NOTAS DE INVESTIGACIÓN

Esta sección tiene por objetivo divulgar artículos breves escritos por economistas del Banco Central de Chile sobre temas relevantes para la conducción de las políticas económicas en general y monetarias en particular. Las notas de investigación, de manera frecuente, aunque no exclusiva, responden a solicitudes de las autoridades del Banco.

REVISITING THE PRICE PUZZLE IN CHILE

Michael Pedersen*

I. INTRODUCTION

Economic theory argues that a contractionary monetary policy has a negative impact on inflation. Despite this, evidence from the empirical literature frequently finds that the estimated impulse-response function of a vector autoregressive (VAR) model implies that inflation increases after an unexpected monetary shock. This is referred to as the price puzzle and was first noted by Sims (1992) for a number of industrialized countries.[1] The present note revisits the price puzzle in Chile with data from 2002 to 2016. Even though the results are not statistically significant, they do show an interesting feature. In line with the main part of the earlier literature, inflation increases after an unexpected monetary shock in the pre-crises period suggesting the presence of a price puzzle in Chile. After the crisis, however, inflation decreases following a monetary shock. This is in contrast with earlier evidence for Chile suggesting that the price puzzle is no longer present.

After Sims (1992) presented evidence of price puzzles in France, Germany, Japan, the U.K. and the U.S., several studies have documented the existence of this puzzle and suggested possible solutions.[2] In the case of Chile, the majority of the existing studies find evidence of a price puzzle, even though the results are often not statistically significant.[3] Valdés (1998) employs, in his structural VAR (SVAR) models, observations from January 1985 to August 1996 of the monetary policy rate, underlying inflation, economic activity

* *Economic Research Department, Central Bank of Chile. E-mail: mpederse@bcentral.cl*

1 *The term "price puzzle" was introduced by Eichenbaum (1992) in a comment to Sims' analysis.*

2 *See Li et al. (2013) and the references therein for a discussion of the issues of measurement, identification, and misspecification.*

3 *Appendix B in Cabrera and Lagos (2002) presents a list of studies on monetary policy in Chile published before 1997. Appendix B in Parrado (2001) resumes empirical studies from 1991 to 2000 that apply structural VAR models to analyze the monetary policy in Chile.*

(Imacec), money supply (M1A), the exchange rate, and, as exogenous variable, the terms of trade (ToT). He finds that the underlying inflation increases after an unexpected monetary shock. Calvo and Mendoza (1999) also employ data from the period where the monetary policy rate was a real interest rate in Chile. They estimate a VAR model with observations from January 1986 to May 1997 including an indexed short-term lending rate, the price index, real effective exchange rate, the Imacec, M1A, the stock of net international reserves, and ToT. They find evidence that a price puzzle is present in Chile, and this also holds when substituting the copper price for the ToT.

Contrary to the other evidence for Chile, Parrado (2001) does not find evidence of a prize puzzle in Chile. He applies data from January 1991 to January 2001 to estimate a SVAR model with level data—some of which are seasonally adjusted—of the Imacec, the consumer price index (CPI), the oil price, the monetary policy rate, the Fed fund (or, as an alternative, a measure of the country risk premium (EMBI)), M1A, and the real exchange rate. All variables are endogenous and contemporaneous restrictions are imposed to identify the shock.

Cabrera and Lagos (2002) estimate a number of models with data from 1986 to 1997. They conclude that the price puzzle is present in the majority of the models and mention that, in accordance with Leeper et al. (1996), this could be due to wrong identification assumptions and VAR specification problems. Chumacero (2005) estimates a SVAR with nine variables: industrial production of the U.S., U.S. wholesale prices, real money holding in the U.S., the federal funds rate, the real exchange rate, the Imacec, CPI, real domestic money holdings and the monetary policy rate. He employs data from January 1985 to July 2001 and finds that domestic prices increase after a shock to the monetary policy rate.

A study that applies a nominal policy rate for Chile is that of de Mello and Moccero (2008), who estimate three dimensional VAR models with data from January 1996 to February 2006, splitting the sample into two parts with September 1999 as the break point, such that the second period is the regime with a freely floating exchange rate. The variables they include are the consumer price index (CPI), the monetary policy rate (inflated by the UF during the period where it was set in real terms) and the output gap (HP-filtered Imacec). They also include the exchange rate as an exogenous variable. The evidence for Chile suggests a price puzzle in both periods, but the responses of the inflation rate are not statistically significant in the second one.

It is crucial for an inflation targeting central bank, such as the Chilean, to understand how the monetary policy affects inflation at different horizons.[4] Despite this, no recent studies address the issue of a possible price puzzle in Chile. Particularly, no evidence exists from the post-crisis period, which is

4 Christiano et al. (1999) argue that studying what happens after a monetary shock is important as it implies assessing whether it is possible to apply structural models to investigate systematic changes in monetary policy rules and institutions.

an interesting one because of the experience gained from the commodity price boom-bust period and the unusually expansionary monetary policy. The objective of the present note is to investigate whether the effect of monetary policy shocks, derived from a simple VAR model, has changed after the global financial crisis.

The next section presents the econometric framework and the results of some preliminary testing on the data. The third section presents the empirical results for Chile.

II. DATA, THE ECONOMETRIC MODEL AND PRELIMINARY TESTS

The period analyzed spans from January 2002 to July 2016 (the effective sample of estimation). The data employed are mainly extracted from the web page of the Central Bank of Chile. The benchmark model includes three variables: the CPI, activity (Imacec) and the interbank interest rate as a proxy for the monetary policy rate.[5] One complementary analysis includes commodity prices, measured by the all commodity price index (PALLFNF) of the International Monetary Fund,[6] and another includes the output gap instead of the Imacec.[7]

In the literature on the inflationary effect of monetary policy, different control variables have been included to search for possible solutions to the price puzzle. The standard model, which is the one analyzed in this note, includes only three variables: the inflation rate, real activity and a monetary policy measure. Hence, the data vector in the statistical model is $\Delta x_t=\{\pi_t, \Delta y_t, \Delta i_t\}$, where π_t is the log difference of the price level, Δy_t is the log difference of real activity, and Δi_t is the difference of the logarithm of one plus the interest rate. The Johansen (2001) trace test strongly suggests that $x_t \sim I(1)$, $\Delta x_t \sim I(0)$ and that no cointegration exists among the variables.

While the Bayesian information criterion suggests including only one lag in the econometric model, Killian (2001) argues that including more lags than suggested by this relatively conservative criterion may lead to more precise impulse-response estimates. The final model includes two lags, a constant term (c), eleven centered seasonal dummies (s_{it}) and dummies (d_i) of the type {…,0,0,1,-1,0,0…} to take outliers into account.[8] With this notation, the VAR model to be estimated is:

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5 The CPI and Imacec series were spliced backwards with monthly growth rates to obtain observations for the entire period.

6 Sims (1992) includes commodity prices in the estimations and shows that this helps to resolve the puzzle. He argues that these prices contain information useful for forecasting inflation. This is, however, challenged by Hanson (2004), who finds little correlation between the abilities to predict inflation and to resolve the price puzzle.

7 Giordani (2004) argues that including the output gap instead of a standard growth measure solves the price puzzle in the United States.

8 The months of the dummies are 2002.1, 2002.3, 2002.5, 2003.1, 2003.2, 2004.2, 2008.10, 2008.12, 2009.2, 2009.3, 2009.7, 2010.4, 2010.5.

$$\Delta x_t = c + \sum_{i=1}^{2} \beta_i \Delta x_{it} + \sum_{i=1}^{11} \gamma_i s_{it} + \sum_{i=1}^{13} \delta_i d_{it} + \varepsilon_t, \quad (1)$$

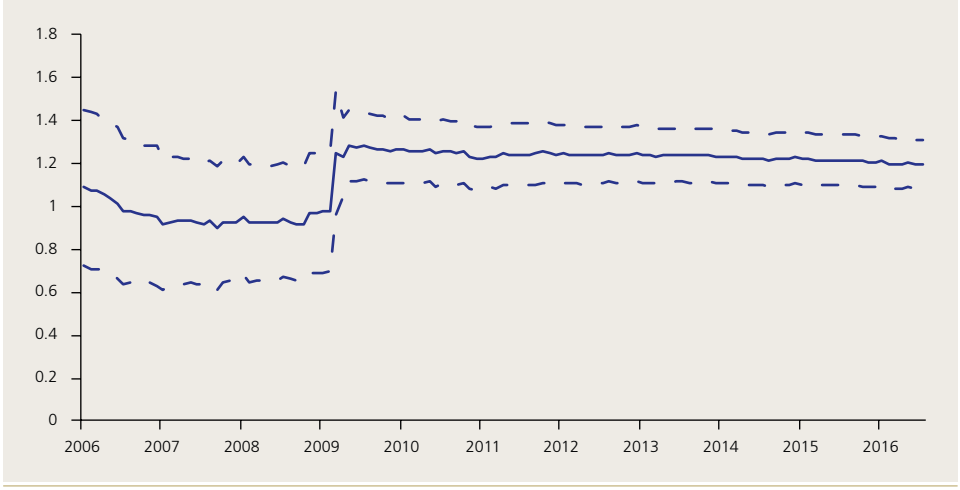
where β_i, γ_i and δ_i are the coefficients to be estimated. The residuals, ε_t, are independent and Gaussian distributed with covariance matrix Ω.[9]

The exercise consists of estimating the VAR model (1) and computing the impulse-response function with the focus on the responses of inflation to an unexpected monetary policy shock. The impulse-responses are derived from the unrestricted reduced form VAR (Boivin and Giannoni, 2002) and shocks are identified by the conventional recursive ordering (Christiano et al., 1999) such that inflation and activity have contemporaneous effects on the interest rate, but not the converse. The results presented are, however, robust with respect to the ordering of the variables.

The exercise is made with two sub-samples, before and after the global financial crisis. Figure 1 shows the full-sample recursive estimates of the first lag of the interest rate in the interest rate equation, i.e. (part of) the persistence of the monetary policy. The graph points to a structural shift in the beginning of 2009 and the Chow break point test supports that January 2009 is indeed a break point.[10] Starting in January 2009, the Central Bank of Chile began a very expansionary monetary policy cycle, reducing the policy rate by 7.75 percentage points between December 2008 and July 2009. Hence, the first sub-sample starts in January 2002 and ends in December 2008.

Figure 1

Recursive coefficient estimates



Source: Author's elaboration.

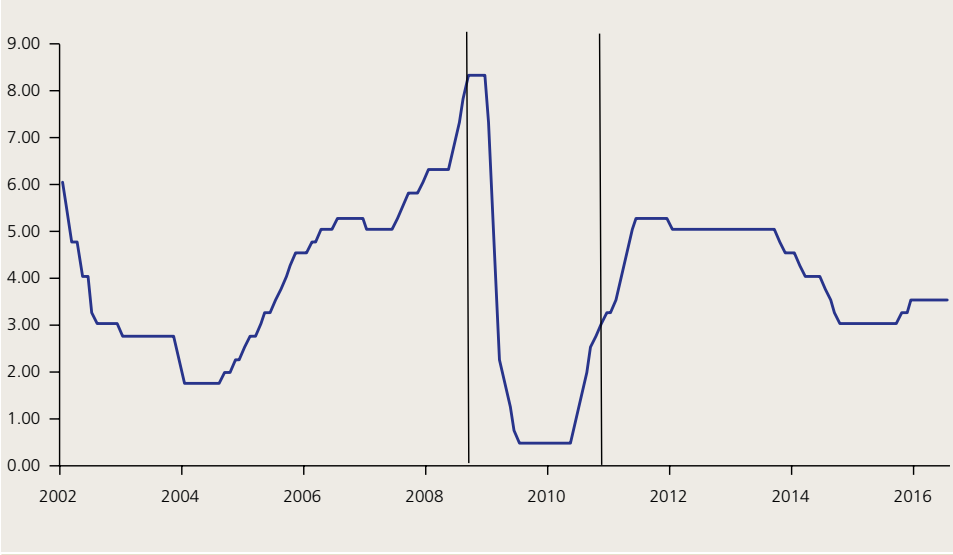
Notes: The solid line shows the estimated coefficient for the lagged interest rate in the VAR for the sample ending the year indicated in the X-axis. Dashed lines are two times the standard error.

9 According to the Doornik and Hansen (2008) test it cannot be rejected that the residuals are normal distributed. Lagrange multiplier tests do not reject the hypotheses of no serial correlations and of no ARCH(12) effects in each of the equations.

10 The test was bootstrapped (1.000 simulations) size adjusted as described by Candelon and Lütkepohl (2001).

Figure 2

Monetary policy rate
(percent)



Source: Central Bank of Chile.
Note: Vertical lines indicate January 2009 and January 2011, respectively.

As shown in figure 2, the monetary policy remained exceptionally expansionary during 2009 and the main part of 2010. This unusual period in Chile's monetary history is excluded from the analysis and, thus, the second sub-sample starts in January 2011, which is also supported as a breaking point by the Chow test.

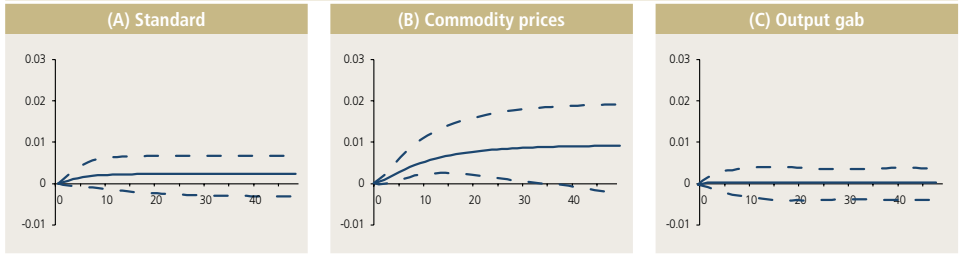
III. EMPIRICAL EVIDENCE

Figure 3 shows the reaction of the price level after an unexpected monetary policy shock using data from the first sub-sample. Even though the reaction is not statistically significant, the response is positive implying that the inflation rate increases after a monetary policy shock. Hence, the evidence from this sub-sample suggests that there was a price puzzle present in Chile during this period, which is in line with the findings of de Mello and Moccero (2008). Including commodity prices as an exogenous variable does not solve this puzzle. In fact, the inflation rate increases even more and the effect is statistically significant in this case. The puzzle is not solved either when replacing output by the output gap,[11] although the responses are substantially lower.

11 *The output gap was calculated with the Baxter and King (1995) band pass filter with 12 leads/lags.*

Figure 3

Accumulated response of inflation to a shock to the interbank rate, Feb-02 to Dec-08

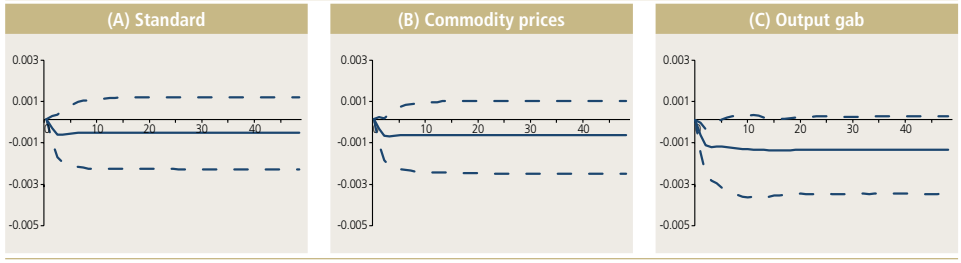


Source: Author's elaboration.

Notes: One-standard-deviation shock. The X-axis shows months after the inicial shock. Dashed lines are 95% bootstrapped (1000 replications) confidence intervals. See Hall (1992).

Figure 4

Accumulated response of inflation to a shock to the interbank rate, Jan-11 to Jul-16



Source: Author's elaboration.

Note: See figure 3. The model with output gap is estimated using data till July 2015.

The results for the sub-sample, which includes observations from 2011 onwards, are illustrated in figure 4. Again the results are not statistically significant, but it is noteworthy that the impact on inflation is negative when the most recent data are employed. When including commodity prices, the effect practically does not change. Hence, in the recent period a price puzzle seems not to be present in Chile, which is in contrast to empirical findings with data from earlier periods. This is also true when utilizing the output gap and in this case, the negative impact on the price level is statistically significant the first four months after the shock.

As mentioned in the introduction, the price puzzle refers to the fact that simple VAR models cannot replicate that an unexpected contractive monetary policy shock should have a negative impact on inflation. As shown in this section, the evidence suggests that before the global financial crisis there was a price puzzle in Chile, while this does not seem to be the case after 2011. In other words, during the most recent period in Chile, a simple VAR can in fact replicate the theoretical result that an unexpected monetary shock results in an inflation rate lower than it would have been without the shock.

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