model for the Chilean economy using Bayesian techniques. They assume a regime change in 2000 that potentially affects the value of the parameters that govern the Phillips curves of nominal prices and wages. Their results show that the fraction of workers who are not optimally adjusting wages every period has increased since 1999. They also find that the weight given to the announced inflation target by automatic updating of nominal wages has increased. The posterior distributions obtained by them indicate that the values of these parameters are in fact statistically higher since 2000. The stability and low level of inflation and the credibility of monetary policy may have reduced the incentive of firms and workers to optimally adjust nominal prices and wages. Moreover, since inflation expectations are more anchored to the inflation target, automatic adjustment of prices and wages tends to be based more on the inflation target.

The magnitude of exchange rate pass-through to inflation is also important to determine the propagation of shocks and monetary policy on inflation. There is a consensus that the transmission of the exchange rate to domestic prices is incomplete in the short-run. Empirical evidence on the deviations from the law of one price for tradable goods has favored this consensus. It has been argued that an incomplete exchange rate pass-through in the short run is due to distribution and transportation costs, segmentation of markets and the presence of nominal rigidities in the domestic price of imported goods. In particular, when the domestic currency prices of imported goods are sticky, then the transmission of the exchange rate to import prices will not be complete in the short run. Hence, changes in the degree of nominal rigidities of import prices will affect the magnitude of exchange rate pass-through: the greater the nominal rigidities, the smaller the exchange rate pass-through. Using this rationale to explain the incomplete exchange pass-through in the short run, both Céspedes and Soto (2006) and Caputo, Medina, and Soto (2006) present evidence that the parameter that controls the magnitude of the nominal rigidities of imported goods increases after the late 1990s, reducing the exchange rate pass-through. The latter work reports that exchange rate pass-through has in fact been statistically lower since 2000. This evidence is also consistent with alternative estimations of the decline of exchange rate pass-through (see García and Restrepo (2002) and De Gregorio and Tokman (2005)). The reduction of exchange rate pass-through has reduced the concern that big swings in the nominal exchange rate may be a source of instability in the inflation rate.

Finally, the central bank has made important efforts to enhance its credibility and transparency so as to minimize the impact of expectations on any of the other channels (an impact that can be described as a channel itself). Publication of a Monetary Policy Report in January, May, and September each year, and publication of the minutes of Monetary Policy Committee meetings only three weeks after each one of the twelve yearly sessions, are some examples of these efforts.

IV. Analyzing the transmission mechanism: evidence from a VAR

To assess whether the monetary transmission mechanism in Chile has changed over the period 1990–2006, we use a reduced-form vector autoregression (VAR) model. The main advantage of VAR models is that they impose a minimum of structure. Starting with Sims (1980), VAR models have been developed as a means of analyzing quantitatively the impact of monetary policy innovations on a set of endogenous variables. One difficulty with VAR models, however, is associated with the criteria for identifying shocks.

Many studies have addressed the issue of how to identify monetary policy shocks for the case of the United States.[14] For open economies, Kim and Roubini (2000) have proposed restrictions for identifying the effects of monetary policy shocks on the exchange rate in order to obtain responses consistent with theory. In the case of Chile, several studies based on VARs have been used to describe the effects of monetary policy.[15]

IV.1 Specification of the VAR model

The base VAR model has the following representation:

$Y_t = A(L)Y_{t-1} + B(L)X_t + u_t$,

[14] See, for example, Bernanke and Blinder (1992), Bernanke, Gertler, and Watson (1997), Christiano, Eichenbaum, and Evans (1999) and Leeper, Sims, and Zha (1996).

[15] See, for example, Valdés (1998) and Parrado (2001).

where $A(L)$ and $B(L)$ are matrix polynomials in the lag operator L, Y_t is a vector of endogenous variables, X_t is a vector of exogenous variables, and u_t is a vector of innovations. These innovations are serially uncorrelated, with zero mean and a variance-covariance matrix $E(u_t u_t') = \Sigma_u^2$. The behavior of the endogenous variables depends both on unexpected disturbances, u_t, and on the systematic component, captured by $A(L)Y_{t-1} + B(L)X_t$, which determines how the shocks are transmitted to the rest of the economy.

The endogenous variables that we include in Y_t are the short-run interest rate, output, the money supply, the consumer price index, and the real exchange rate. This set of variables is used to identify the shocks in the impulse-response experiment analyzed below.[16] The short-run interest rate is the indexed monetary policy rate, the rate used by the Central Bank of Chile as the policy instrument until 2001, when nominalization began and it was replaced by the interbank nominal interest rate. For the measure of output we use the IMACEC (a monthly index of activity), for the money supply we use M1, and for prices we use the consumer price index. The last three variables are expressed in log terms and are seasonally adjusted. The real exchange rate is the standard multilateral measure of the price of foreign goods relative to that of domestic goods (in log terms), so that an increase in this ratio represents a real depreciation. The exogenous variables are copper and oil prices and the foreign interest rate, the latter measured as the US federal funds rate. We use monthly data from January 1991 through July 2006. The preferred specification considers two lags for both endogenous and exogenous variables.

IV.2 Stability of the estimated VAR

The stability of the estimated parameters governing the relationship among macroeconomic variables has been analyzed for the United States by Stock and Watson (1997), who find evidence of instability in the bivariate relationship among seventy-six macroeconomic variables. Bernanke, Gertler, and Watson (1997) also report evidence of instability in a monetary VAR. In the case of Chile, evidence of a reduction in output and inflation volatility, as reported above, also suggests the possibility of a modification in the propagation of shocks associated with the changes in macroeconomic policies of recent years, as documented in the following subsection.

Using the VAR estimation procedure, we can perform a stability investigation to analyze whether the observed changes in the volatility of output and inflation reflect a deeper modification in the dynamics of the endogenous variables. For each equation of the VAR, we test jointly for the stability of all coefficients using the cusum-square test. The results, shown in Figure 4, suggest that the output and short-term interest rate equations have a remarkably high level of instability. The equations for the price index, the money stock, and the real exchange rate show moderate instability. These results provide evidence of changes in the dynamic relationship among macroeconomic variables in the case of Chile. Moreover, as described above, several different macroeconomic policies were implemented during the period under analysis, and therefore the instability that we find might be capturing the role of these policies in shaping the transmission of shocks in the Chilean economy.

[16] This order is arbitrary and can be criticized as an imprecise way of identifying underlying shocks. However, the purpose of this paper is to analyze whether the propagation of shocks has changed over the sample period. Although some shocks are not clearly identified with this ordering strategy, changes in the mechanism by which reduced-form shocks are transmitted can be used to understand how modifications in the macroeconomic environment have affected the dynamic relationships among variables.

IV.3 Changes in the transmission mechanism

The previous subsection suggests the presence of breaks in the estimated VAR. In principle, one could estimate the dates of these breaks using the information from the cusum-square test. However, the exact timing of the breaks is not necessarily the same for each equation. Hence this test does not clearly identify the timing, although the test for output and interest rates suggests that a break occurred in the late 1990s. We could use more formal tests to establish the break, but on the basis of the discussion above, we consider a break occurring at the end of the 1990s. As we have documented above, several macroeconomic policy changes were carried out in and around 1999. Since then monetary policy has been conducted within a full-fledged inflation targeting framework, and since August 2001 the instrument of monetary policy has been a nominal interest rate. Also since 2001, fiscal policy has explicitly followed a rule that requires it to behave in a countercyclical manner. Thus our first sample covers the period from January 1991 to December 1999, and the second sample starts in January 2000.

Using the VAR estimation, we can evaluate the variance of the shocks to each endogenous variable and the conditional volatility of the endogenous variables. Regarding the shocks to each equation, the last row in each panel of Table 1 reports the standard error of each equation for the indicated subperiod. This evidence shows that indeed the volatility of shocks has declined in the present decade: the volatility of output and that of prices declined by a third. Therefore one could expect that a reduction in the volatility of shocks explains some of the "great moderation" effects in Chile. However, since the model is not a structural VAR, the volatility of shocks could also be the result of a more stable macroeconomic environment.

To get additional evidence on volatility, we compute the conditional volatility of the endogenous variables. To do this, we compute the forecasting standard errors of each endogenous variable for horizons ranging from 1 to 3 years. Table 1 also presents the results for the two subsamples analyzed. All variables except the real exchange rate show a smaller conditional volatility for the second subperiod (2000–06) than for the first. This conclusion is robust to the different horizons considered. These values confirm the evidence of a reduction in the magnitude of shocks after 1999.

One is thus tempted to conclude that the reduction in the conditional volatility of macroeconomic variables is explained by a reduction in the size of the shocks hitting the Chilean economy. However, when we compare the reduction in the standard deviation of exogenous shocks (the last row of each panel in Table 1) with the standard deviation of the forecast errors, we see that the decline of the latter is much larger. Moreover, the decline in the volatility of forecast errors is the combined result of the reduction in the volatility of shocks and the stabilizing effects of the transmission mechanism. Therefore the transmission mechanism of the current policy framework plays a crucial role in the "great moderation".

To shed more light on this issue, we compare the responses of the variables for both subsamples. To isolate the changes in the transmission mechanism, we consider impulses of the same magnitude in both samples in our VAR instead of the usual practice of using a shock equal to 1 standard deviation of the estimated innovations. This allows us to analyze the dynamic responses of variables while controlling for the size of the shocks.

Exchange rate shock

Figure 5 displays the responses of the short-term interest rate, output, prices, and the real exchange rate to an innovation of 1 percent in the real exchange rate equation. A comparison of the responses confirms a reduction in the pass-through of the exchange rate change to domestic prices. Several studies have analyzed this pass-through in Chile and elsewhere. As documented above, the evidence has shown that, in Chile, the pass-through has declined since the exchange rate has been allowed to float, in a manner consistent with Taylor (2000). Despite the rise in the volatility of the exchange rate since the free floating regime was introduced in 1999, the stability and low level of the inflation has reduced the

persistence of changes in inflation and costs, and therefore it is likely that firms will have less incentive to pass to domestic prices the fluctuations in the exchange rate.

Shocks that generate a real depreciation are associated with a contraction in output in both samples. This cannot be interpreted as the contractionary effect of the depreciation, but rather as a negative correlation stemming from a shock that induces both a depreciation and a decline in output, such as a negative shock to productivity or the terms of trade. However, the fall in output in the first subperiod is larger and more persistent, despite the fact that the short-term interest rate declines in this subperiod whereas it rises in the second. This may be due to the fact that firms and banks have tended to be less vulnerable to exchange rate fluctuations since 2000, due to the substantial derivatives market deepening as the result of greater exchange rate flexibility (De Gregorio and Tokman (2005)). In a related work, Caputo, Medina, and Soto (2006) present evidence that the exchange rate has acted as a shock absorber since 1999, making the economy less prone to external fluctuations.

Price level shock

The responses to an innovation of 0.25 percent in the price index are shown in Figure 6. In the first subperiod, the price level remains high: it is still above the initial level after 3 years. In contrast, in the VAR for the second subperiod, prices return to their original level within a little less than two years. The output response associated with this shock implies a contraction for the first subperiod but a moderate expansion for the second.

These differences in behavior may reflect the role of the inflation targeting regime in Chile. The successful reduction of inflation during the 1990s and the implementation of a full-fledged inflation targeting framework in the second subperiod increased the credibility of the monetary authority's commitment to price stability. Additionally, the implementation of such a framework in an environment of low and stable inflation has made monetary policy more forward looking. Hence inflation expectations have become more anchored, and price shocks should have exerted a less persistent effect. During the previous period, as noted above, monetary policy was based on an indexed interest rate, and there were partial targets on the exchange rate. These developments can explain a less persistent behavior of price shocks since 2000. Moreover, the return of prices to their original level has been achieved at no cost in terms of output since 2000. This result may reflect the fact that the greater credibility with respect to the price stability objective reached at the end of the 1990s has reduced the cost associated with subduing inflation pressures. Also, as has been already mentioned, inflation targeting has gained credibility and thus automatic adjustment of nominal prices and wages based on past inflation has become a less frequent practice. Therefore the inertia of inflation dynamics might have fallen as well.

Copper price shock

Figure 7 presents the responses of the variables to an innovation of 8 percent in the copper price. This shock is exogenous for the variables in the VAR model and has an autoregressive coefficient of 0.99. The response of output within the first year is a little higher in the second subperiod than in the first. However, output keeps rising significantly in the first subperiod, during the second and third years after the shock. Hence the same shock in the copper price has medium-term consequences in output that are smaller and less persistent in the second subperiod than in the first, consistent with the more informal discussion above. In other words, this result confirms that output has become less sensitive to copper price fluctuations. The responses of short-term interest rates also show differences in behavior across the two subsamples. In the first subperiod the interest rate rises initially but then declines. In contrast, the reduction in the interest rate is slow after the first month in the sample that starts in 2000. However, the fall in the interest rate is less prolonged in this subperiod than in the first.

The short-run real appreciation caused by this shock tends to be somewhat larger in the first subperiod than in the second. In a medium-term horizon, the real appreciation caused by a copper price increase is larger in the 2000–06 sample than in the earlier sample. More

dramatic differences are found in the responses of the price index: the price level increases in the first sample but falls in the second, and the absolute magnitudes of the deviation of the price level with respect to its initial value are larger in the first sample than in the second. Hence our estimations suggest that copper price increases generated inflation pressures during the 1990s but that these are no longer present after 2000.

Differences in the transmission of copper price movements to the aggregate economy might reflect the implementation of macroeconomic policies aimed at reducing the amplitude of the business cycle in Chile. In particular, the fiscal commitment, established in 2001, to spend the "structural" part of fiscal revenue has better insulated the economy from copper price fluctuations.[17] Under this fiscal rule, as structural revenue is computed with a long-run copper price, it is less sensitive to current copper price movements. The adoption of a floating exchange rate regime since late 1999 has also promoted the role of this variable as a relative price to absorb changes in external conditions. Thus the flexibility of the exchange rate in response to copper price fluctuations may have helped to reduce the response of output to copper price shocks.

V. Conclusions

Chilean macroeconomic policies have changed significantly in recent years. Chile has also seen important changes in macroeconomic performance: the volatility of both output growth and inflation has been reduced, consistent with the "great moderation" observed in other countries, and inflation has declined and remained at levels unprecedented in Chile with its tradition of high inflation. Although the volatility observed in the 1990s was already below that of previous years, the present decade has seen a further significant decline, coincident with the changes in the macroeconomic policy framework. The reduction in the size of shocks partly explains the reduction in volatility, but the response to the large swings in the copper price in the last few years lends support to the hypothesis that macroeconomic policy has also played a significant role in reducing volatility.

This paper has reported a time-series analysis, based on a reduced-form VAR, of how the mechanisms by which macroeconomic shocks are transmitted have changed in Chile. The VAR estimations provide evidence on how the monetary transmission mechanism has evolved, given the important changes in macroeconomic policies and the development of the financial sector. The VAR results confirm that only a part of the reduction in volatility is potentially due to less volatile exogenous shocks. After controlling for the size of shocks, the VAR estimations do suggest that modifications in the propagation of shocks are important in explaining the reduced volatility of output and inflation. In fact, credibility, together with the implementation of a full-fledged inflation targeting framework, has made inflation expectations more anchored and therefore the inertia of inflation dynamics has fallen. Additionally, the development of the derivatives market has made firms and banks less vulnerable to exchange rate fluctuations, reducing the exchange rate pass-through. Thus, changes in the transmission mechanisms are responsible for the bulk of Chile's "great moderation".

Some recent studies of the Chilean economy have attempted to disentangle the different factors explaining the changes in the transmission mechanism. In addition to the effects of

[17] However, one has to be careful in avoiding overemphasizing the role of current fiscal policy framework, since during the 1990s there was a de facto stable structural surplus around 1 percent of GDP (De Gregorio (2006), Figure 4). The difference with the current framework is that expansion of fiscal expenditure was procyclical since it was set around the forest of annual GDP growth.

macroeconomic policies, one also has to consider the increased degree of openness, the deepening of the financial system, and the more stable external environment, all of which have contributed to greater stability. On this broader assessment the jury is still out, but certainly the most important changes in recent years have been those in the macroeconomic framework.

Although Chile's financial sector has witnessed important advances in recent years, there is as yet no evidence on how this development has impacted the monetary transmission mechanism. Certainly a more sophisticated financial system should have contributed to the recent reduction in output volatility, as the greater access of consumers and firms to financing has increased their ability to stabilize expenditure when faced with fluctuations in income. An interesting topic for future research would be a deep analysis of the role played by the financial sector in changing the transmission mechanism.

Table 1

Forecasting standard errors

	Variable				
Subperiod and horizon	**Short-term interest rate**	**Output**	**Price index**	**Money supply**	**Real exchange rate**
1990–99					
1 year	0.86	1.69	0.63	3.62	3.32
2 year	1.01	1.84	1.09	4.13	4.32
3 year	1.07	1.85	1.49	4.38	4.79
SEE	0.45	1.35	0.31	2.15	1.43
2000–06					
1 year	0.40	1.04	0.49	2.81	3.64
2 year	0.55	1.18	0.69	3.62	4.28
3 year	0.56	1.21	0.73	3.73	4.37
SEE	0.14	0.87	0.22	1.79	1.87

Source: Authors' calculations.

SEE = standard error of the equations.

Figure 1

Level and volatility of GDP growth, five-year windows

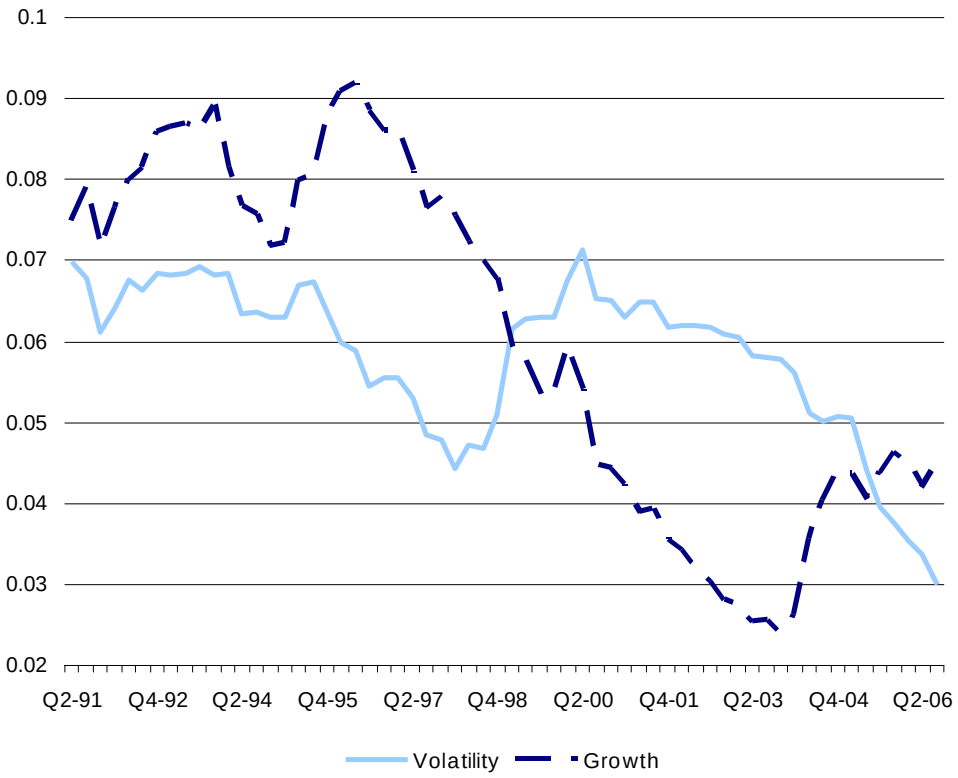


Figure 2

Inflation level and volatility, five-year windows

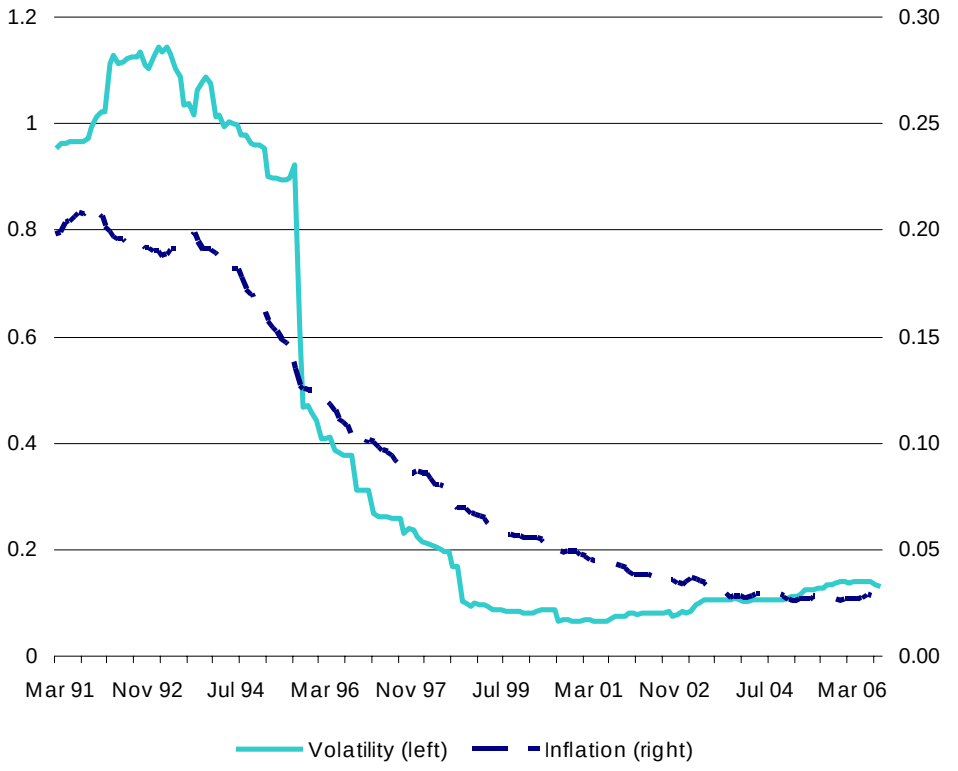


Figure 3

Volatility and level of the output gap, five-year windows

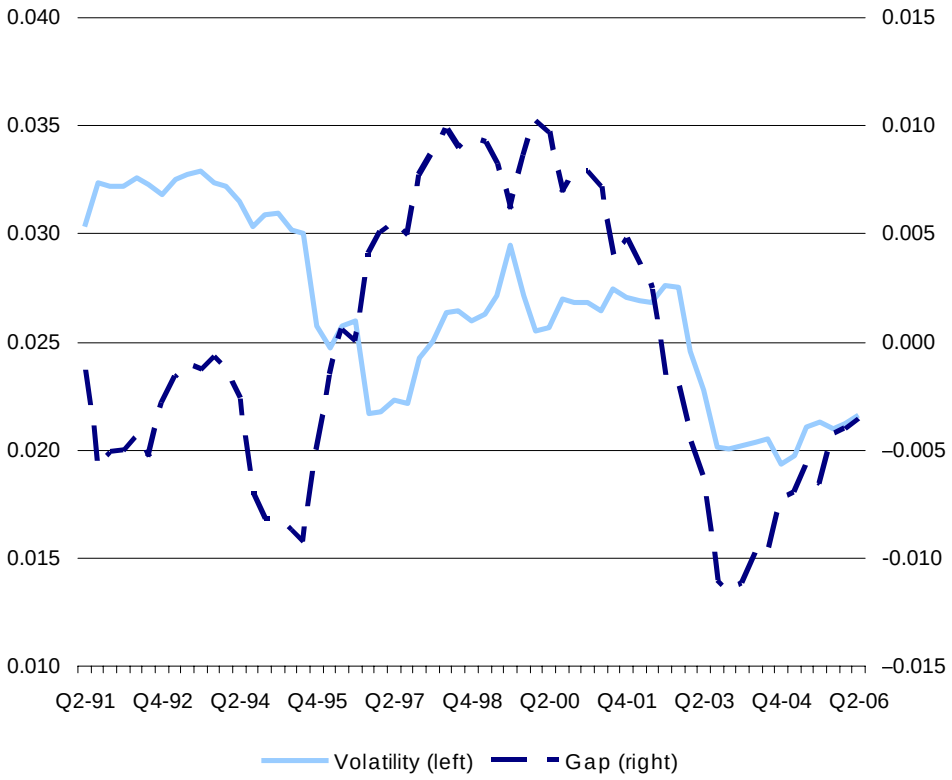


Figure 4

Stability of equations of the VAR

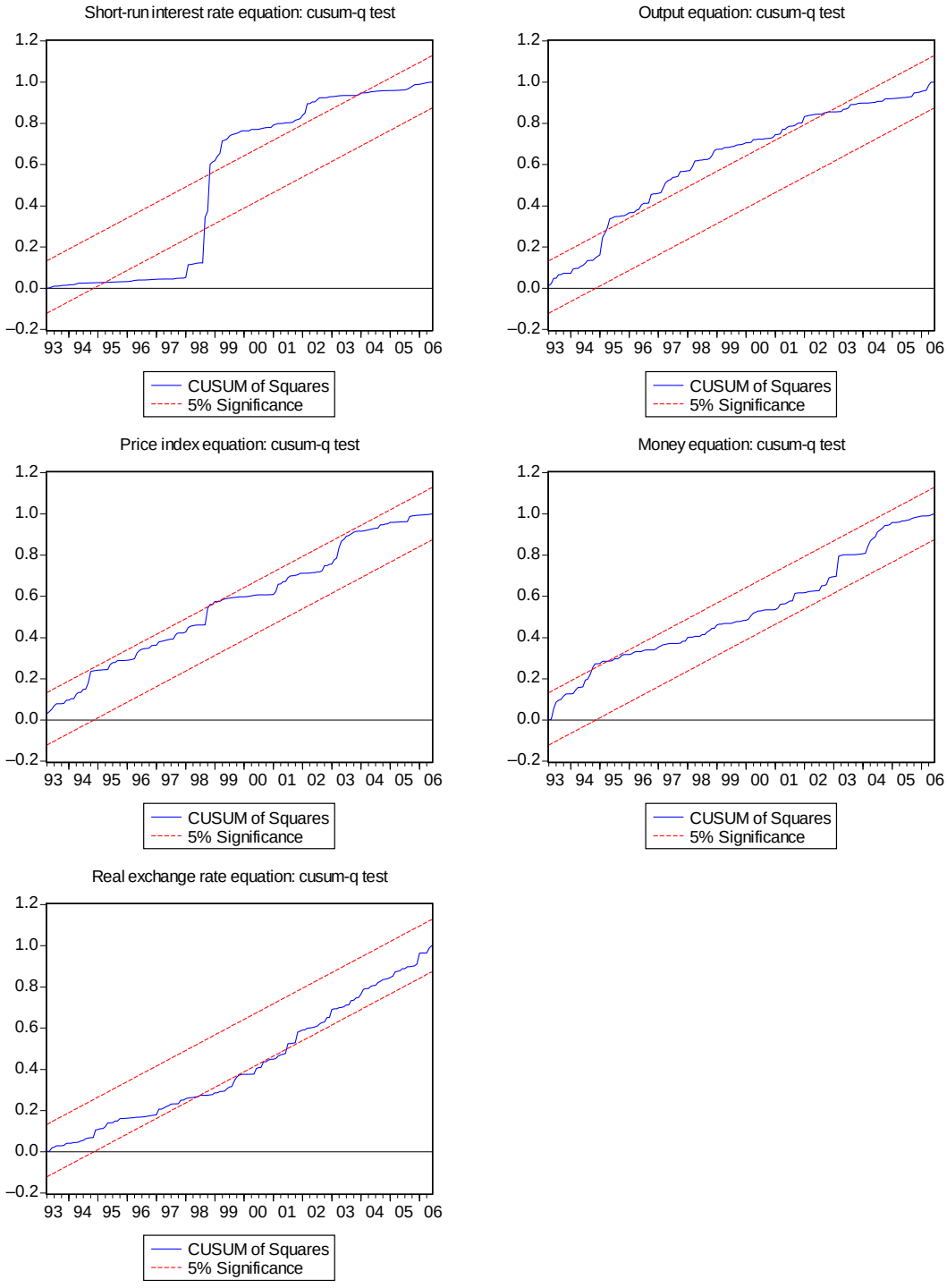


Figure 5

Responses to a real exchange rate shock

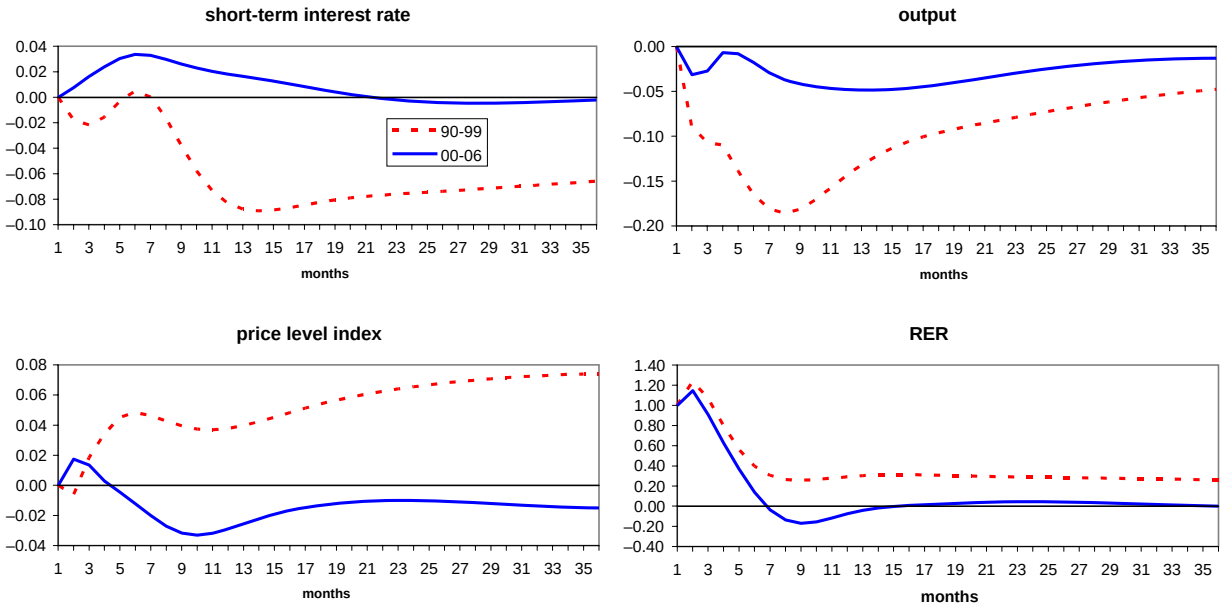


Figure 6

Responses to a price level shock

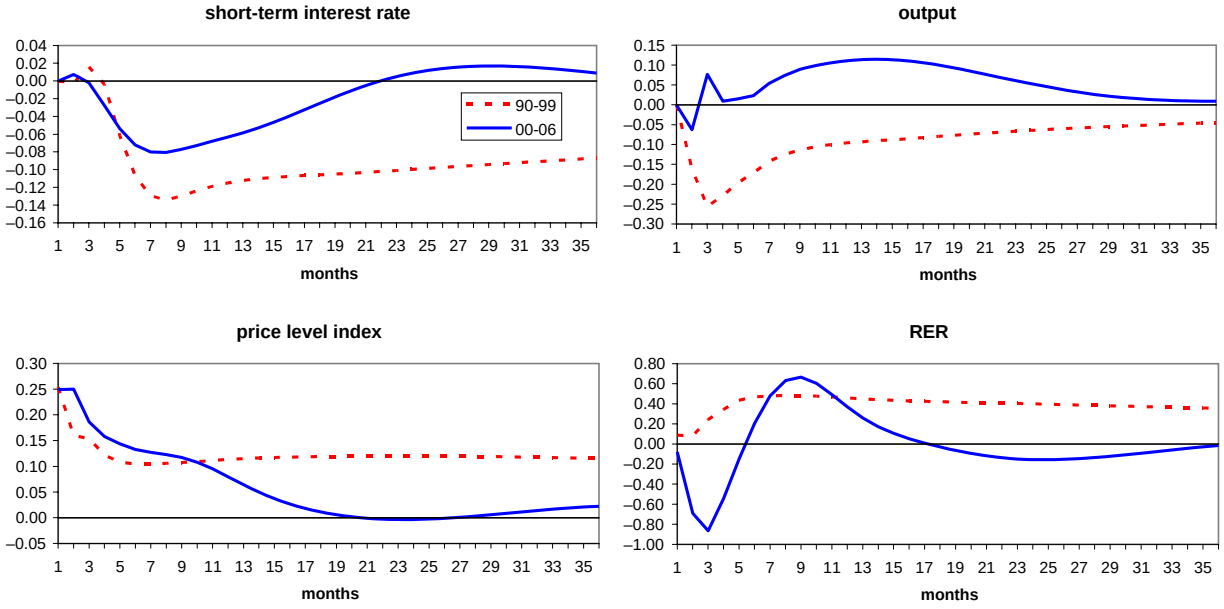
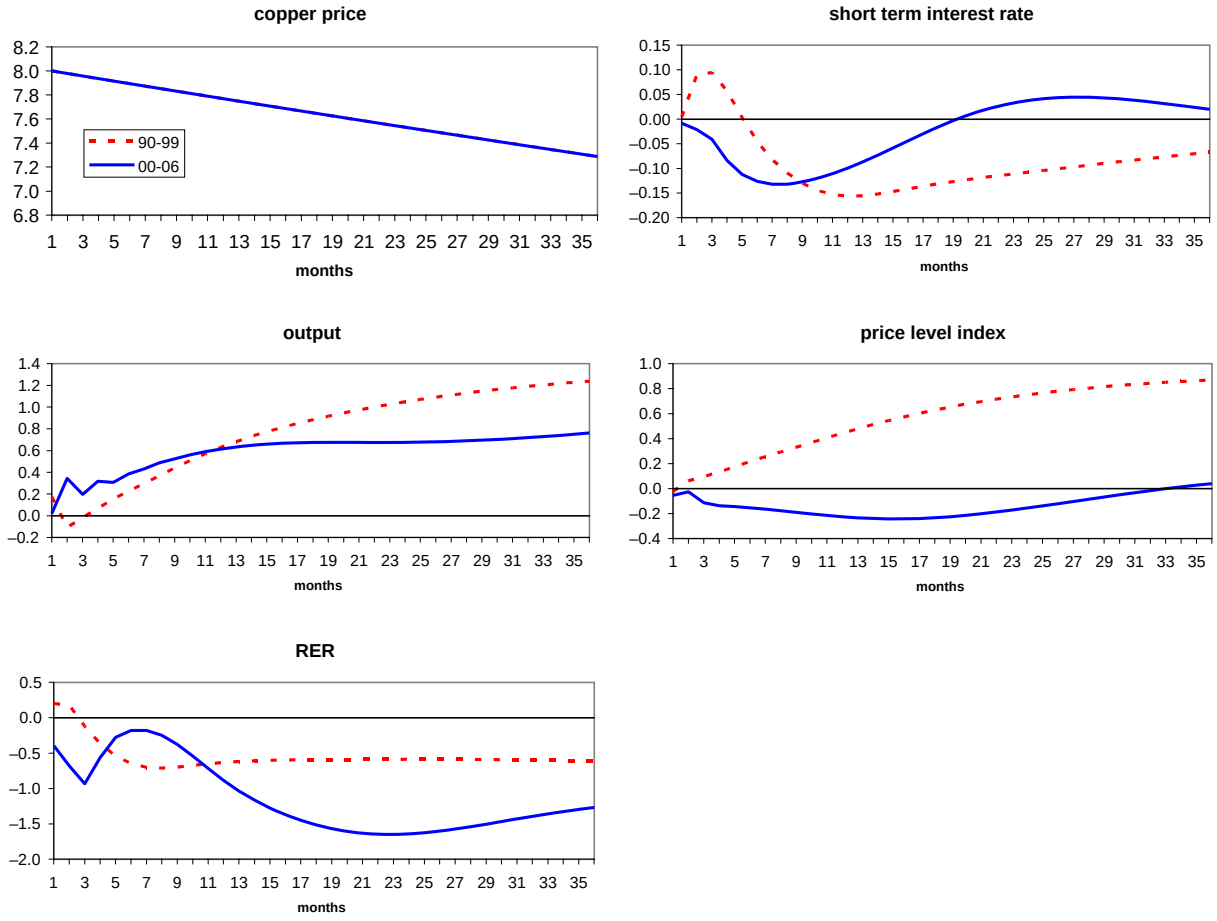


Figure 7

Responses to a copper price shock



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