EXCHANGE RATE PASS-THROUGH TO PRICES: VAR EVIDENCE FOR CHILE*

Andrés Sansone A.**
Santiago Justel V.***

I. INTRODUCTION

Exchange rate pass-through (ERPT) to inflation takes place through two main channels. One channel is the direct effect, on an open economy, brought about by a change in prices of imported goods and services in local currency. Hence, the exchange rate has a direct effect on the prices of inputs and the final imported goods in the CPI basket.

The second channel is related to the effect that the exchange rate has on relative prices between tradable and non-tradable goods and services. In this sense, a depreciation of the domestic currency will increase relative prices of traded goods and services to non-traded ones thus influencing the relative consumption and increasing inflation of domestic products.

For the design of monetary policy, understanding exchange rate pass-through is important. A low exchange rate pass-through is thought to provide greater freedom for pursuing an independent monetary policy and to make it easier to implement inflation targeting (Choudhri and Hakura, 2001). Hence, both the size and the speed of the ERPT have an impact on the transmission mechanism of monetary policy and on inflation forecasts.

This paper aims to determine the size and speed of pass-through to different price indices in Chile. Exchange rate pass-through into domestic energy, food and core consumer prices is estimated. Disaggregated price data is used, as core inflation is considered by some monetary policy authorities to better reflect the underlying trend of inflation. Moreover, it will enable us to analyze relative pass-through.

The analysis is conducted with a vector autoregression (VAR) model, which is well suited to capture both the size and the speed of the impact of exchange rate movements upon prices. Results over time are examined by estimating the model over different sample periods.

* *The authors are thankful to Wildo Gonzalez, Miguel Fuentes, Lucas Bertinatto, Diego Saravia, Claudio Soto and an anonymous referee for useful comments. Opinions and remaining mistakes are of exclusive responsibility of the authors and do not necessarily represent the opinion of the Central Bank of Chile.*
** *Macroeconomic Analysis Department, Central Bank of Chile. E-mail: asansone@bcentral.cl*
*** *University of Californa at Los Angeles. Email: sjustel@ucla.edu*

The rest of the paper is structured as follows. The second section presents a review of related literature. The third section presents the historical relationship between inflation and exchange rate movements. Section four describes the econometric framework and the data. The fifth section presents the empirical results for the baseline and the alternative specification. Conclusions are presented in the last section.

II. BRIEF LITERATURE REVIEW

According to the purchasing power parity (PPP) condition, the degree of pass-through from exchange rate to tradable goods prices should be one, i.e. any exchange rate movement should be fully passed-through to tradable goods prices. However, there is wide consensus that pass-through is not always complete. Dornbush (1987) shows using a Cournot oligopoly model, that the incomplete pass-through could arise from an imperfect competition market.[1] Other relevant papers include Heckscher (1916) and Obstfeld and Taylor (1997), where the incompleteness arises as a consequence of lack of perfect arbitrage in the presence of transaction costs and uncertainty.

From an empirical perspective, literature has found evidence that exchange rate pass-through is incomplete and substantially weaker since 1990 in developed countries (Takhtamanova, 2010) (McCarthy, 2000) and in emerging/developing countries (Goldfajn and Werlang, 2000). There is a large body of literature trying to explain this. For instance, Taylor (2000) argues that the decline in the ERPT is due to the low inflation environment that has been achieved in many countries and that it may be reversed if a high inflation environment surges. Devereaux and Yetman (2002) also suggest that there is a positive relationship between pass-through and mean inflation, but also find a positive relationship between pass-through and exchange rate volatility. In contrast, Edwards (2006) points out that the countries that have adopted inflation targeting have experienced a decline in the ERPT, but have not experienced an increase in exchange rate volatility. In this line of thinking, Mishkin and Schmidt Hebbel (2007) show that exchange rate pass-through seems to be attenuated by the adoption of inflation targeting by enhancing the credibility of the monetary policy and therefore anchoring inflation expectations. However, Gagnon and Ihrig (2004) suggest that the low-inflation environment since 1990's has reduced the exchange rate pass-through to consumer prices but their attempt to correlate the decline in the pass-through with estimated changes in monetary policy behavior failed. In another line of reasoning, Campa and Goldberg (2002) argue that the main reason for the decline in the exchange rate pass-through elasticity is due to the decline of commodities (energy and raw materials) in the import composition (toward manufactures).

---

1 Krugman (1986) and Fisher (1989) also attribute the incompleteness of the exchange rate pass-through to the market structure.

For Chile, there are some contributions exploring the exchange rate pass-through to import prices. Fuentes (2007) studies the ERPT to the price of imported goods for developing countries, among them Chile. The author finds that the exchange rate pass-through to import prices is high, fast and complete within a year and that there is no evidence of decline over time. Álvarez et al. (2008) also analyze the ERPT for Chile to import prices but at a disaggregated level and using monthly data. Their findings are consistent with the idea of a high and complete ERPT into import prices. However, these papers don't analyze the ERPT to consumer prices. Ca'Zorzi et al. (2007) examine the degree of ERPT not only into import prices but also into domestic prices based on VAR models for 12 emerging market, including Chile, using quarterly data for the period 1980-2003. The paper provides empirical evidence showing a high degree of pass-through into imports prices but a decline in the ERPT along the pricing chain.

Several studies have reported a reduction in exchange rate pass-through to consumer prices in Chile. García and Restrepo (2001) using a rolling correlation and a rolling simple regression estimate that the ERPT coefficient to consumer prices has decreased since the beginning of the nineties. Additionally, the authors, modeling wages and prices as I(2) series, analyze the exchange rate pass-through effect when the nominal exchange rate unexpectedly increases by 100%, finding an accumulated impact on consumer prices, excluding regulated prices and gas, of around 33% in the first two years (eight quarters).

Bravo and García (2002), using monthly data for the period 1991-2000 and different VAR models, find an exchange rate pass-through of 10% and 20% for one and two years, respectively.

Morandé and Tapia (2002) use a rolling window unrestricted VAR model to show that the pass-through coefficient exhibits a decreasing trend from almost 40% in the beginning of the 1990s, to becoming non-significant in the final windows (1996-2001). The authors estimate that the pass-through is positively affected by inflation volatility, the degree of real exchange rate misalignment and the output gap.

Noton (2003) develops a microeconomic model of imperfect Cournot competition to estimate the impact of depreciation on inflation. He estimates that the pass-through ranges between 9% and 11% in the short run and between 21% and 32% in the long run for the period 1986-2001. The author also finds the existence of an endogenous structural break in the last quarter of 1991, after which the pass-through coefficient declines considerably.

Finally, Céspedes and Valdés (2006) find empirical evidence using a sample of 25 countries including Chile, in which greater central bank independence leads to a lower ERPT coefficient. In this sense, the greater autonomy granted to the Central Bank of Chile with the Basic Constitutional Act of 1989 have influenced the EPRT coefficient.

This paper extends the literature relating pass-through to inflation in Chile mainly in two aspects. First, it attempts to fill the gap in empirical evidence on the exchange rate pass-through since the full adoption of the inflation targeting regime in Chile. A second contribution is the analysis of the pass-through along disaggregated price data. In particular, we evaluate the ERPT into domestic energy, food and core consumer prices. This will contribute to understand which components of the consumer price index are more sensitive to exchange rate movements.

III. STYLIZED FACTS

A simple way of describing the relationship between exchange rate movements and inflation is to calculate the correlation between inflation and the exchange rate. Using monthly data from January 1987 to December 2013 we observe that the correlation coefficient between annual inflation and depreciation is 0.47.

However, if we want to examine how the coefficient has changed over time, it is possible to estimate a rolling regression of annual inflation against the lagged annual depreciation of the exchange rate. In this case, the rolling correlation statistic (coefficient) was computed using rolling windows of 96 months.

Figure 1 shows the results of the estimation using rolling windows with its 95% confidence interval. The figure provides evidence of a steady decline in the correlation coefficient during the mid-nineties, a recovery during 2000 to 2003 and rather stable since then. It is worth noting, that the exchange rate correlation coefficient is nowadays ten times lower than in the early nineties, decreasing from almost 50% to less than 5% in the last two decades. The confidence intervals support that this decrease has been statistically significant.

Figure 1

Rolling regression between annual inflation and exchange rate movements

Coefficient and 95% confidence band

Source: Own estimations based on Central Bank of Chile and National Statistics Institute of Chile data.

IV. EXCHANGE RATE SHOCKS AND VARS

1. Methodology

The latter analysis fails to control for other factors that also determine inflation and exchange rate movements. In order to deal with this issue, a vector autoregressive (VAR) analysis[2] is implemented. The VAR methodology has been widely used[3] to examine the ERPT and allows us to measure simultaneous relationships between variables.

We follow McCarthy (2000), who develops a simple VAR model to identify the ERPT to prices along the distribution chain. Given the absence of historical data for producer prices (PPI) in Chile, we adapt McCarthy (2000)'s strategy to identify the ERPT as follows: we propose a VAR model, with monthly inflation, monetary policy rate (MPR), monthly activity and changes in the nominal exchange rate. We also take into consideration exogenous/external variables such as: international prices, interest rate and real activity.

1.1 VAR model

Following Hamilton (1994), let y_t denote an (n x 1) vector containing the values that n variables assume at date t.

A general standard VAR model is defined by,

$$\Phi(L)y_t = c + B(L)x_t + \varepsilon_t \qquad (1)$$

where c is an (n x 1) vector of constants, x_t denotes an (m x 1) vector of exogenous variables, ε_t is an (n x 1) vector generalization of white noise:

$$E(\varepsilon_t) = 0$$

$$E(\varepsilon_t \varepsilon_\tau') = \begin{cases} \Omega & \text{for } t = \tau \\ 0 & \text{otherwise,} \end{cases}$$

with Ω being an (n x n) symmetric positive definite matrix. Finally, $\Phi(L)$ and $B(L)$ are (n x n) and (n x m) polynomial matrices in the lag operator L.[4] The row i¸ column j element of $\Phi(L)$ is a scalar polynomial in L:

$$\Phi^{ij}(L) = \delta_{ij} - \Phi_{ij}^{(1)}L - \Phi_{ij}^{(2)}L^2 - \ldots - \Phi_{ij}^{(p)}L^p,$$

where $\delta_{ij} = 1$ if $i = j$, zero otherwise. With this specification, Ordinary Least Square yields consistent estimates of matrices in $\Phi(L)$ and B.

---

2 According to Faruqee (2004) the use of a VAR approach to examine exchange rate pass-through has several advantages compared to single-equation-based methods.

3 Ca'Zorzi et al.. (2007), Choudhri et al.. (2005), Hahn (2003), McCarthy (2000), Faruqee (2006) and Stulz (2006).

4 The lag operator L is defined as following: $L\, y_t = y_{t-1}$, and $L^i\, y_t = y_{t-i}$.

In this representation,

$$y_t = \left[\Delta \log Y_t,\ \Delta i_t,\ \Delta \log E_t,\ \Delta \log P_t^c \right],$$
$$x_t = \left[\Delta \log Y_t^*, \Delta i_t^*\ , \Delta \log P_t^*, \Delta \log P_t^O, \Delta \log P_t^F \right].$$

Y_t accounts for economic activity, i_t measures the short-term interest rate, E_t is the nominal exchange rate (units of local currency per U.S. dollar) and P_t^c represents the consumer price index. Regarding the exogenous variables, Y_t^* is a measure of external activity, i_t^* is the short-term U.S. interest rate, P_t^* is an external price index consisting of a weighted wholesale (or consumer) price index in U.S. dollars. Finally, P_t^O is the price of oil and P_t^F reflects food prices. Since the variables are non-stationary integrated of order 1 and the hypothesis of cointegration was rejected, we estimate the model in log-differences.

With the purpose of determining the lag length of the VAR, we use the Bayesian information criterion (BIC). For the exogenous variables we choose contemporaneous effects together with three lags.

In an alternative specification, the endogenous variable vector is defined as

$$\tilde{y}_t = \left[\Delta \log Y_t,\ \Delta i_t,\ \Delta \log E_t,\ \Delta \log P_t^E, \Delta \log P_t^A, \Delta \log P_t^{SAE} \right],$$

where we split the consumer price index into three indices: P_t^E is the consumer price index of energy, P_t^A is the price index of food and P_t^{EFE} is the core consumer price index excluding energy and food.

The main objective of this alternative specification is to obtain evidence on how exchange rate shocks affect different prices over time.

The VAR is estimated by single-equation ordinary least squares (OLS). Given that Chile is a small open economy; exogenous variables are considered.

1.2 Estimating exchange rate pass-through

The VAR model defined in (1) can be represented as an MA (∞) process

$$y_t = \mu + \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \ldots + \Psi_n \varepsilon_{t-n} + \ldots = \mu + \Psi(L)\varepsilon_t + \Psi(L) B x_t\ , \quad (2)$$

The operators $\Psi(L)$ and $\Phi(L)$ are related by $\Psi(L)=[\Phi(L)]^{-1}$.

With this representation, impulse response functions (IRF) can be computed. Impulse responses trace out the responsiveness of the dependent variables in the VAR to shocks to the error term. The MA (∞) representation does not guarantee orthogonal (unrelated) perturbations, so it is necessary to impose an identification strategy in order to pinpoint structural shocks.

Following McCarthy (2000), short-run restrictions on contemporaneous structural innovations are used. The residuals from the VAR model (1), ε_t, are orthogonalized using Cholesky decomposition to identify structural shocks, u_t.

$$Pu_t = \varepsilon_t, \tag{3}$$

P is the Cholesky decomposition of the variance-covariance matrix Ω.[5] This strategy to identify structural innovations relies heavily on the ordering of the variables in (1). For the first variable in (1), the orthogonalized innovation is $u_{1t} = \varepsilon_{1t}/P_{11}$, for each variable j >1, the respective shock is defined by

$$u_{jt} = \varepsilon_{jt} - P_{j1}u_{1t} - P_{j2}u_{2t} - \ldots - P_{j\,j-1}u_{j-1\,t}\,.$$

Based on Ca'Zorzi et al. (2007), Choudhri et al. (2005), Hahn (2003) and McCarthy (2000), the following order has been chosen:

dln(Real activity) $\rightarrow$ *d(Monetary policy)* $\rightarrow$ *dln(Exchange Rate)* $\rightarrow$ *dln(CPI)*

With this representation, inflation at t can be explained by its expected component (based on the available information at the end of t-1), foreign and domestic demand shocks, exchange rate shocks and idiosyncratic shocks.

Foreign shocks are proxied by the behavior of the exogenous variables (external activity, U.S. interest rate, external price index, oil and food prices). Demand shocks are obtained from the dynamic of economic activity after controlling for the impact of the external shocks. Monetary policy is ordered next, enabling a contemporaneous impact of demand shocks on monetary policy. Next, exchange rate is ordered after monetary policy, reflecting the effects of policy interest rates as well as demand and supply shocks over the exchange rate. Finally, the price variables are included, leaving prices as the most endogenous variable. Due to the lagged availability of CPI data, it seemed more reasonable to allow for a contemporaneous impact of exchange rate than vice versa.

This particular order implies that the nominal exchange rate reacts immediately to activity and monetary shocks. It also means that there is a causality running from the exchange rate to prices. Thus, consumer prices react simultaneously to exchange rate shocks. This ordering scheme also assumes that the monetary authority sets its policy variable after observing lagged prices and the current level of output. All these assumptions allowed us to identify nominal exchange rate shocks.

Alternative plausible orderings of the variables in the VAR are made. Those settings are discussed in appendix B.

---

5 *P is an (nxn) lower triangular matrix that satisfies: PP'= Ω.*

The exchange rate pass-through with this methodology is calculated as the cumulative impulse response function (cIRF) of the inflation due to a shock in the nominal exchange rate. For normalization purposes, we divide this cumulative impulse response by the cIRF of nominal exchange rate due to its own shock. In other words, we define *ERPT* as:

$$ERPT_h = \frac{cIRF^h_{P,E}}{cIRF^h_{E,E}} \tag{4}$$

So, $ERPT_h$ is the cumulative response of inflation due to an exchange rate movement and can be regarded as the fraction of a 100% depreciation in h periods ahead that passes through to domestic prices.

This approach to identify shocks has its pros and cons. On the positive side, this methodology has been used by several studies already cited, and it is based on an agnostic scheme, that is, there are no restrictions about the sign and magnitude of the effect of the nominal exchange rate on inflation. On the downside, this particular method of identification does not take into account the existence of long-run relations between variables and there is no economic interpretation of the nominal exchange rate shock. For example, movements in the exchange rate could be due to productivity movements, external interest rate innovations or a relative price shock. Each of these structural shocks has different effects on prices and exchange rates, therefore with this recursive strategy we are accounting for an "average" effect. As the objective is to measure the exchange rate pass-through for Chile, this agnostic and standard strategy that has not been used recently for Chile is considered.[6]

1.3 Data description

As mentioned, endogenous variables included are real activity, nominal interest rate, nominal exchange rate and consumer price index. These variables are typically used in the literature; however, in order to include some features of a small open economy, we add exogenous variables as foreign price indices, interest rate and a measure of external real activity.

Regarding endogenous variables, real activity (Y_t) is measured by the Central Bank's monthly indicator of Chilean real economic activity, Imacec. This index represents around 90 per cent of goods and services that are included in GDP; therefore, the Imacec partially emulates the behavior of Chilean GDP at monthly basis. Monetary policy rate (i_t) is proxied by the 90-day deposit rate[7], nominal

---

6 Only Ca'Zorzi et al (2007) report the ERPT for Chile through this methodology but for the purpose of the research, there are two problems, first the sample is outdated (1980-2003) having problems with structural breaks (inflation targeting, floating regime), secondly, even though they measure the effects on emerging markets, they put oil price as an endogenous variable, although it is clear that emerging markets are small open economies.

7 This particular rate is used because we are interested in having a long-time series and nominal interest rate as a policy instrument was implemented in 2001.

exchange rate (E_t) simply is Chilean peso – U.S. dollar parity. Finally, prices are measured by the Consumer price index (P_t^c). In the alternative specification, prices are taken into account by CPI-Energy (P_t^E), CPI-Food (P_t^F) and a core measure, CPIEFE (P_t^{EFE}), which excludes energy and food prices.

With respect to exogenous variables: external activity (Y_t^*) is included by a trade-weighted Industrial Production Index, foreign interest rate (i_t^*), is U.S. 3-month Treasury bill: secondary market rate, P_t^* is an index of external prices relevant to the Chilean economy and it is a trade-weighted price index,[8] in U.S. dollars. Finally, commodity prices for oil and food (P_t^O,P_t^F) are respectively WTI and World Bank food price index. All variables were seasonally adjusted using ARIMA-X12.

We use data from January 1986 to December 2013 except for CPI-Energy, CPI-Food and CPIEFE, which sample starts in April 1989.

A more detailed description of the data is provided in Appendix A.

V. EMPIRICAL RESULTS/ESTIMATION RESULTS

1. Full sample

This section presents the main results using the VAR model (1). As already explained above, ERPT is identified by the ratio between two cIRFs. Figure 2 shows results for the baseline and the alternative specification. Both models were estimated with the full sample, i.e. 1986-2013 for the baseline and 1989-2013 for the alternative specification.

This figure tracks the pass-through of a shock in the exchange rate into prices. ERPT to CPI reaches 0.13 after twelve months and stabilizes at 0.2 after two years. As indicated by the confidence bands, the response is significantly different from zero at 5%. ERPT to core CPI shows a similar behavior, reaching 0.17 after two years. ERPT to CPI-energy exhibits two distinct characteristics. First, this ERPT is considerably higher if compared to other aggregates, reaching 0.4 after two years. This result turns out to be consistent with the fact that Chile is a net importer of fuel, which is one of the main components of CPI-energy. Fuel prices respond one-to-one to the exchange rate after a few months. Then, and for the same reason, it is also clear that the rise in Energy prices due to a nominal depreciation is quite fast, reaching 0.37 after three months and 0.4 after two years.

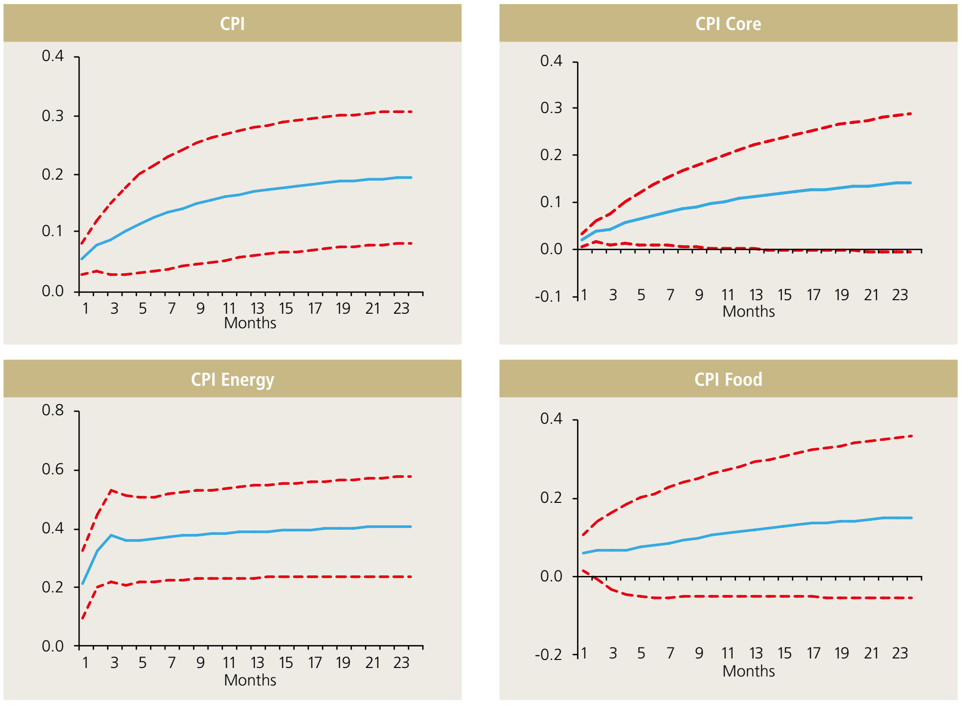
Finally, the ERPT to food prices it is not significantly different from zero. One of the possible reasons could be that this price index is very volatile because it contains prices of fruits and vegetables, which are not necessarily closely related to exchange rate fluctuations.

8 For price indices, for each country, the wholesale price index is used when it is available; otherwise, the consumer price index is used.

Figure 2

Exchange rate pass-through – Full sample

Coefficient and 95% confidence band



Source: Own estimations.

Note: Confidence band computed using bootstrap.

2. Changes in ERPT

Results from the previous section are in line with the literature for the Chilean case, but some problems arise when the full sample is used. As we already stated, much literature has shown that ERPT for Chile has declined since the early nineties. Reasons that already have been discussed: inflation targeting, economic stability, institutional credibility and independence, particularly Central Bank autonomy. All these issues lead us to conclude that ERPT calculated using the full sample with those particular controls could be overestimated because with the full sample we are not considering structural changes in the Chilean economy, such as inflation targeting and free floating exchange rate. These two changes could help, potentially, to reduce ERPT.

In order to take into account this issue, we estimate (1) from 2002 to 2013. This period of time is considered because in 1999 the Central Bank of Chile ended the exchange rate band. Besides that, in 2001 the Central Bank made explicit the inflation target and later in that year the nominal monetary policy rate was adopted as the instrument for monetary policy.[9] Edwards (2006), Céspedes and Valdés (2006), among other authors, show that countries that have adopted inflation targeting have experienced a significant decline in the ERPT.

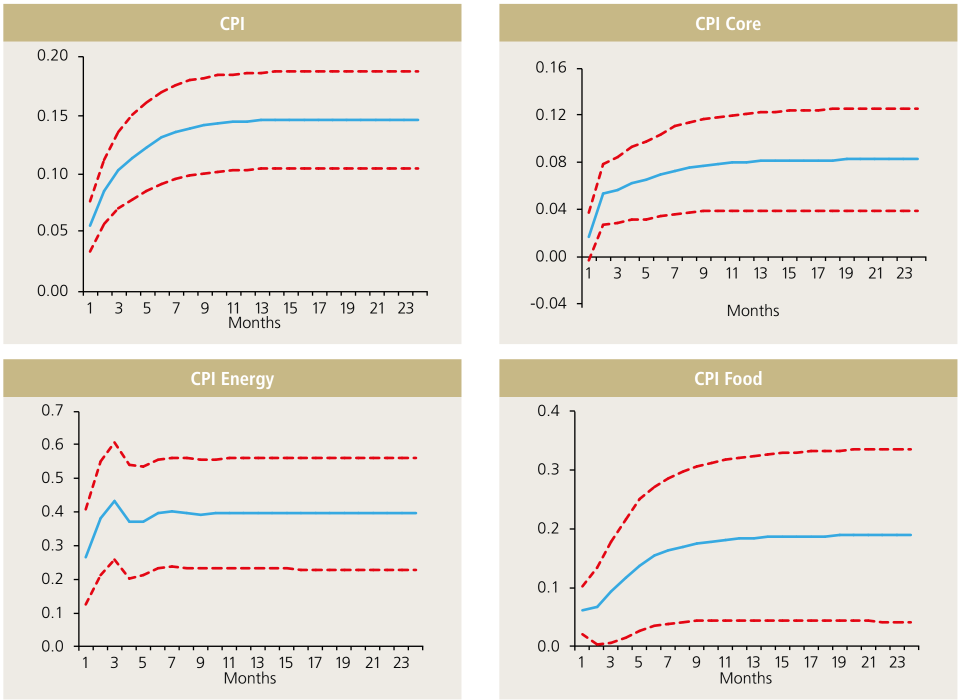
In order to consider the ERPT since the full adoption of inflation targeting, the sample starts in 2002.

The most interesting result is the evidence on declining ERPT to CPI and Core CPI. With the intention to explore on this issue we perform a rolling regression on (1) to calculate the ERPT for each eight-year window. The main results are presented in figure 4.

Figure 3

Exchange rate pass-through – 2002-2013

Coefficient and 95% confidence



Source: Own estimations.

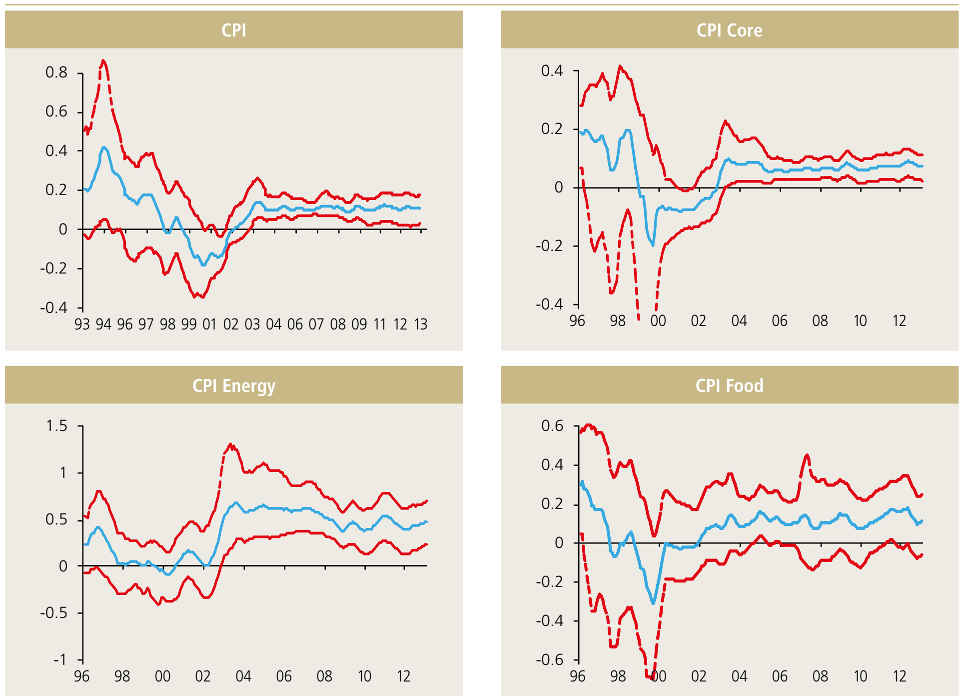
Note: Confidence band computed using bootstrap.

9 In August 9, 2001, the Central Bank of Chile opted to nominalize monetary policy. Previously, the MPR was an inflation-indexed interest rate.

Figure 4

Rolling Estimations: Long Run Pass-through

Coefficient - 90% confidence (moving average)



Source: Own estimations.

Note: Confidence band computed using bootstrap.

The results show that the long-run ERPT to CPI and Core CPI have declined over the period of analysis. Both decrease at the beginning of the nineties and after 1998 they fall intensively and, even become negative.[10] At the beginning of the 2000s the ERPT grows again and remains stable since then. ERPT to Headline CPI falls from between 20% and 40% at the beginning of the 1990s to 12% by the end of our sample. ERPT to Core CPI also decreases from about 20 to 8%. These results match those presented in figure 3.

ERPT to CPI energy is not significantly different from zero during the 90's. This could be attributed to the establishment of the Stabilization Fund for Petroleum Prices (FEPP). The initial version of the FEPP was established in 1991. Marquez

10 This pattern is in line with the one presented in García and Restrepo (2001).

(2000) argues that the FEPP was successful in mitigating fuel price movements. The scheme was reformed in 2000 due to the rapid exhaustion of the fund's resources. Since the mid-2000s, the ERPT has been stable around 50%.

Finally, ERPT to CPI food is not significantly different from zero throughout the sample. As mentioned above, one of the possible reasons could be that this price index is very volatile because it contains prices of fruits and vegetables. It is worth noting that, since the beginning of inflation targeting scheme, the ERPT to all CPI indices has stabilized.

VI. CONCLUSION

Exercises are performed to determine the level of exchange rate pass-through to local prices and explore how pass-through rates have evolved over time. In addition to studying headline inflation, this paper also examines pass-through to domestic energy, food and core prices.

Nowadays nominal exchange rate pass-through to headline inflation in Chile should be expected to be around 14% in a year. Core CPI pass-through is found to be lower that headline pass-through and is between 4% and 12% in the medium term. Both in the headline and the core CPI the effect of exchange rate movements takes three to four quarters to be fully passed through to prices.

Regarding the ERPT evolution, the evidence shows that exchange rate pass-through has declined since the establishment of an inflation targeting regime in comparison with the earlier one. Moreover, pass-through has remained fairly stable post the change in monetary policy regime.

REFERENCES

Álvarez, R., P. Jaramillo, and J. Selaive (2008). "Exchange Rate Pass-Through into Import Prices: The Case of Chile". Working Paper N°465, Central Bank of Chile.

Bravo, H. and C.J. García (2002). "Medición de la Política Monetaria y el Traspaso (Pass-Through) en Chile". *Economía Chilena* (3): 5–28.

Campa, J. and L. Goldberg (2002). Exchange Rate Pass-Through into Import Prices, A Macro or Micro Phenomenon?" NBER Working Paper No. 8934.

Ca'Zorzi, M., E. Hahn and M. Sánchez (2007). *Exchange Rate Pass-Through in Emerging Markets*: European Central Bank.

Céspedes, L.F. and R.O. Valdés (2006). "Autonomía de Bancos Centrales: La Experiencia Chilena." *Economía Chilena* 9(1): 25–45.

Choudhri, E.U., H. Faruqee and D. S. Hakura (2005). "Explaining the Exchange Rate Pass-Through in Different Prices." *Journal of International Economics* 65: 349–74.

Choudhri, E.U. and S. Hakura (2001). "Exchange Rate Pass-Through to Domestic Prices: Does the Inflationary Environment Matter?" Working paper 01/194, International Monetary Fund.

Devereux, M. and J. Yetman (2002). "Price Setting and Exchange Rate Pass-Through: Theory and Evidence." Hong Kong Institute for Monetary Research Working Paper No. 22/2002, December.

Dornbusch, R. (1987). "Exchange Rates and Prices." *American Economic Review* 77(1): 93–106.

Edwards, S. (2006). "The Relationship between Exchange Rates and Inflation Targeting Revisited". NBER Working Paper No. 12163.

Faruqee, H. (2006). "Exchange rate pass-through in the euro area". *IMF Staff Papers*, 63-88.

Fisher, E. (1989). "A model of exchange rate pass-through". *Journal of International Economics*, 26(1), 119-137.

Fuentes, M. (2007). "Pass-Through to Import Prices: Evidence from Developing Countries." Working Paper No. 320, Instituto de Economía. Pontificia Universidad Católica de Chile.

Gagnon, J.E. and J. Ihrig (2004). "Monetary Policy and Exchange Rate Pass-Through." *International Journal of Finance & Economics* 9(4): 315–38.

García, C.J. and J.E. Restrepo (2001). “Price Inflation and Exchange Rate Pass-Through in Chile.” Working Paper No. 128, Central Bank of Chile.

Goldfajn, I. and S.R. da Costa Werlang (2000). “The Pass-Through from Depreciation to Inflation: A Panel Study.” Pontifícia Universidade Católica de Rio de Janeiro, Departamento de Economía.

Hahn, E. (2003). “Pass-Through of External Shocks to Euro Area Inflation.” Working Paper No. 243, European Central Bank.

Hamilton, J.D. (1994). *Time Series Analysis* (vol. 2). Princeton, NJ: Princeton University Press.

Heckscher, E.F. (1916). “Växelkursens Grundval vid Pappersmyntfot.” *Ekonomisk Tidskrift* 18: 309-312.

Krugman, P. (1986). “Pricing to market when the exchange rate changes”. *NBER Working Paper Series*, No. 1926.

Marquez, M. (2000). *El Fondo de Estabilización de Precios de Petróleo (FEPP) y el Mercado de los Derivados en Chile.* CEPAL.

McCarthy, J. (2000). “Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies”. *FRB of New York Staff Report*, (111).

Mishkin, F. and K. Schmidt-Hebbel (2007). “Does Inflation Targeting Make a Difference?” NBER Working Paper No. 12876.

Morandé, F. and M. Tapia (2002). “Exchange Rate Policy in Chile: From the Band to Floating and Beyond.” Working Paper No. 152, Central Bank of Chile.

Noton, C. (2003). “The Pass-Through from Depreciation to Inflation: Chile 1986-2001.” *Estudios de Economía* 30(1): 133–55.

Obstfeld, M. and A.M. Taylor (1997). “Nonlinear Aspects of Goods-Market Arbitrage and Adjustment: Heckscher’s Commodity Points Revisited.” *Journal of the Japanese and International Economies* 11(4): 441–79.

Stulz, J. (2007). “Exchange Rate Pass-Through in Switzerland: Evidence from Vector Autoregressions.” Swiss National Bank Economic Studies No. 4.

Takhtamanova, Y. F. (2010). “Understanding changes in exchange rate pass-through. *Journal of Macroeconomics*, 32(4), 1118-1130.

Taylor, J. B. (2000). “Low inflation, pass-through, and the pricing power of firms”. *European economic review*, 44(7), 1389-1408.

APPENDIX A

THE DATA

We use monthly data from January 1986 to December 2013 except for CPI-Energy, CPI-Food and CPIEFE, which sample starts in April 1989. All variables were seasonally adjusted using ARIMA-X12

Definitions

- **Real activity (Y_t)**: *Indicador Mensual de Actividad Económica* (Imacec), monthly indicator of Chilean real activity. Source: Central Bank of Chile.
- **Monetary policy rate (i_t):** 90 day deposit rate. Source: Central Bank of Chile.
- **Nominal exchange rate (E_t):** Nominal exchange rate of the Chilean peso versus U.S. dollar. Source: Central Bank of Chile.
- **Consumer price indices (CPI):** CPI all items (P_t^c). In alternative specification, prices are taken into account by CPI Energy (P_t^E), CPI Food (P_t^F) and a core measure, CPIEFE (P_t^{EFE}), which excludes energy and food prices. Source: Central Bank of Chile and National Statistics Institute of Chile.
- **External activity (Y_t^*):** Trade-weighted Industrial Production Index. Source: Central Bank of Chile, Bloomberg LP and own calculations.
- **Foreign interest rate (i_t^*):** U.S. 3-Month Treasury Bill: secondary market rate. Source: Bloomberg LP.
- **Foreign consumer prices (P_t^*):** Index of external prices relevant to Chilean economy (IPE). This is a trade-weighted price index, in U.S. dollars. Source: Central Bank of Chile.
- **Commodity prices for oil (P_t^O):** WTI price index. Source: Bloomberg LP
- **Commodity prices for food (P_t^F):** World Bank food price index. Source: World Bank.

APPENDIX B

ROBUSTNESS CHECK

Identification by means of a Choleski-decomposition is only unique up to the ordering of the variables; therefore, a different ordering may lead to different conclusions.

In this appendix, we investigate different orderings of the variables in the Choleski decomposition. In the baseline model, economic activity was put in first place, followed by the exchange rate and the monetary policy instrument. The price variables were ordered last.

The first alternative is to consider a different ordering where exchange rate is placed first in the order of variables. Then, the variables of the system are reordered as follows:

Such ordering has been used in Stulz (2007). Here, the exchange rate precedes the other endogenous variables, accounting for the fact that in a small open economy framework the exchange rate could be considered a foreign variable and therefore placed first.

An alternative change concerns the monetary policy variable. McCarthy (2000) suggests that monetary policy should be ordered last to reflect the effect of inflation and all the other shocks over monetary policy interest rates, i.e.

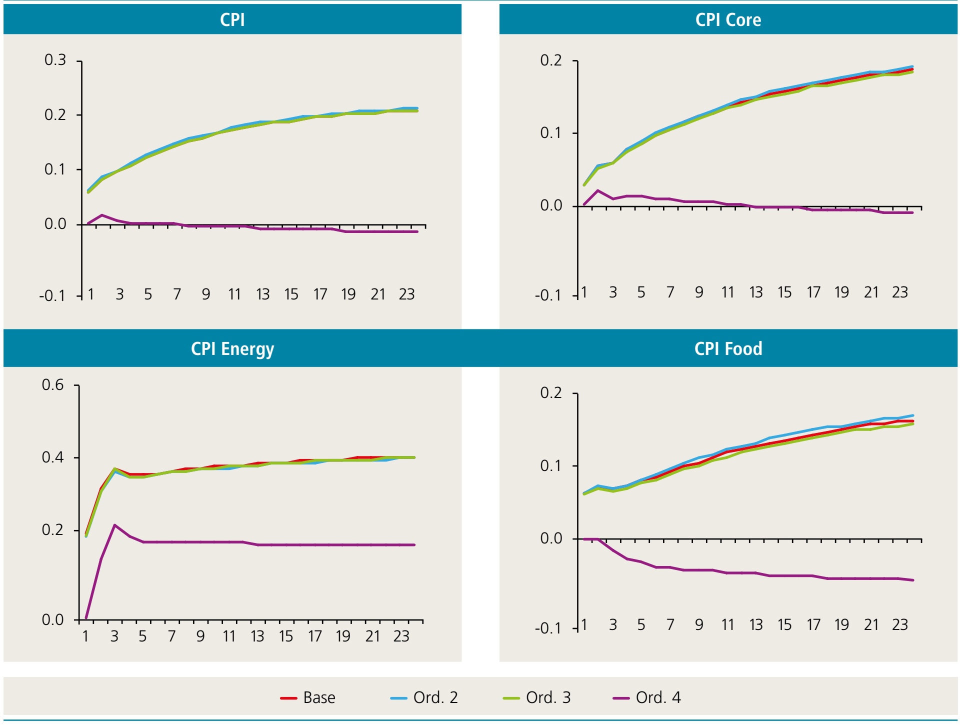
Finally, as a third alternative, we considered the following ordering:

Here, the exchange rate is placed last. According to Faruqee (2006), this ordering is motivated by the view that prices are predetermined in the very short run and, thus, cannot respond to an exchange rate shock; whereas the exchange rate can respond to various shocks. However, Faruqee (2006) warns that although this restriction may be valid for many prices, it may prove inappropriate for others.

Figure 4 provides a comparison of the IRF to the different price disagregations to exchange rate shocks across the different orderings. As can be seen, the results from the impulse responses of all price indices are virtually indistinguishable from those of the baseline model. The only exception to these results arises from ordering the exchange rate last (i.e. ordering 4). This result is probably arising from the fact that in this ordering the exchange rate shock has zero contemporaneous effect on prices by construction. As Faruqee (2006) points out, this restriction is generally not true for tradable prices and, given that in Chile the share of tradable goods in the consumption basket is high, this assumption should thus not be imposed a priori.

Figure B1

Exchange rate pass-through – Full sample



Source: Own estimations.