

INFLATION TARGETING AND MONETARY ANALYSIS IN CHILE AND MEXICO

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Abstract

This paper studies the information content of monetary and open economy variables in two inflation targeting (IT) economies: Chile and Mexico. For Chile a real money gap and a money growth indicator are found to be relevant in predicting deviations of observed from target inflation. In contrast, for Mexico real exchange rate measures are robust predictors of deviations of actual from (i) expected inflation during the pre-IT (1999) period, and (ii) target inflation in the post-IT span.

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1. Introduction

During the 1990s a substantial number of countries adopted inflation targeting (IT) as a formal monetary policy strategy (See Bernanke et al, 1999; Mishkin and Schmidt-Hebbel, 2001; Amato and Gerlach, 2002). Once such framework is in place, is there a role for monetary and open economy indicators in the conduct of monetary policy? This is an important empirical question for academics and policymakers alike. For instance, on the role of money in economies that adopt inflation targeting King (2002, page 162) notes that "...there is a paradox in the role of money in economic policy. It is this: that as price stability has become recognised as the central objective of central banks, the attention actually paid by central banks to money has declined".

This paper contributes to the topic by inquiring into the information content of monetary and open economy indicators in two Latin American emerging market economies: Chile and Mexico¹. The exercise is conducted along the lines of an augmented version of the P-star model (Hallman et al, 1991), analogous to the one employed by Gerlach and Svensson, and Trecroci and Vega (2002), but *also* incorporating open economy indicators. This last element is crucial for the analysis of monetary policy issues in emerging market economies (Calvo and Reinhart, 2002).

The rest of the paper proceeds as follows. Section 2 provides an overview of monetary policy and inflation targeting in Chile and Mexico. A model of inflation and

¹ It is worth pointing from the outset that these two countries have in the past provided a fertile ground for comparative economic analyses. E.g. Arrau and De Gregorio (1993); Edwards (1998).

money is expounded in section 3. The data and its univariate characteristics, as well as the estimation of the several gap measures are dealt with in section 4. The block Granger non-causality methodology is elucidated, and the corresponding analyses of the Philips curves are undertaken, in section 5. Concluding remarks are contained in section 6.

2. Monetary policy and inflation targeting in Chile and Mexico²

Inflation targeting (IT) is a monetary policy strategy that became popular in the 1990s, New Zealand being the first country to adopt it in 1990³. Brazil, Chile, Colombia, Mexico, and Peru are a group of Latin American countries that have adopted IT as their monetary policy strategy⁴. Amongst this group, Chile and Mexico provide two interesting cases, not least because similar circumstances and corresponding policy responses have in the past been observed in these economies (e.g. Edwards, 1998)⁵. The Central Bank of Chile adopted inflation targeting in order to achieve disinflation, whereas it can be argued that the Bank of Mexico did so having a relatively low and

² A detailed explanation of IT in Chile and Mexico, and other Latin American economies, is furnished in the works of Mishkin and Savastano (2000), and Corbo and Schmidt-Hebbel (2001).

³ Mishkin and Schmidt-Hebbel (2001) study inflation targeting countries' experience with such a policy.

⁴ It is adequate to clarify that, particularly during disinflation, inflation targets could be interpreted as conditional forecasts, and not necessarily rules. Similarly, they should be seen as a transparency enhancing technology, but not necessarily as a commitment strategy.

⁵ Focusing on Chile and Mexico within this group is also supported by the fact that Colombia and Peru cannot be unambiguously classified as inflation targeting countries, as noted by Mishkin and Schmidt-Hebbel (2001). However, Stone (2003) classifies Colombia -alongside Brazil, Chile, and Mexico- as countries with a 'clear commitment to inflation targeting'. On the other hand, Brazil experienced very high inflation at the beginning of the 1990s, which complicates an analysis of the type undertaken in this paper.

stable inflation. In what follows a closer look is taken at the developments in monetary policy making in these economies.

2.1. Chile

Chile formally granted independence to its central bank in 1989. Alongside this step came a mandate to have inflation as the monetary policy makers' primary objective. In 1990 a more formal monetary policy stance was signalled by the announcement of an inflation target to fall within a range of 15-20% for 1991.

It is worth noting that from the mid-1980s until August 1999 the Central Bank of Chile had an exchange rate band regime in place (See Morandé and Tapia, 2002). Nevertheless, after the formal introduction of IT the authorities have always made clear that their primary objective is the pre-announced inflation target. The exchange rate band was supposed to help in keeping the real exchange rate at a level consistent with external equilibrium. However, in 1998 the Chilean monetary authorities did not allow the exchange rate to depreciate in order to accommodate a negative terms of trade shock. Instead, their policy reaction was to raise interest rates and narrow the exchange rate band. This led to the IT being undershot in that year.

This isolated episode aside, and as can be seen in Table 1, and graphically in Figure 3, Chile's IT has been successfully reduced after its introduction, helping to bring down inflation from 29% (1990.Q4) to 3.8% (1999.Q1). From 1995 the central bank started to announce a *point* rather than a *range* IT. Moreover, in the light of this success in 2000 the Central Bank of Chile committed to a target of 2-4% for 2001 onwards. It is important to emphasise that the success of the IT strategy in Chile is also

a product of fiscal surpluses, and a tight regulation and supervision of the financial system.

2.2. Mexico

December 1987 is an important date in the recent history of the Mexican economy, since it was on this date that the ‘Pacto’ stabilisation programme was introduced. As a result, in the lapse between 1987 and 1991 monetary policy in Mexico was based on a pegged exchange rate regime. Also, under this strategy government spending saw a marked decrease. This prudent fiscal management helped in the reduction of the inflation rate from 132% (1987) to around 20% (1989), while output growth increased from 1.4% (1987) to 12.9% (1989). In fact, Cecchetti et al (2000) argue, and support empirically, that monetary policy in Mexico became more efficient, as measured by the lower variability of inflation and output, from 1991 onwards, at least in part due to the policies undertaken in the late 1980s.

Accordingly, and in order to provide a more flexible exchange rate framework, the Bank of Mexico adopted exchange rate bands in 1991. However, this period came to an abrupt halt in December 1994, with the well-known Mexican crisis that coined the ‘Tequila effect’. The economic and political developments that led to such a meltdown implied a substantial widening of the prevalent exchange rate band, and a devaluation of the Peso.

At the beginning of 1995 the Mexican authorities aborted the pegged exchange rate regime, switching to a policy in which the monetary base played a mayor role (See Khamis and Leone, 2001). This new policy stance included the announcement of an

annual inflation target of 19%, which was subsequently increased to 42% due to the Peso's instability. Although the announced target of 17% for the monetary base was achieved, the inflation rate was 10% higher than the announced goal.

The Bank of Mexico continued to announce targets for money and inflation in the next two years, but without success. In 1998 the inflation target was missed by 7%, even though the target for base money was undershot by 1.5%. Under these circumstances the monetary authorities tried to reassure the public that their main goal was to control inflation. With the more formal implementation of an IT monetary policy in 1999, Mexican monetary policy's effectiveness has consolidated.

3. A model of inflation and money

The investigation is based on an augmented version of the P-star model of Hallman et al (1991). The P-star concept arises from a simple representation of the equation of exchange

$$MV \equiv PY \tag{1}$$

where M is nominal money, V is the average velocity of circulation, P is the aggregate price level, and Y is real aggregate output. Re-arranging (1) and assuming long run values for V^* and Y^* produces

$$P^* \equiv \left(\frac{M}{Y^*} \right) V^* . \tag{2}$$

In (2) M determines P^* . Substituting (2) in (1), and after further manipulations the following arises

$$p^* - p \equiv (y - y^*) + (v^* - v). \quad (3)$$

In (3) all the variables are expressed in logs. The key element in (3) is the price gap $(p^* - p)$ component, which plays a prominent role in the determination of inflation in a Phillips curve equation of the form

$$\pi_t = \pi_{t-1}^e - \rho(p_{t-1} - p_{t-1}^*) + \xi_t, \quad (4)$$

where $\rho > 0$. As can be seen, the P^* model substitutes the output gap and velocity with the negative of the price gap as the main determinant of inflation. This is the ‘baseline’ inflation adjustment equation in Hallman et al (1991). The theoretical models by McCallum (1980) and Mussa (1981) also incorporate adjustment equations analogous to (4).

Gerlach and Svensson, and Trecroci and Vega (2002) consider a nested version of the price gap and Phillips curve models for empirical purposes. The structure of this model is composed of the following elements,

$$\pi_t = \pi_{\langle t|t-1 \rangle}^e + \eta(y_{t-1} - y_{t-1}^*) + \varphi(\tilde{m}_{t-1} - \tilde{m}_{t-1}^*) + \xi_t, \quad (5)$$

$$\pi_{\langle t|t-1 \rangle}^e = \hat{\pi}_t, \quad (6)$$

$$\tilde{m}_t = (m_t - p_t) = \beta_0 + \beta_y y_t + \beta_R R_t + v_t, \quad (7)$$

$$p_t^* \equiv m_t - \beta_0 - \beta_y y_t^* - \beta_R R_t^*, \quad (8)$$

$$\tilde{m}_t - \tilde{m}_t^* \equiv (m_t - p_t) - (m_t - p_t^*) \equiv -(p_t - p_t^*) = (m_t - p_t) - \beta_0 - \beta_y y_t^* - \beta_R R_t^*. \quad (9)$$

To intuitively highlight the indicators underlying equation (9) it could also be rewritten as

$$(p_t^* - p_t) \equiv \beta_y (y_t - y_t^*) + \beta_R (R_t - R_t^*) + v_t \equiv \tilde{m}_t - \tilde{m}_t^*. \quad (9a)$$

- Equation (5) is a mixture of a Phillips curve and a price gap model of inflation, where π , π^e , y , y^* , \tilde{m} , and \tilde{m}^* are actual and expected inflation rates, output and potential output, and actual and long run real money balances, respectively. η and φ are parameters to be estimated empirically. ξ is expected to be a well-behaved disturbance term.
- Equation (6) specifies how inflation expectations (π^e) are formed, where $\hat{\pi}$ is the central bank's inflation objective. Note that this implies that the model focuses on explaining deviations of inflation from its target.
- Equation (7) is a long-run money demand function, which assumes a standard specification. In (7) y is real output and R is a measure of the opportunity cost of holding money. β_0 , β_y , and β_R are parameters to be estimated, and v is expected to be a well-behaved disturbance term.

- Equation (8) generates the equilibrium price level (p^*), for a level of the money stock assuming that the other variables in the model are at their equilibrium levels, by inverting the long-run money demand given by equation (7).
- Equation (9) defines the real money gap as the negative of the price gap. Additionally, equation (9a) emphasises the model's accounting for the role of information from the goods market via the output gap, the stance of monetary policy through the interest rate gap, and the money market in the form of the monetary overhang, v_t .

A further element that should be considered in the empirical assessment of the above model is the role of the exchange rate. Svensson (2000), for instance, provides three key reasons as to why this is particularly important for inflation targeting open economies. Firstly, the exchange rate explicitly allows for an additional channel through which monetary policy can be transmitted. Secondly, the exchange rate is a *forward-looking* variable, and therefore can provide valuable information in the design and implementation of monetary policy. Thirdly, foreign shocks mainly propagate through the exchange rate.

In addition to the above elements, in a thought provoking paper Calvo and Reinhart (2002, page 394) note that "...central bankers in emerging market economies appear to be extremely mindful of external factors in general and the foreign exchange value of their currency, in particular." Some of the reasons Calvo and Reinhart highlight for the important role played by the exchange rate in monetary policymaking, and which give rise to what they label *fear of floating*, even under an IT regime, are

- Liability dollarisation;
- Output costs associated with exchange rate fluctuations;

- Inelastic supply of funds at time of crises; and
- Lack of credibility and fear of loss of access to the international capital markets.

In the light of these factors the present paper proposes a further augmentation of equation (5) as follows

$$\pi_t = \pi_{\langle t|t-1 \rangle}^e + \eta(y_{t-1} - y_{t-1}^*) + \varphi(\tilde{m}_{t-1} - \tilde{m}_{t-1}^*) + \alpha(e_{t-1} - e_{t-1}^*) + \xi_t. \quad (10)$$

Equation (10) incorporates departures of actual (e) from equilibrium (e^*) exchange rates, where α is a parameter to be estimated⁶.

4. Data

Data on money, real income, prices, interest rates, exchange rates, and inflation objectives are employed in the empirical analyses that follow. The data are monthly, and span from 1990.01 to 2001.06 for Chile, and from 1986.01 to 2001.06 Mexico⁷. In what follows all the time series are expressed in logs, with the exception of the interest rates, which are expressed in percentage points. The definitions and sources of the data are contained in Table A1.

In order to ascertain the order of integration of the economic time series under scrutiny the Augmented Dickey-Fuller test (Dickey and Fuller, 1979) is implemented.

⁶ On the relevance of the exchange rate for inflation targeting economies also see Ho and McCauley (2003).

⁷ Note that for Chile the data covers only the IT regime, whereas for Mexico the statistical information encompasses several periods. Specifically, a pegged exchange rate policy (1987-1991), an exchange rate band (1991-1994), monetary targeting (1995-1998), and inflation targeting (1999-present).

Panel A of Table 2 displays the results. All the series seem to contain a unit root in their levels, but become stationary after being differenced. The exceptions are e and p^D , and p for Chile, which appear $I(2)$ and $I(0)$, respectively. Nevertheless, in assessing the above results the reader should bear in mind the low power of these tests in rejecting the null of a unit root. The univariate properties of the data under scrutiny can be further examined by glancing at Figures 1 and 2, which present data for Chile and Mexico, respectively.

4.1. Inflation objectives

The variable $\hat{\pi}$ is given by the annual inflation targets announced by the Central Bank of Chile and the Bank of Mexico (Table 1). However, in the light of the fact that the Bank of Mexico adopted a ‘formal’ IT from January 1999 (Mishkin and Schmidt-Hebbel, 2001) expected (forecast) inflation (π^e) up to that point in time is used in estimating the structural model. Such a variable is proxied by the *filtered* series derived from π by applying a univariate structural time series model and the *Kalman filter* (Harvey, 1989; Koopman et al, 2000). This variable intends to reproduce the economic agents’ expected inflation by using a technically compelling technique. Details on this estimation are provided in Appendix 2. Figures 3 and 4 display actual and target inflation for Chile; and actual, expected, and target inflation for Mexico, respectively.

4.2. Output gaps

The output gap series, $(y - y^*)$, are expressed as deviations of log output from its potential. Potential real output, y^* , is the *smoothed* series estimated from y by applying a basic structural model (BSM) and the *Kalman filter* (See Koopman et al, 2000).

4.3. Exchange rate gaps

In estimating the exchange rate gaps *bivariate (stage three) cointegration tests of PPP* were applied (See Froot and Rogoff, 1995; Edwards and Savastano, 1999), after experimenting with alternative specifications. In equation form

$$e_t = \lambda(p_t - p_t^F) + \zeta_t \quad , \quad (11)$$

where e is the nominal exchange rate measured in units of home currency per unit of foreign currency, while p and p^F are the domestic and foreign price levels, respectively. Equation (11) implies that the exchange rate between the currencies of two countries should equal the ratio of their price levels. Note that in (11) λ is expected to be around one.

Panel B of Table 2 exhibits the long run solutions to the autoregressive distributed lag (*ADL*) (Hendry, Pagan, and Sargan, 1984) PPP cointegrating relations⁸. The coefficients are statistically significant and economically interpretable, with λ values of 0.92 and 0.88 for Chile and Mexico, respectively. Furthermore, the *ADF* test applied to the residuals of such equations rejects non-stationarity. Henceforth, PPP

cointegrating relations hold for Chile and Mexico (See Froot and Rogoff, 1995; and Edwards and Savastano, 1999, for related empirical evidence). These results are employed in the computation of the real exchange rate gaps for both economies.

4.4. Real money gaps

A simple, textbook, money demand relationship relating real monetary balances to a scale variable and a measure of the opportunity cost of holding money, such as equation (7), is used to estimate the real money gaps. Panel B of Table 2 displays the long run solutions to the corresponding *ADL* equations. All the estimated coefficients are statistically significant and have economically sensible coefficients. Notably, the estimated income elasticities, 1.72 for Chile and 1.38 for Mexico, are similar in magnitude to those obtained by Edwards (1998, Table A2, page 700).

Furthermore, these elasticities could be seen as endorsing the findings of Arrau and De Gregorio (1993). These authors explicitly consider, and find a role for, financial innovation in the modelling of the demand for M_1 in Chile and Mexico. One simple way of rationalising the income elasticities greater than unity displayed in Table 2 is by hypothesising that money has increased faster than output in the period under analysis, and therefore the velocity of circulation has decreased in this time span. This conjecture is validated by Figure 5, which shows a decreasing velocity of circulation of M_2 for Chile and Mexico during the period under scrutiny. In the light of the fact that this paper analyses a broad monetary aggregate, the above patterns could be arising, for instance,

⁸ Note that for Chile (11) is an *unbalanced regression*, given that $e \sim I(2)$ and $(p - p^F) \sim I(1)$ (See Banerjee et al, 1993). The *ADL* specification used should, however,

as a result of more advanced financial services, which should allow consumers to hold more of their money in the non-money component of M_2 without compromising their liquidity. However, other factors, e.g. generated by policy, could also be playing a role.

Finally, the *ADF* tests applied to the residuals of such equations reject non-stationarity. Consequently, money demand cointegrating relations exist for Chile and Mexico during the periods under investigation. These results are used in the calculation of the real money gaps for both economies.

At this point it is convenient to exhibit graphically the output, money, and exchange rate gaps calculated for Chile and Mexico, which are gathered in Figure 6.

5. Block Granger non-causality analyses

As highlighted by Stock and Watson (2001), due to the rich lag dynamics implied in the application of vector autoregressions (VARs; Sims, 1980) to time series data statistics derived from these estimations, such as Granger causality tests, tend to be more informative than the usual regression coefficients. In the empirical assessment of the model outlined in section 3 this paper computes multivariate and bivariate block Granger non-causality tests for Chile and Mexico.

The econometric methodology behind the block Granger non-causality test can be illustrated by using an augmented vector autoregression of order n , VAR (n), such as

$$y_t = \alpha_0 + \lambda t + \sum_{i=1}^n \Omega_i y_{t-i} + \Psi x_t + \xi_t \quad (12)$$

help to address that issue.

where y_t is a $m \times 1$ vector of jointly determined (endogenous) variables, t is a linear time trend, x_t is a $p \times 1$ vector of exogenous variables, and ξ_t is a well-behaved disturbance term. If in (12) y_t is divided in two subsets y_{1t} and y_{2t} , which are $m_1 \times 1$ and $m_2 \times 1$ vectors, respectively, and $m = m_1 + m_2$, the following block decomposition can be written down

$$y_{1t} = \alpha_{10} + \lambda_{11}t + \sum_{i=1}^n \Omega_{i,11}y_{1,t-i} + \sum_{i=1}^n \Omega_{i,12}y_{2,t-i} + \Psi_1 x_t + \xi_{1t} \quad (13)$$

$$y_{2t} = \alpha_{20} + \lambda_{21}t + \sum_{i=1}^n \Omega_{i,21}y_{1,t-i} + \sum_{i=1}^n \Omega_{i,22}y_{2,t-i} + \Psi_2 x_t + \xi_{2t}.$$

The hypothesis that the subset y_{2t} is not Granger causal on y_{1t} is given by $\Omega_{12} = 0$, with $\Omega_{12} = (\Omega_{1,12}, \Omega_{2,12}, \Omega_{3,12}, \dots, \Omega_{n,12})$. The log-likelihood ratio statistic that arises from testing $\Omega_{12} = 0$ has $m_1 m_2 n$ degrees of freedom, and is χ^2 asymptotically distributed⁹.

5.1. Chile

The study proceeds by analysing equation (10), that is, the joint impact of $y - y^*$, $\tilde{m} - \tilde{m}^*$, and $e - e^*$ on $\pi - \hat{\pi}$. The outcome of the multivariate block Granger non-causality VAR tests are reported in Table 3. For Chile they support the joint significance of $y - y^*$, $\tilde{m} - \tilde{m}^*$, and $e - e^*$ on $\pi - \hat{\pi}$.

⁹ See, for instance, Pesaran and Pesaran (1997) for further details on this methodology.

However, the corresponding bivariate tests show that the hypothesis of non-causality can only be rejected for the real money gap. Therefore, it can be said that for Chile the P^* model provides some rationale for using a real money gap indicator in the conduct of monetary policy under an IT regime. These outcomes are further analysed below.

5.2. Mexico

Following the results in Cecchetti et al (2000) the baseline estimation period adopted for Mexico is 1991.01-2001.06. As mentioned above, these authors find that monetary policy in Mexico became more effective from 1991. Additionally, given that in Mexico a formal IT strategy is dated as having initiated in 1999 (Mishkin and Schmidt-Hebbel, 2001) the study analyses three periods: 1991.01-2001.06, 1991.01-1998.12, and 1999.01-2001.06. If the way in which money and the other relevant variables considered affect inflationary developments have changed due to the introduction of IT this should be reflected through the estimates for each period.

As for Chile, Mexico's outcomes reject the hypothesis of non-causality from $y - y^*$, $\tilde{m} - \tilde{m}^*$, and $e - e^*$ to $\pi - \hat{\pi}$ for the three time spans under analysis. However, the bivariate results indicate that of these indicators only $e - e^*$ is individually significant (at the 7%) during 1991.01-2001.06. Furthermore, $e - e^*$ also seems to contain significant information (at the 1% level) on determining $\pi - \hat{\pi}$ in the sub-periods 1991.01-1998.12 and 1999.01-2001.06. Table 3 also shows that $y - y^*$ and $\tilde{m} - \tilde{m}^*$ help in predicting $\pi - \hat{\pi}$, but only for the post-IT regime ranging from 1999.01 to 2001.06.

5.3. Robustness check

In order to establish the robustness of the results contained in the previous sub-sections bivariate block Granger non-causality VAR tests are employed using alternative money, output, and exchange rate indicators. The output gap proxy is achieved by passing y through the Hodrick-Prescott filter (HPF) (Hodrick and Prescott, 1997) using a value of 129,600 for the HPF's smoothness parameter λ , as suggested by Ravn and Uhlig (2002) for the analysis of monthly data. Also, two money growth measures, $\Delta\tilde{m}$ and $\Delta\tilde{m} - \Delta y$, and a standard real exchange rate indicator, $REXR$, are considered. Note that $\Delta\tilde{m}$ and Δy are calculated as annual changes in the log of the money and output variables, respectively, whereas $REXR$ is given by $e - p + p^f$.

The outcome of the bivariate block Granger non-causality tests are reported in Table 4. For Chile only the output gap and money growth indicators are found to be significant. Similarly, Mexico's results endorse the robustness of the previous findings: the indicator $REXR$ contains statistically significant information on inflation in the three periods under scrutiny. Henceforth, it can be argued that the exchange rate is a useful predictor of inflation in Mexico during the last decade, and should be a closely monitored variable by the monetary authorities. This comes as no surprise, particularly in the time span under scrutiny, which encompasses the well-documented Mexican exchange rate crisis of 1995¹⁰.

¹⁰ See, for instance, the November 1996, volume 41, issue of the *Journal of International Economics*.

In contrast to Mexico's case, it seems that in Chile the role played by the exchange rate was not statistically significant. This could be reflecting the effectiveness of the exchange rate band regime implemented during most of the sample under study, referred to in section 2.1 (See Morandé and Tapia, 2002). In this respect, Reinhart and Rogoff's (2002) novel approach to the classification of exchange rate regimes catalogues Chile's exchange rate regimes during 1989-2001 as: pre-announced crawling band around the US Dollar (June 1, 1989-January 22, 1992), *de facto* announced crawling band around the US Dollar (January 22, 1992-June 25, 1998), pre-announced crawling band to US Dollar (June 25, 1998-September 2, 1999), and managed floating (September 2, 1999-December 2001).

Additionally, for Mexico $\Delta\tilde{m}$ is rejected as being non-causal on $\pi - \hat{\pi}$ during both 1991.01-1998.12 and 1999.01-2001.06, whereas $HPF(y - y^*)$ is so only for the post IT period. From this last findings it is natural to derive the preliminary conclusion that at the early stages of an IT regime the monetary authorities should be particularly careful in monitoring a wide array of variables.

5.3. Impulse responses

The research proceeds by calculating the generalised impulse response functions (GIRs) of $\pi - \hat{\pi}$ from shocks to the VARs containing the variables found to be statistically relevant in the previous sections (See Koop et al, 1996; Pesaran and Shin, 1998).

Figures 7 and 8 show the outcomes of these exercises for Chile and Mexico, respectively. (Note that the error bands for the impulse responses are calculated using Monte Carlo methods.) Figure 7's panel (a) exhibits the GIR of $\pi - \hat{\pi}$ to a one standard

deviation shock to the equation for the real money. Notably, the impact of that shock on inflation lasts up to the 24th month. This is in harmony with the well-known long and variable lags in the transmission of monetary impulses postulated by Milton Friedman (1961) (See Batini and Nelson, 2001, for a related study). Figure 7's panel (b) displays the impact on $\pi - \hat{\pi}$ of a one standard deviation shock to the equation for the $HPF(y - y^*)$, showing a strong and positive effect of the output gap on inflationary developments.

The variables found to be most robust (i.e. significant in the various sub-periods considered) in explaining inflation in Mexico, namely $e - e^*$, $REXR$, and $\Delta \tilde{m}$, are examined for the full sample period (1991.01-2001.06) by studying the GIRs arising from shocks to the VAR equations explaining their behaviour. A positive impact on $\pi - \hat{\pi}$ from a disturbance to the equation for $e - e^*$ is shown in Figure 8's panel (a), lasting up to twelve months. The effect of ruffling the equation for $REXR$, displayed in panel (b), generates an analogous pattern. These two graphs visually demonstrate the forefront role played by the exchange rate in determining Mexico's inflationary dynamics. Finally, panel (c) portrays that shocks to $\Delta \tilde{m}$ can generate significant swings on $\pi - \hat{\pi}$, lasting up to two years. Henceforth, the role of money should also be carefully assessed in the conduct of monetary policy in Mexico.

6. Conclusion

This paper analyses the information content of monetary and open economy indicators in the conduct of monetary policy in two inflation targeting Latin American economies: Chile and Mexico. The main findings of the analyses reveal that for Chile both the real

money gap and real money growth indicators contain significant information on deviations of inflation from the inflation target. In contrast, for Mexico different measures of the real exchange rate are found to be consistently relevant in the pre and post-IT (1999) periods. These results are of considerable importance to policymakers. They convey that neglecting the role that monetary and open economy indicators play in monetary policy making within an IT framework could be detrimental to the successful operation of such a strategy.

References

- Amato, Jeffery D., and Stefan Gerlach (2002) Inflation targeting in emerging market and transition economies: Lessons after a decade, *European Economic Review*, **46**, 781-790.
- Arrau, Patricio, and José De Gregorio (1993) Financial innovation and money demand: Application to Chile and Mexico, *Review of Economics and Statistics*, **75**, 524-530.
- Banerjee, Anindya, Juan Dolado, John W. Galbraith, and David F. Hendry (1993) *Cointegration, error-correction, and the econometric analysis of non-stationary data*, Oxford University Press, Oxford.
- Batini, Nicoletta, and Edward Nelson (2001) The lag from monetary policy actions to inflation: Friedman revisited, Bank of England External MPC Unit Discussion Paper No. 6, December.
- Bernanke, Ben S., Thomas Laubach, Frederick Mishkin, and Adam S. Posen (1999) *Inflation targeting: Lessons from the international experience*, Princeton University Press.
- Calvo, Guillermo A., and Carmen M. Reinhart (2002) Fear of floating, *Quarterly Journal of Economics*, **117**, 379-408.
- Cecchetti, Stephen G., A. Flores-Lagunes, and S. Krause (2000) Has monetary policy become more efficient in Mexico? Mimeo, Department of Economics, The Ohio State University.
- Corbo, Vittorio, and Klaus Schmidt-Hebbel (2001) Inflation targeting in Latin America, Central Bank of Chile Working Paper No. 105, September.

- Dickey, D.A., and W.A. Fuller (1979) Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association*, **74**, 427-431.
- Edwards, Sebastian (1998) Two crises: Inflationary inertia and credibility, *Economic Journal*, **108**, 680-702.
- Edwards, Sebastian, and Miguel A. Savastano (1999) Exchange rates in emerging economies: What do we know? What do we need to know? NBER Working Paper No. 7228, Cambridge, MA, July.
- Friedman, Milton (1961) The lag in the effect of monetary policy, *Journal of Political Economy*, **69**, 447-466
- Froot, Kenneth A., and Kenneth Rogoff (1995) Perspectives on PPP and long-run real exchange rates, Chapter 32 in G. Grossman and K. Rogoff (Eds.) *Handbook of International Economics, Volume III*, Elsevier Science Publishers, The Netherlands.
- Gerlach, Stefan, and Lars E.O. Svensson. Money and inflation in the Euro area: A case for monetary indicators? Forthcoming, *Journal of Monetary Economics*.
- Hallman, Jeffrey, Richard D. Porter, and David H. Small (1991) Is the price level tied to the M2 monetary aggregate in the long run? *American Economic Review*, **81**, 841-858.
- Harvey, Andrew (1989) *Forecasting, structural time series models and the Kalman filter*, Cambridge University Press, Cambridge.
- Hendry, David F., Adrian R. Pagan, and J. Denis Sargan (1984) Dynamic specification, Chapter 18 in Zvi Griliches and Michael Intriligator (Eds.), *Handbook of Econometrics, Volume II*, pages 1023-1100, Elsevier Science Publishers, The Netherlands.
- Ho, Corrinne, and Robert N. McCauley (2003) Living with flexible exchange rates: issues and recent experience in inflation targeting emerging market economies, BIS working paper no. 130, Basle, February.
- Hodrick, Robert J., and Edward C. Prescott (1997) Postwar US business cycles: an empirical investigation, *Journal of Money, Credit, and Banking*, **29**, 1-16.
- Khamis, May, and Alfredo Leoni (2001) Can currency demand be stable under a financial crisis? The case of Mexico, *IMF Staff Papers*, **48**, 344-366.
- King, Mervyn (2002) No money, no inflation – the role of money in the economy, *Bank of England Quarterly Bulletin*, **42**, 162-177.

- Koop, Gary, M. Hashem Pesaran, and Simon M. Potter (1996) Impulse response analysis in nonlinear multivariate models, *Journal of Econometrics*, **74**, 119-147.
- Koopman, Siem Jan, Andrew C. Harvey, Jurgen A. Doornik, and Neil Shepard (2000) *STAMP: Structural Time Series Analyser, Modeller and Predictor*, Timberlake Consultants Press, London.
- MacKinnon, James G. (1991) Critical values for cointegration tests, Chapter 13 in Robert Engle and Clive W. Granger (eds.), *Long-run economic relationships: Readings in cointegration*, 267-276, Oxford University Press, Oxford.
- McCallum, Bennett T. (1980) Rational expectations and macroeconomic stabilisation policy, *Journal of Money, Credit and Banking*, **12**, 716-746.
- Mishkin, Frederic S., and Miguel A. Savastano (2000) Monetary policy strategies for Latin America, NBER Working Paper 7617, Cambridge, MA, March.
- Mishkin, Frederic S., and Klaus Schmidt-Hebbel (2001) One decade of inflation targeting in the world: What do we know and what do we need to know? NBER Working Paper 8397, Cambridge, MA, July.
- Morandé, Felipe G., and Matías Tapia (2002) Exchange rate policy in Chile: From the band to floating and beyond, Central Bank of Chile Working Paper No. 152, April.
- Mussa, Michael (1981) Sticky prices and disequilibrium adjustment in a rational expectations model of the inflation process, *American Economic Review*, **71**, 1020-1027.
- Pesaran, M. Hashem, and Bahram Pesaran (1997) *Working with Microfit 4.0: Interactive econometric analysis*, Oxford University Press.
- Pesaran, M. Hashem, and Yongcheol Shin (1998) Generalised impulse response analysis in linear multivariate models, *Economics Letters*, **58**, 17-29.
- Ravn, Morten O., and Harald Uhlig (2002) On adjusting the HP-filter for the frequency of observations, *Review of Economics and Statistics*, **84**, 371-380.
- Reinhart, Carmen M., and Kenneth S. Rogoff (2002) The modern history of exchange rate arrangements: A reinterpretation, NBER Working Paper No. 8963, Cambridge, MA.
- Sims, Christopher A. (1980) Macroeconomics and reality, *Econometrica*, **48**, 1-49.
- Stock, James H., and Mark W. Watson (2001) Vector autoregressions, *Journal of Economic Perspectives*, **15**, 101-115.

Stone, Mark R. (2003) Inflation targeting lite, IMF working paper 03/12, Washington, DC, January.

Svensson, Lars E.O. (2000) Open-economy inflation targeting, *Journal of International Economics*, **50**, 155-183.

Trecroci, Carmine, and Juan Luis Vega (2002) The information content of M3 for future inflation in the Euro area, *Weltwirtschaftliches Archiv*, **138**, 22-53

**Table 1 Chile and Mexico
Inflation targeting: Adoption dates and targets width**

Country	Date introduced	Target price index	Target width	
Chile	January 1991	Headline CPI	1991	15-20%
			1992	13-16%
			1993	10-12%
			1994	9-11%
			1995	±8%
			1996	±6.5%
			1997	±5.5%
			1998	±4.5%
			1999	±4.3%
			2000	±3.5%
			2001	2-4%
Mexico	January 1999	Headline CPI	1999	13%
			2000	<10%
			2001	6.5%

Source. Mishkin and Schmidt-Hebbel (2001), Table 2.

Note: CPI = consumer price index.

**Table 2 Chile and Mexico
Unit root and cointegration tests**

A. ADF unit root tests				
Variables	Levels		First differences ($\Delta I2$)	
	Chile (1991.02- 2001.06)	Mexico (1987.02- 2001.06)	Chile (1992.02- 2001.06)	Mexico (1988.02- 2001.06)
\tilde{m}	-2.368	-0.6335	-2.937*	-5.194**
y	-2.422	-0.7214	-3.006*	-4.365**
R	-2.710	-2.519	-3.483*	-3.926**
e	0.336	-2.488	-1.665	-3.815**
p^D	-1.773	-1.763	-1.812	-7.265**
p	-6.586**	-2.042	-2.927*	-6.783**
p^F	0.022	-1.685	-3.870**	-3.748**
$p^D - p^F$	-0.782	-1.949	-3.554**	-7.228**
B. Long run solutions to ADL equations				
Variables	Chile (1991.01-2001.07)		Mexico (1988.01-2001.06)	
	Money demand Equation (1)	PPP Equation (2)	Money demand Equation (3)	PPP Equation (4)
$Cons$	-1.21 (0.448)**	6.24 (0.025)**	9.03 (0.693)**	1.53 (0.071)**
β_y	1.72 (0.078)**	-	1.38 (0.143)**	-
β_R	-0.02 (0.011)*	-	-0.003 (0.001)**	-
λ	-	0.92 (0.093)**	-	0.88 (0.087)**
ADF test	-8.052 (-4.40)	-7.908 (-3.98)	-9.465 (-4.37)	-8.904 (-3.96)
$WALD - \chi^2$	493.74 (2)**	97.84 (1)**	262.72 (2)**	101.367 (1)**

Notes. - Part A: the augmented Dickey-Fuller test (ADF) is based on a regression of the form $\Delta y_t = \alpha + \phi y_{t-1} + \sum_{i=1}^T \Theta \Delta y_{t-i} + \delta t + \varepsilon_t$, where ε_t is a random error term, and α and t are a constant and time trend, respectively. The ADF test corresponds to the value of the t-ratio of the coefficient ϕ . The null hypothesis of the ADF test is that y_t is a non-stationary series, which is rejected when ϕ is significantly negative. Only a constant was added to the tests. ** and * denote rejection of the unit root hypothesis at the 1% and 5% level, respectively. Part B: (1) Coefficients' standard errors are inside parentheses. $WALD - \chi^2$ is a test of the null that all long-run coefficients are zero, with $\chi^2(\cdot)$ distribution. (2) ADL = autoregressive distributed lag. Critical values (1%) for the ADF test applied to the residuals of the cointegrating relations are from MacKinnon (1991), and are shown in parentheses next to the corresponding ADF statistic. A significant test means rejection of the hypothesis of non-stationarity, i.e. a cointegrating relationship exists between the variables under analysis. (3) ** and * denote a coefficient/test is significant at the 1% and 5% levels, respectively. (4) The ADL equations allowed for twelve lags of each of the variables considered. Further details on these procedures can be obtained from the author upon request.

Table 3 Chile and Mexico
Multivariate and bivariate block Granger non-causality VAR tests of the augmented Phillips curve/P-star model

Null hypotheses		LR test statistic (probability)							
		Chile		Mexico					
		1992.09-2001.06	Lags	1991.01-2001.06	Lags	1991.01-1998.12	Lags	1999.01-2001.06	Lags
$y - y^*$	Non causal on $\pi - \hat{\pi}$	76.909 (0.000)**	10	51.302 (0.047)*	12	98.816 (0.000)**	12	33.483 (0.004)**	5
$\tilde{m} - \tilde{m}^*$	Non causal on $\pi - \hat{\pi}$	0.776 (0.678)	2	5.752 (0.569)	7	5.664 (0.685)	8	13.763 (0.017)*	5
$e - e^*$	Non causal on $\pi - \hat{\pi}$	26.648 (0.009)**	12	11.081 (0.522)	12	11.244 (0.423)	11	24.733 (0.010)**	11
	Non causal on $\pi - \hat{\pi}$	8.242 (0.766)	12	20.257 (0.062)†	12	47.948 (0.000)**	12	37.452 (0.000)**	12

Notes: the block Granger non-causality statistic is calculated through a LR test, and has a χ^2 distribution. The test statistics are displayed with corresponding probability values inside parentheses. For both countries an unrestricted vector autoregression (VAR) of an initial lag order of 12 was used. For Mexico, the multivariate estimations for 1999.01-2001.01 start with 6 lags due to data limitations. The lag lengths were determined through the Schwarz Bayesian Criteria (SBC). †, * and ** denote rejection of the null at the 10%, 5%, and 1% levels, respectively.

Table 4 Chile and Mexico
Bivariate block Granger non-causality VAR tests of the robustness of the augmented Phillips curve/P-star model

Null hypotheses	LR test statistic (probability)							
	Chile		Mexico					
	1992.09-2001.06	Lags	1991.01-2001.06	Lags	1991.01-1998.12	Lags	1999.01-2001.06	Lags
<i>HPF</i> Non causal on ($y - y^*$) $\pi - \hat{\pi}$	21.572 (0.010)**	9	10.050 (0.526)	11	15.811 (0.148)	11	21.291 (0.011)*	9
$\Delta \tilde{m}$ Non causal on $\pi - \hat{\pi}$	19.995 (0.067)†	12	15.807 (0.200)	12	25.757 (0.012)*	12	26.012 (0.004)**	10
$\Delta \tilde{m} - \Delta y$ Non causal on $\pi - \hat{\pi}$	10.376 (0.497)	11	5.625 (0.897)	11	13.724 (0.249)	11	0.476 (0.490)	1
<i>REXR</i> Non causal on $\pi - \hat{\pi}$	12.042 (0.442)	12	22.624 (0.031)*	12	60.235 (0.000)**	12	23.539 (0.009)**	10

Notes: the block Granger non-causality statistic is calculated through a LR test, and has a χ^2 distribution. The test statistics are displayed with corresponding probability values inside parentheses. For both countries an unrestricted vector autoregression (VAR) of an initial lag order of 12 was used. The lag lengths were determined through the Schwarz Bayesian Criteria (SBC). †, * and ** denote rejection of the null at the 10%, 5%, and 1% levels, respectively.

Appendix 1 Data definitions and sources

**Table A1 Chile and Mexico
Data definitions and sources**

Variables	Chile	Mexico
M	M_2A , real private money, monthly averages in thousands of millions of 1986 Chilean Pesos.	$M_2 = M_1$ + internal financial assets in the hands of residents, thousands of Mexican Pesos.
Y	Monthly indicator of economic activity, IMAE, 1986 = 100.	Industrial production index, 1993 = base.
R	PRBC, 90 days in annual percentage points.	Interest rate of 28 days CETES, in annual percentage points.
E	Observed monthly exchange rate, Chilean Pesos per United States Dollar.	Exchange rate, Mexican Pesos per United States Dollar, monthly average.
P^D	Producer price index, June 1992 = 100.	Wholesale price index, excluding oil, 1994 = base.
P	Consumer price index, December 1998 = 100.	Consumer price index, 1994 = base.
P^*	Foreign (US) producer price index, 1982 = base, from the FRED of the Federal Reserve Bank of St Louis (http://www.stls.frb.org/fred/data/ppi/ppiaco).	

Sources.

Chile: Unless otherwise indicated, Central Bank of Chile, <http://www.bcentral.cl/Indicadores/eindicadores.htm>.

Mexico: Unless otherwise indicated, Central Bank of Mexico, <http://www.banxico.org.mx/eInfoFinanciera/FSinfoFinanciera.html>.

Figure 1 Data Chile, 1990.01-2001.06

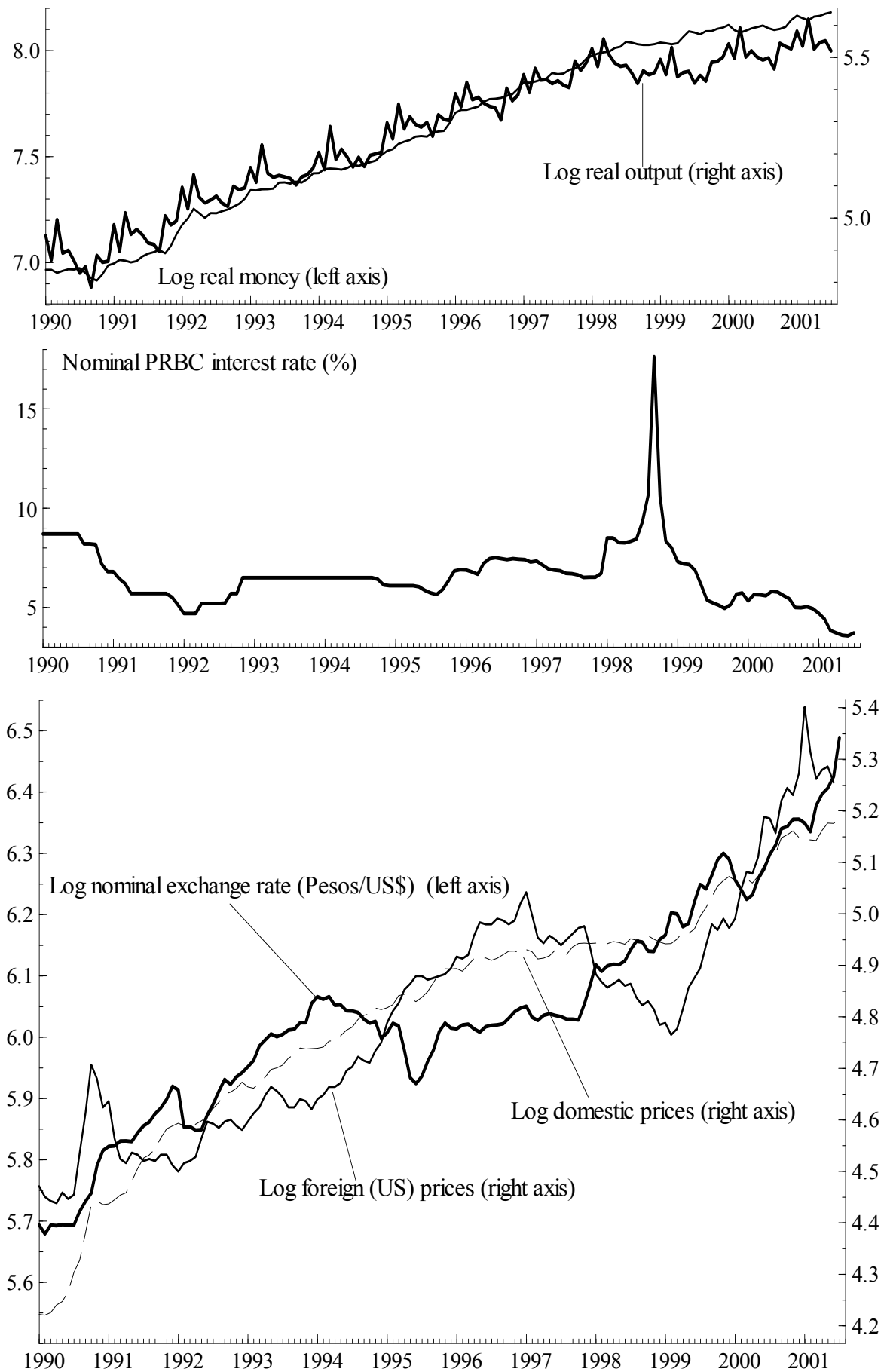


Figure 2 Data Mexico, 1986.01-2001.06

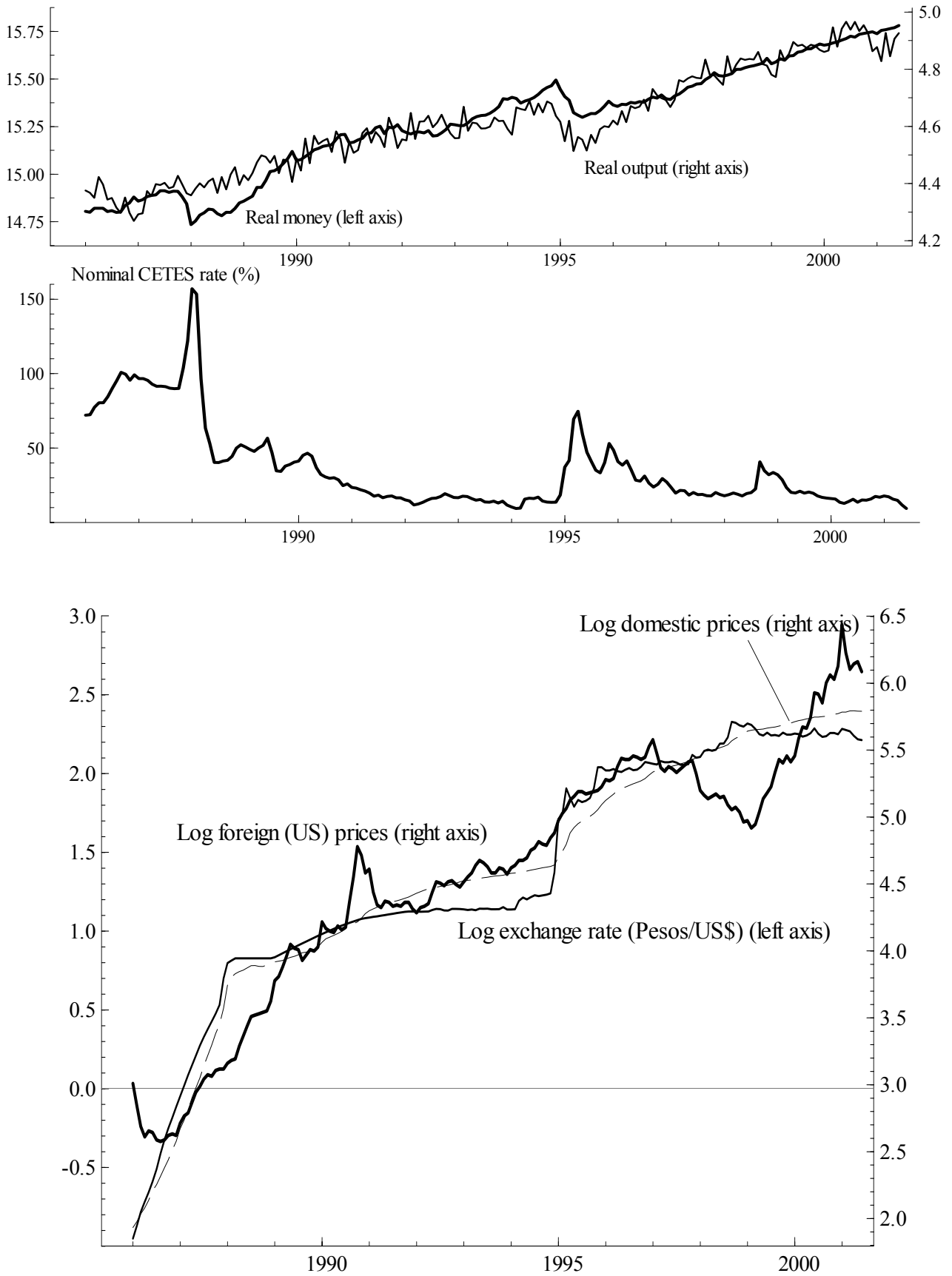


Figure 3 Chile
Actual and target inflation (percent), 1991.01-2001.06

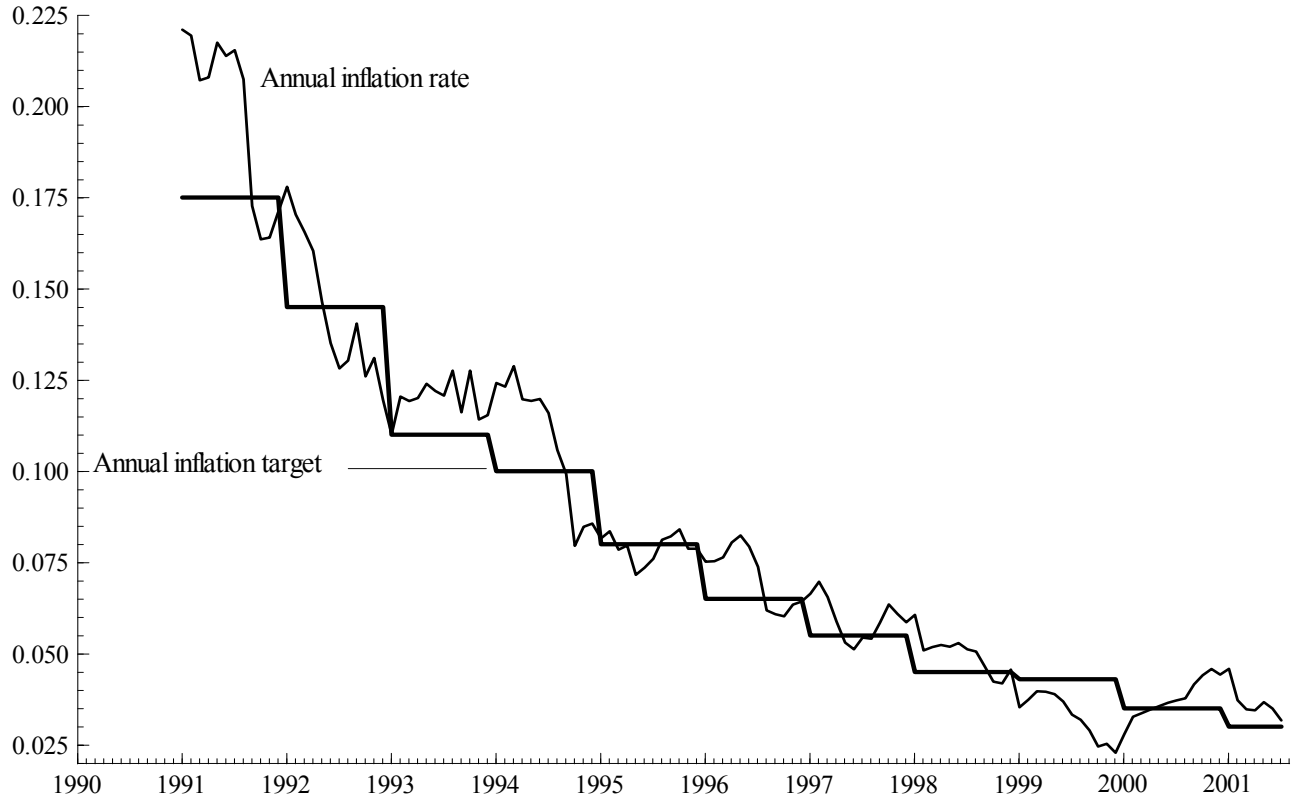


Figure 4 Mexico
Actual and expected/target inflation (percent), 1987.07-2001.06

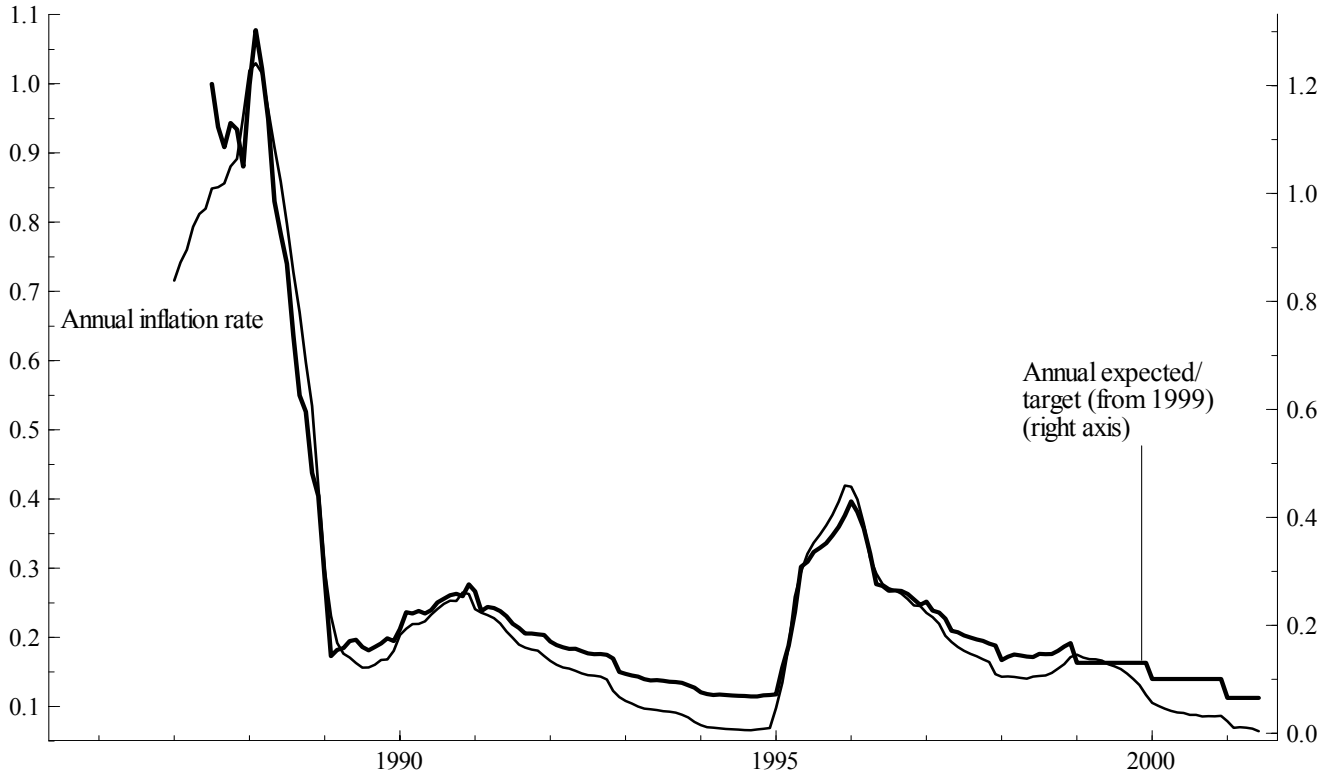


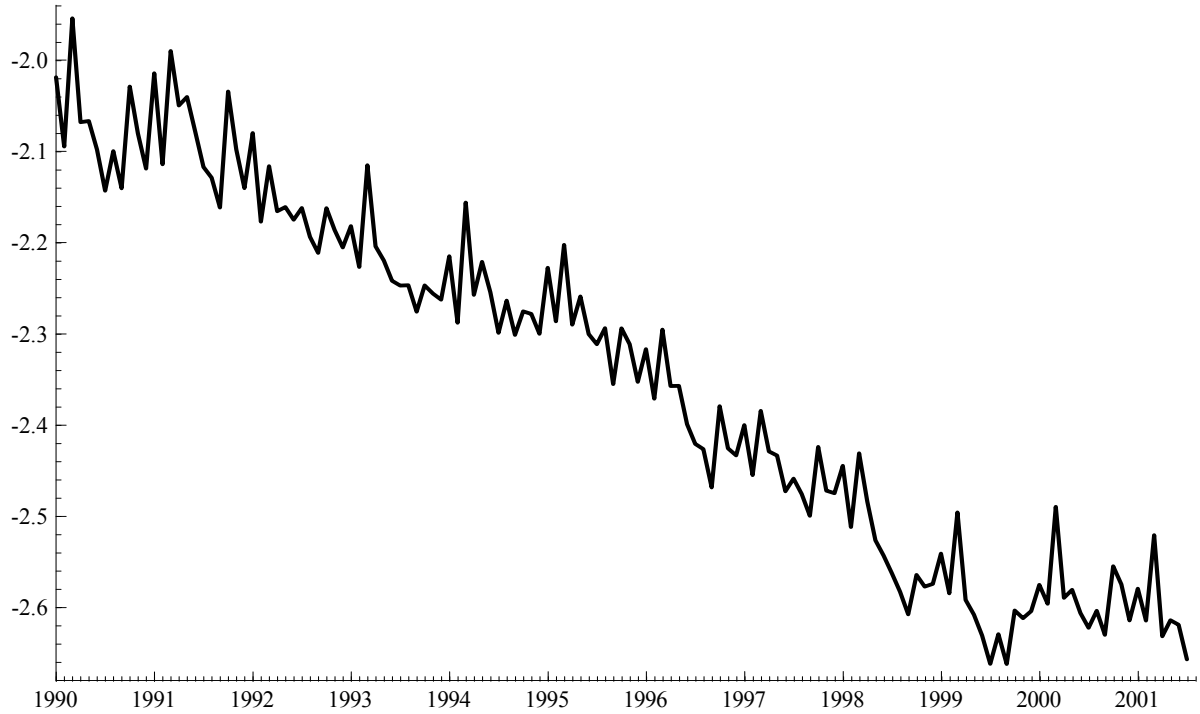
Figure 5 M_2 velocity in Chile and Mexico**Chile, 1990.01-2001.07****Mexico, 1986.01-2001.06**

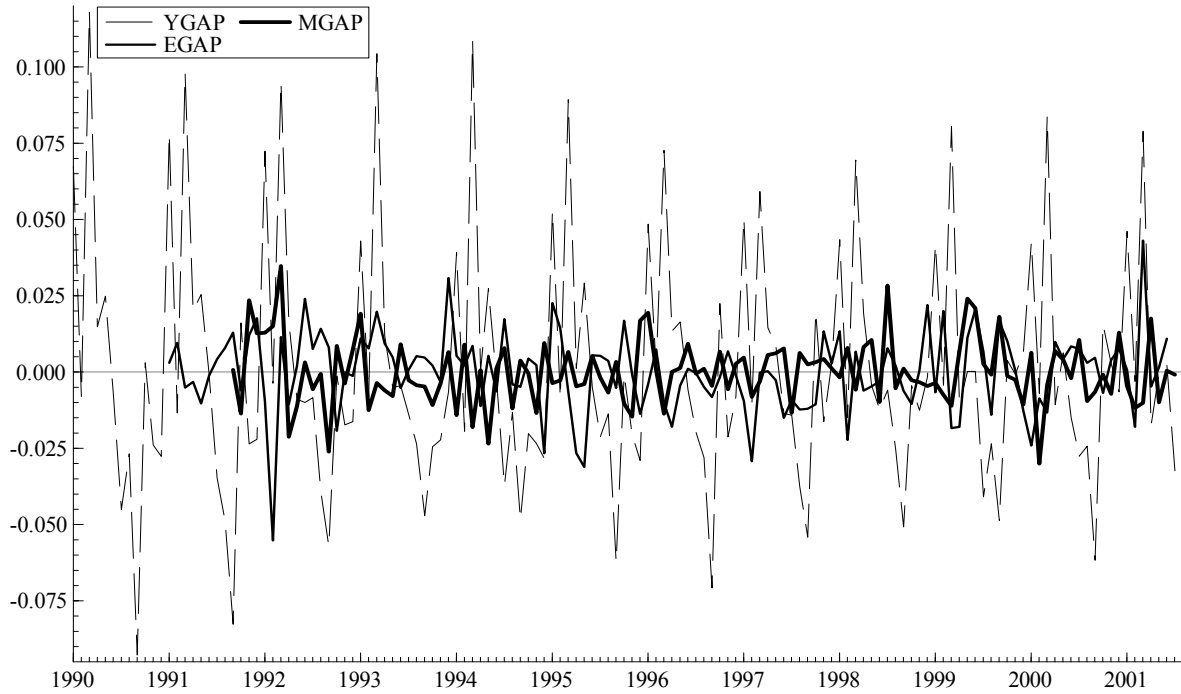
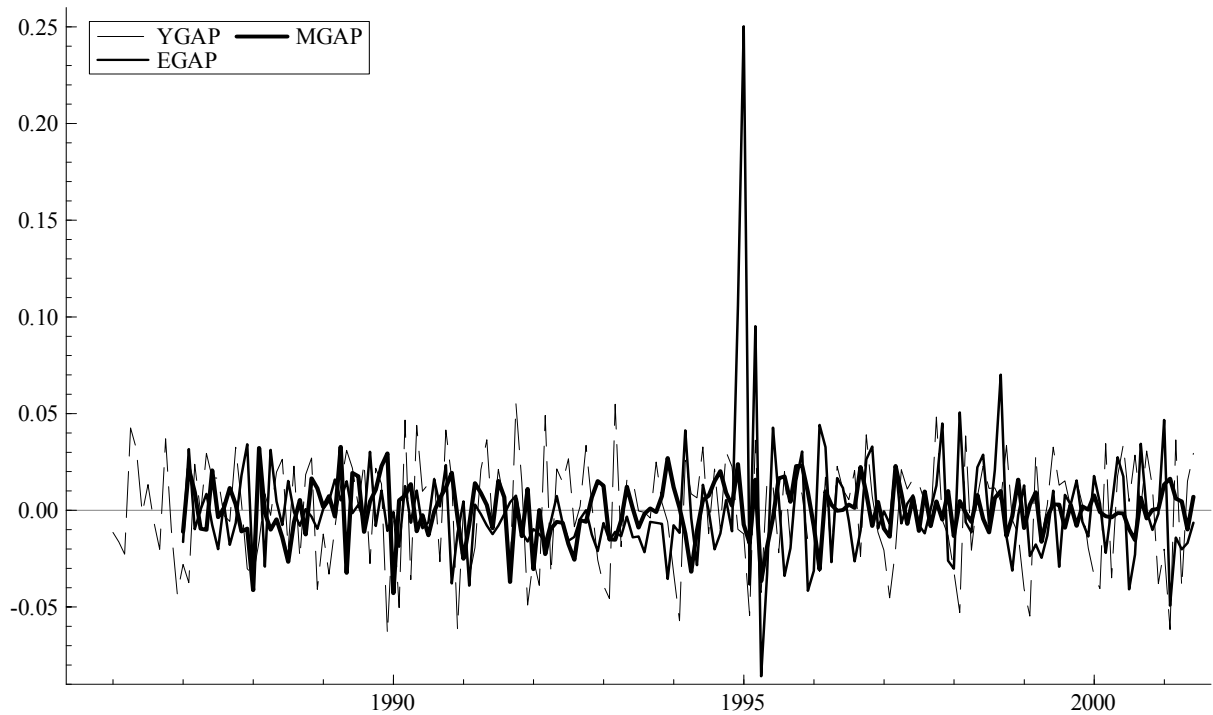
Figure 6 Output, money, and exchange rate gaps**Chile****Mexico**

Figure 7 GIRs of $\pi - \pi^*$ to one S.D. shock in the equation for (a) $(\tilde{m} - \tilde{m}^*)$ and (b) $HPF(y - y^*)$ with Monte Carlo standard errors Chile, 1992.6-2001.6

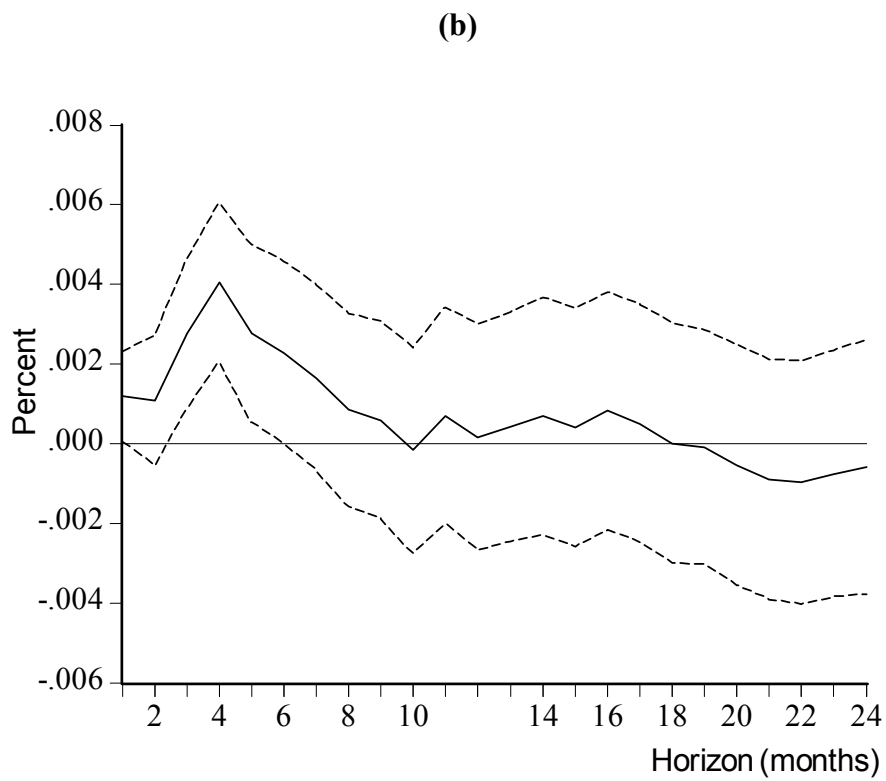
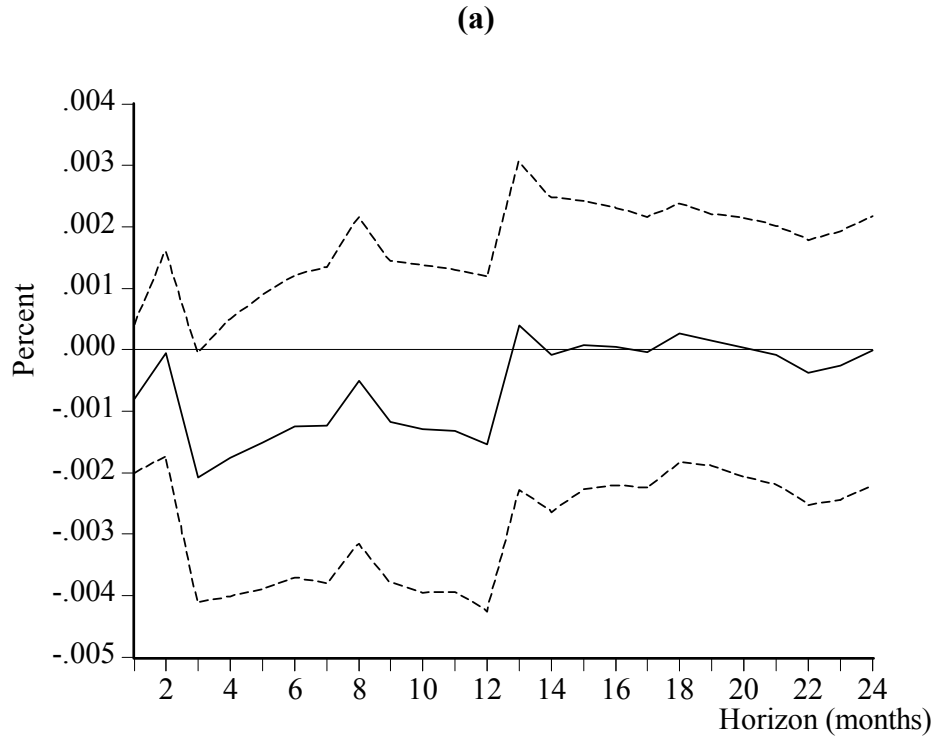


Figure 8 GIRs of $\pi - \pi^*$ to one S.D. shock in the equation for the (a) $(e - e^*)$, (b) $REXR$, and (c) $\Delta \tilde{m}$ with Monte Carlo standard errors Mexico, 1991.1-2001.6

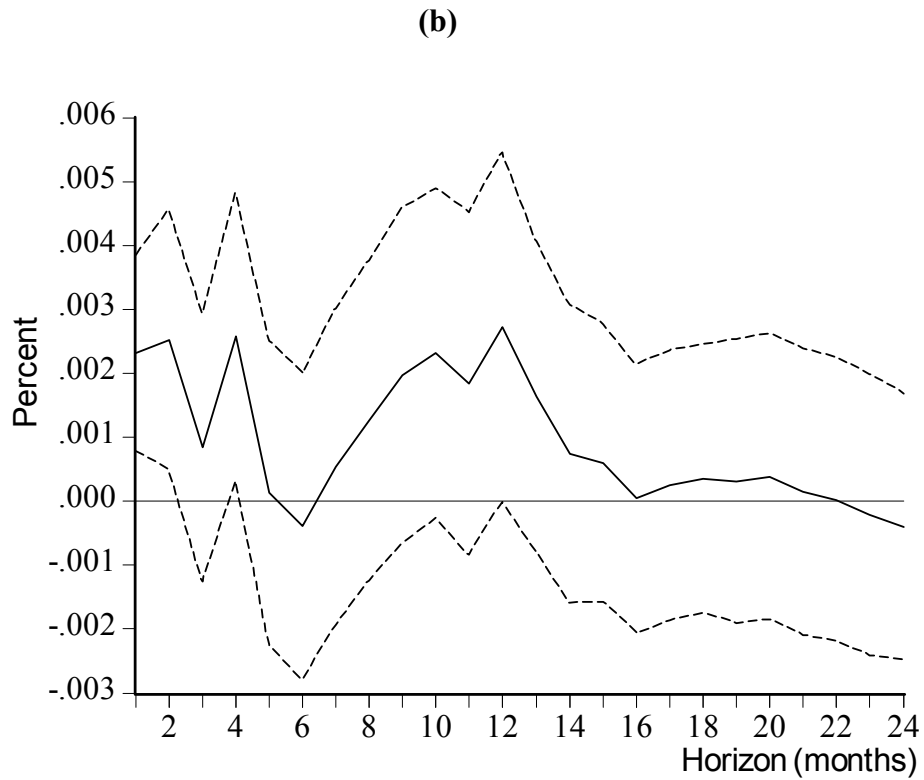
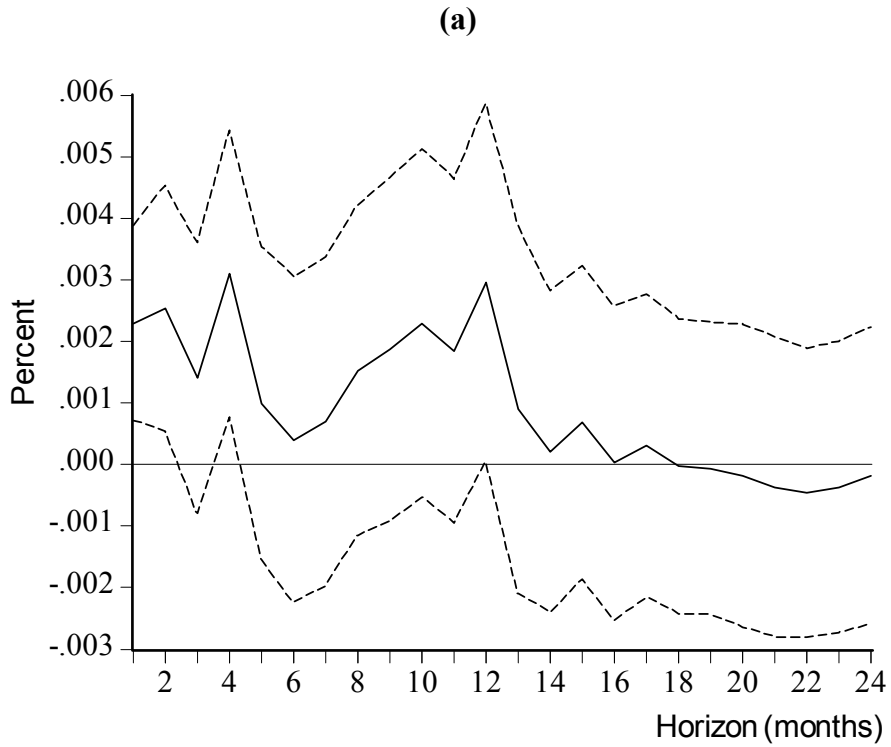
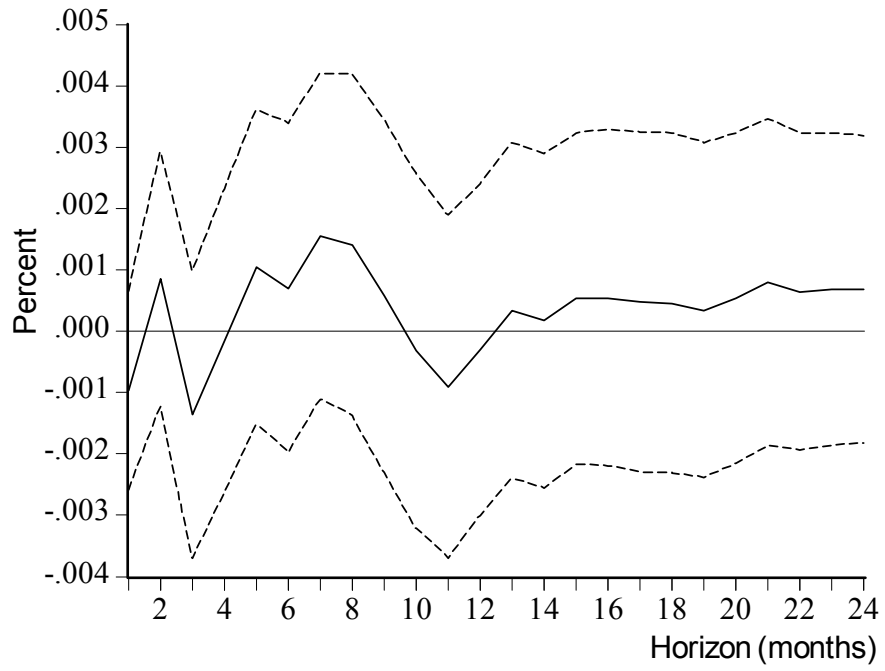


Figure 8 continued...

(c)



Appendix 2 Econometric estimation of the inflation target for Mexico, 1987.04-2001.06

In the light of the fact that Mexico adopted a formal inflation target from January 1999, a proxy for an ‘implicit’ inflation target ($\hat{\pi}$) is estimated using a *univariate structural time series model* (Harvey, 1989). Details on the specification and related statistics are displayed in Table A2.

Table A2 Univariate structural time series model for inflation in Mexico, 1987.04-2001.06

Model	
$\hat{\pi}_t = \text{Fixed level} + \text{cycle} + \text{irregular} + \text{interventions}$	
Statistics	
Level (final state vector)	T-ratio = 5.0692
= 0.0052	RMSE = 0.00103
Standard error of equation	0.0084
<i>RPEV</i>	0.000071
R_d^2	0.8726
R_s^2	0.8724

Notes: RMSE = root mean square error. RPEV = residuals prediction error variance. R_d^2 and R_s^2 are goodness of fit statistics that compare the results with a random walk plus drift and a random walk with fixed seasonal dummies, respectively. See Koopman et al (2000) for details on these tests.

1. The baseline specification employed for the case at hand is based on a ‘local linear trend’ model that can be written as

$$\begin{aligned} \hat{\pi}_t &= \lambda_t + \zeta_t, \\ \zeta_t &\sim NID(0, \sigma_\zeta^2). \end{aligned} \tag{A1}$$

In this application, the model search process led to an equation in which the level (λ) is fixed, i.e. does not contains a stochastic element.

Furthermore

2. Two lags of the dependent variable are used in fitting (A1).
3. Cycle and irregular components are also added to equation (A1). Further details on the rationality of these elements can be found in Koopman et al (2000).
4. Interventions affecting λ in (A1) are included in the periods 1987.12, 1988.01, and 1988.02 to account for the impact of ‘The Pacto’ economic program.
5. All the elements outlined in points 2. to 4. are statistically significant at the 1% level, with the exception of the intervention for 1988.01 which is so at the 2% level.
6. The fitted model is used to calculate the *filtered* estimate of the trend in (A1) at all points in the sample, (remarkably) using only data available up to the previous period, i.e. $\hat{\pi}_{\langle t|t-1 \rangle}$. Therefore, the ‘econometric inflation target’ intends to reproduce the economic agents’ expected central bank inflation objective. Empirically, this is achieved by using a technically compelling updating technology, the *Kalman filter*, to estimate the state (λ).
7. Note that the λ implied by the final state vector, reported in Table A2, is 0.0052, which amounts to an annual inflation rate of 0.0624 (6.24%) at the end of the sample period.

Further details on the above exercise can be obtained from the author upon request.