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

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Abstract

This paper investigates the exchange rate pass-through (ERPT) to different price indices in Chile. The analysis is carried out with a vector autoregressive (VAR) model with exogenous variables. Models were estimated using monthly data for Chile from January 1987 to December 2013. Average pass-through ratio to total CPI is estimated to be between 0.1 and 0.2 in the medium term. These results indicate a lower ERPT after the adoption of inflation targeting. Moreover, from 2002 onwards the effect of an exchange rate movement takes around four quarters to pass-through completely, compared to one to two years for the full sample.

Resumen

Este artículo investiga el traspaso del tipo de cambio a diferentes índices de precios en Chile. El análisis es llevado a cabo usando un modelo de vectores autoregresivos (VAR) con variables exógenas. Los modelos fueron estimados usando datos mensuales para Chile entre Enero de 1987 y Diciembre de 2013. Se encuentra que el traspaso promedio al índice de precios al consumidor (IPC) es de 0,1 y 0,2 a mediano plazo. Los resultados indican que el traspaso ha disminuido desde la adopción del régimen de metas de inflación por parte del Banco Central de Chile. Por otra parte, desde 2002 en adelante, el efecto de las variaciones en el tipo de cambio toman cerca de cuatro trimestres en traspasarse completamente, comparado con uno a dos años al considerar la muestra completa.

I.   Introduction

Exchange rate pass-through (ERPT) to inflation spreads 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, exchange rate has a direct effect on the price of inputs and the final imported goods in the CPI basket.

The second channel, is related to the effect that exchange rate has on relative price 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 and, therefore, 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 reflect better 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 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. In the fourth section there is a description of 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 good prices should be one, i.e. any exchange rate movement should be fully pass-through to tradable good prices. However, there is a 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

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[1] Krugman (1987) and Fisher (1989) also attribute the incompleteness of the degree of exchange rate pass-through to the market structure.

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 (Taktamanova, 2010) (McCarthy, 2000) and in emerging/developing countries (Goldfajn and Werlang, 2000). There is a large 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 could 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 which have adopted inflation targeting have experienced a decline in the ERPT but have not experienced an increase of 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 improving 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).

For Chile, there are some contributions exploring the exchange rate pass-through into 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. Alvarez et al. (2008) also analyze the ERPT for Chile into 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 into consumer prices in Chile. Garcia 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 a 100%, finding an accumulated impact on consumer prices, excluding regulated prices and gas, of around 33% in the first two years (8 quarters)

Bravo and Garcia (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 90's, 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 9-11% in the short run and between 21- 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 Valdes (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 organic law 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 introduction 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 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 results of the estimation using rolling windows with its 95% confidence interval. The figure provides evidence of a steadily 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 at the beginning of the 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
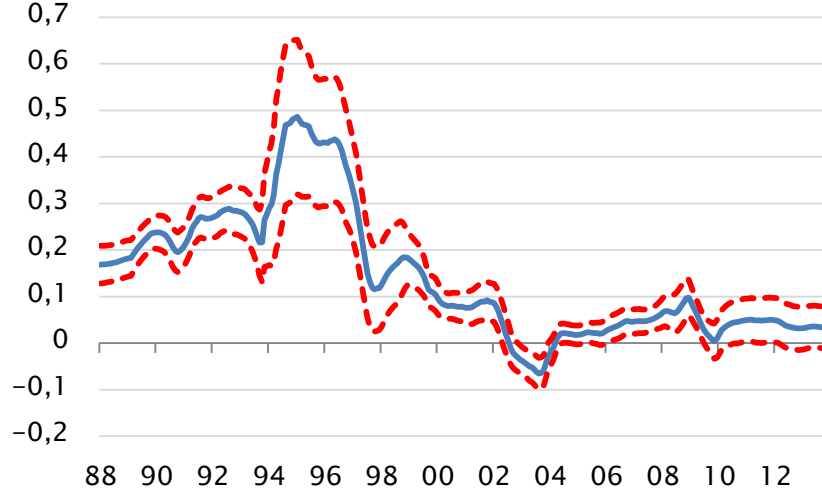
Source: Own estimations based on Central Bank of Chile and National Statistics Institute of Chile data

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.

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) strategy to identify the ERPT as follows: we propose a VAR model, with monthly inflation, monetary policy rate (MPR), monthly activity and changes of nominal exchange rate. We also take into consideration exogenous/external variables such as: international prices, interest rate and real activity.

a.   *VAR Model*

Following Hamilton (1994), let y_t denote a $(n \times 1)$ vector containing the values that n variables assume at date t. A general standard VAR model is defined by,

$$\Phi(L)y_t = c + B(L)x_t + \varepsilon_t \tag{1}$$

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[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.

where c is a $(n \times 1)$ vector of constants, x_t represents a $(m \times 1)$ vector of exogenous variables, ε_t is a $(n \times 1)$ 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 a $(n \times n)$ symmetric positive definite matrix. Finally, $\Phi(L)$ and $B(L)$ are $(n \times n)$ and $(n \times m)$ polynomial matrices in the lag operator L.[3] The row i, column j element of $\Phi(L)$ is a scalar polynomial in L,

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

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.

In this representation,

$$y_t = [\Delta \log Y_t, \ \Delta i_t, \ \Delta \log E_t, \ \Delta \log P_t^c],$$

$$x_t = [\Delta \log Y_t^*, \Delta i_t^*, \Delta \log P_t^*, \Delta \log P_t^O, \Delta \log P_t^F].$$

Y_t accounts for economic activity, i_t measures short-term interest rate, E_t is the nominal exchange rate (price of local currency per US 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 US interest rate, P_t^* is an external price index, consisting of a weighted wholesale (or consumer) price index in US 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 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

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

where we split 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^{SAE} which is the core consumer price index excluding energy and food.

The main objective from this alternative specification is to obtain evidence on how exchange 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.

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[3] Lag operator L is defined as following: $L \, y_t = y_{t-1}$, and $L^i \, y_t = y_{t-i}$

b.   *Estimating exchange rate pass-through*

The VAR model defined in (1) can be represented as a $MA(\infty)$ process

$$y_t = \mu + \varepsilon_t + \Psi_1\varepsilon_{t-1} + \Psi_2\varepsilon_{t-2} + \cdots + \Psi_n\varepsilon_{t-n} + \cdots = \mu + \Psi(L)\varepsilon_t + \Psi(L)Bx_t , \qquad (2)$$

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 $MA(\infty)$ 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.

$$P u_t = \varepsilon_t , \qquad (3)$$

P is the Cholesky decomposition of the variance-covariance matrix Ω. [4] 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 $u_{1t} = \frac{\varepsilon_{1t}}{P_{11}}$, for each variable $j > 1$, the respective shock is defined by

$$u_{jt} = \varepsilon_{jt} - P_{j\,1}u_{1t} - P_{j\,2}u_{2\,t} - \cdots - P_{j\,j-1}u_{j-1\,t}$$

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

$$\text{dln(Real activity)} \rightarrow \text{d(Monetary policy)} \rightarrow \text{dln(Exchange Rate)} \rightarrow \text{dln(CPI)}$$

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, US 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 prices variables are

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[4] P is an $(n \times n)$ lower triangular matrix that satisfies: $PP' = \Omega$

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 nominal exchange rate reacts immediately to activity and monetary shocks. It also means that there is a causality running from 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 rates shocks.

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

ERPT through this methodology is calculated as the cumulative impulse response function (cIRF) of the inflation due to a shock in 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:

$$\text{ERPT}_h = \frac{cIRF_{P,E}^h}{cIRF_{E,E}^h} \qquad (4)$$

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 domestic prices.

This approach to identify shocks presents pros and cons. On the positive side, this methodology has been used by several studies already cited, and it is based in an agnostic scheme, that is, there are no restrictions about the sign and magnitude of the effect of 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 exchange rate could be due to productivity movements, external interest rate innovations or relative prices 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 made recently for Chile is considered.[5]

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[5] 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.

c.   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 to endogenous variables, real activity (Y_t) is measured by the Indicador Mensual de Actividad Económica (IMACEC), a monthly indicator of Chilean real activity. This index represents around 90 per cent of goods and services that are included en GDP; therefore IMACEC partially emulates the behavior of Chilean GDP at monthly basis. Monetary policy rate (i_t) is proxied by 90 day deposit rate[6], nominal exchange rate (E_t) simply is Chilean peso – US 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, CPI-SAE (P_t^{SAE}), which excludes energy and food prices.

In the exogenous variables, external activity (Y_t^*) is included by a trade-weighted Industrial Production Index, foreign interest rate (i_t^*), is US 3-Month Treasury Bill: secondary market rate, P_t^* is an index of external prices relevant to Chilean economy and it is a trade-weighted price index,[7] in US 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 CPI-SAE, which sample starts in April 1989.

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

## V.   Empirical Results/Estimation results

a.   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 full sample, i.e. 1986-2013 for the baseline and 1989-2013 for the alternative specification.

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[6] 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.

[7] For price indices, for each country, wholesale price index is used when it is available, otherwise, consumer price index

Figure 2
Exchange rate pass-through – Full Sample
Coefficient and 95% confidence band
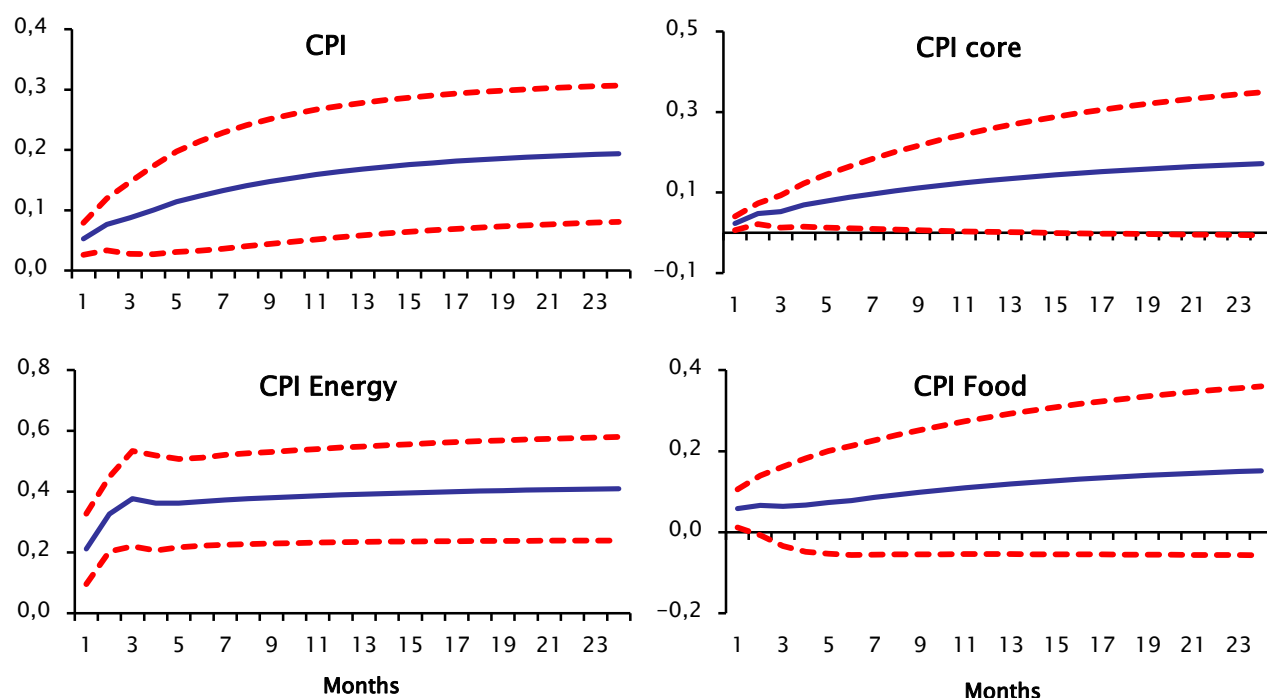
Note: Confidence band computed using bootstrap
Source: Own estimations.

This figure tracks the pass-through of a shock in exchange rate into prices. ERPT to CPI reaches 0.13 after twelve months and stabilizes to 0.2 after two years. As it is indicated by the confidence bands, the response is significantly different from zero at 5%. ERPT to core CPI shows similar behavior, reaching 0.17 after two years. ERPT to CPI energy exhibits two distinct characteristics. First, this ERPT is considerable higher if compared to other aggregates, reaching 0.4 after two years. This result turns 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.

b.   Changes in ERPT

Results from the previous section are in line with the literature for the Chilean case, but some problems arise when full sample is used. As we already stated, much literature has shown that ERPT for Chile has declined since early 90's. Reasons that already have been discussed: inflation targeting, economic stability, institutional credibility and independence, particularly of Central Bank. All these issues lead us to conclude that ERPT calculated using full sample with those particular controls could be overestimated because with full sample we are not considering structural changes in Chilean economy, as inflation targeting and free floating exchange rate. These two changes could help, potentially, to decline 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.[8] In order to consider these structural changes, the sample starts in 2002.

Figure 3
Exchange rate pass-through – 2002-2013
Coefficient and 95% confidence
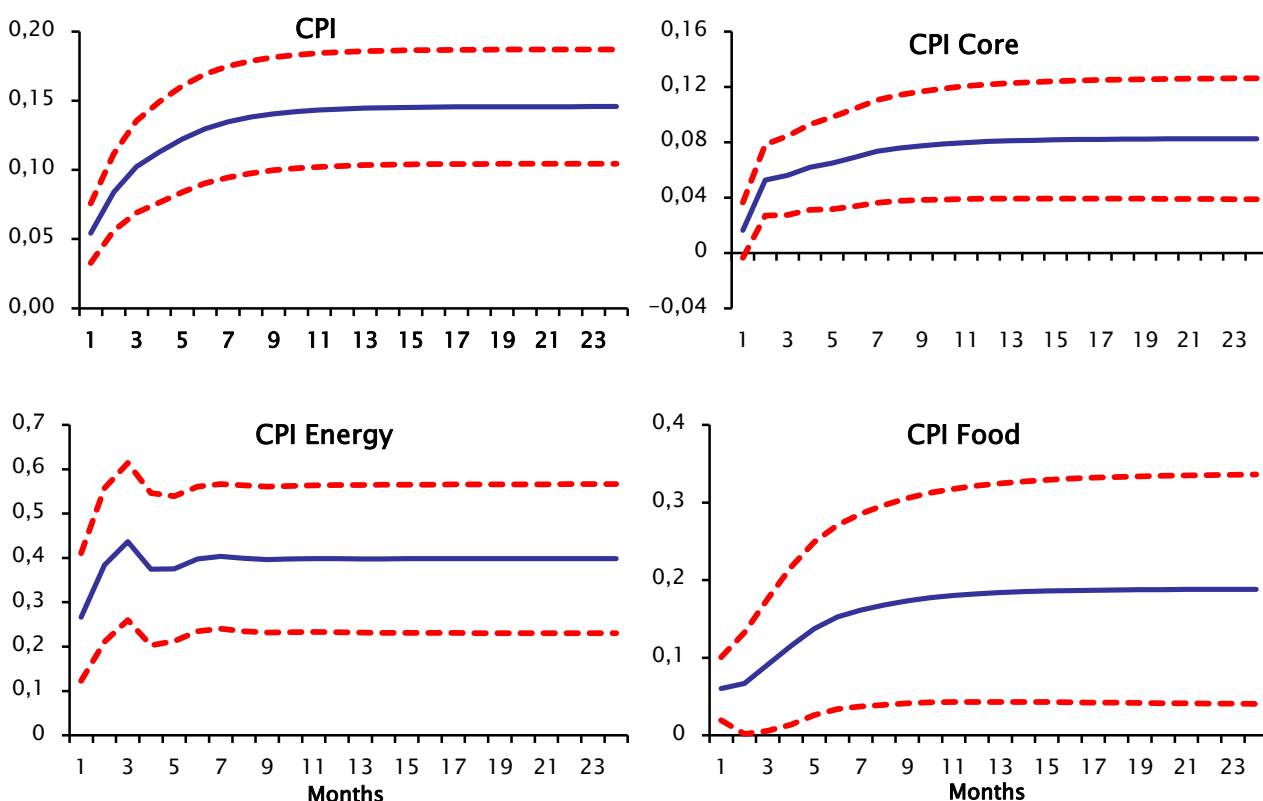
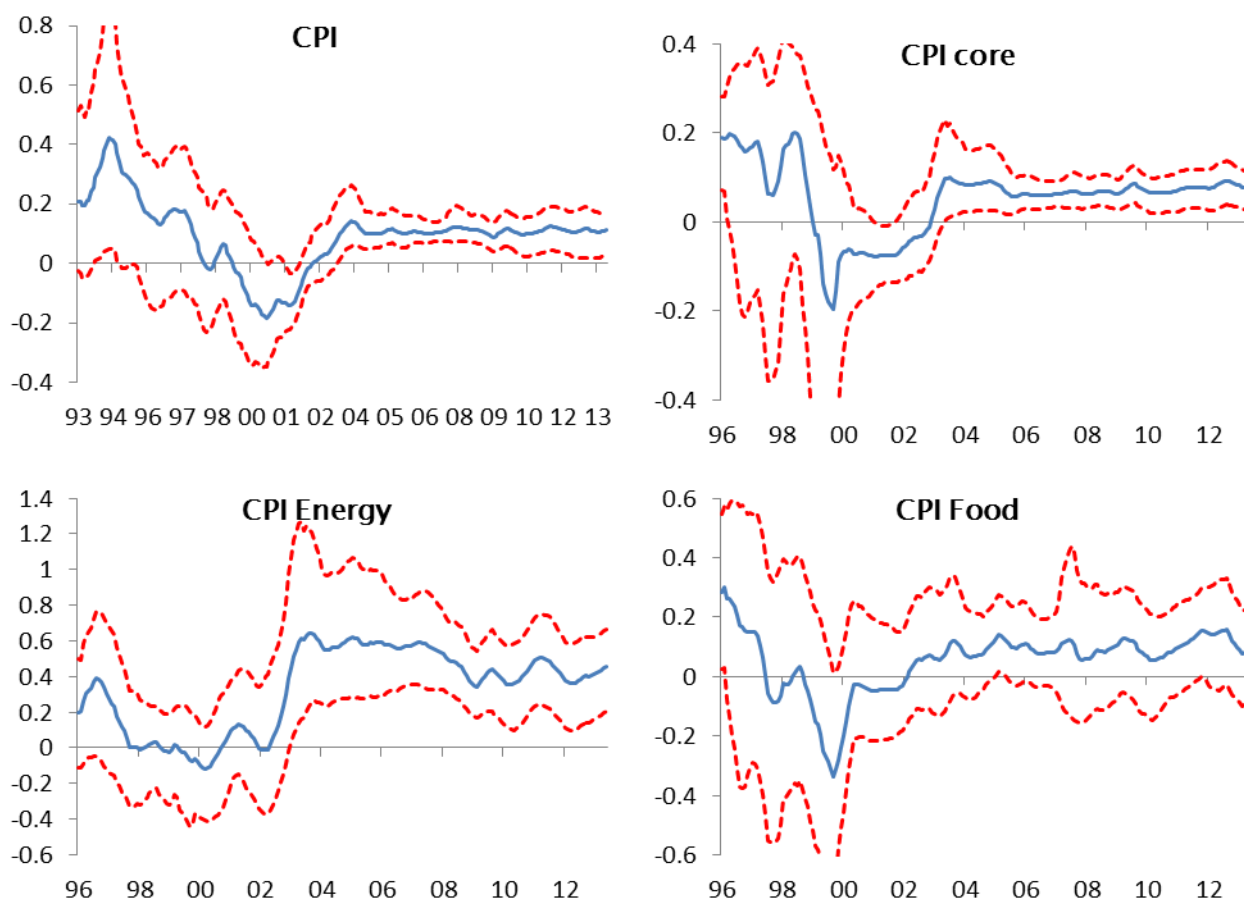Note: Confidence band computed using bootstrap
Source: Own estimations.

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

Figure 3 displays the result for the estimation. With this sample, all coefficients are significantly different from zero at 5% and they stabilize within a year, with the exception of CPI Energy, which behavior is similar to the first estimation. EPRT to headline and core inflation are 0.14 and 0.08, respectively, in the long run. Compared to the previous results, it is clear that with this recent sample ERPT to CPI and Core CPI are lower. This result is consistent with the literature, which points out, among other issues, the decline in ERPT and the role of monetary policy.

Regarding to ERPT to Energy, the behavior and values in both estimations are similar. Finally, ERPT to Food prices seems higher with the recent sample; reasons for this may rely in the increase of the share of imports relative to the volume of food consumption.

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 4
Rolling Estimations: Long Run Pass through
Coefficient - 90% confidence (moving average)

Note: Confidence band computed using bootstrap
Source: Own estimations.

The results show that the long run ERPT of 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[9]. At the beginning of the 2000's the ERPT grows again and remains stable since then. ERPT to Headline CPI reduces from between 20 and 40 percent at the beginning of the 90s to 12 percent by the end of our sample. ERPT to Core CPI also decreases from about 20 percent to 8 percent. 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 (2000) argues that the FEPP was successful in mitigating fuel prices movements. The scheme was reformed in 2000 given the rapid exhaustion of the fund's resources. Since mid-2000s, the ERPT has been stable around 50%.

Finally, ERPT to CPI food is not significantly different from zero during 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.

Worth noting that, since the beginning of inflation targeting scheme the ERPT to all CPI indices has stabilized.

VI.   Conclusion

In this paper exercises are performed to determine the level of exchange rate pass-through to local prices and how pass-through rates have evolved over time. In addition to study 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 movement 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 lowered since the establishment of an inflation targeting regime in comparison with the earlier. Moreover, pass-through has remained fairly stable post the change in monetary policy regime.

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[9] This pattern is in line with the one presented on Garcia and Restrepo (2001)

Appendix A: Data Appendix

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

     a.   ***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 US 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, CPI SAE (P_t^{SAE}), 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^*):** US 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,[10] in US 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.

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[10] For price indices, for each country, wholesale price index is used when it is available, otherwise, consumer price index

Appendix B: Robustness check

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

In this section, 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:

$$\text{dln(Exchange Rate)} \rightarrow \text{dln(Economic activity)} \rightarrow \text{d(Monetary policy)} \rightarrow \text{dln(CPI)} \qquad \text{Ord. 2}$$

Such ordering is been used in Stulz (2006). 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.

$$\text{dln(Economic activity)} \rightarrow \text{dln(Exchange Rate)} \rightarrow \text{dln(CPI)} \rightarrow \text{d(Monetary policy)} \qquad \text{Ord. 3}$$

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

$$\text{dln(Economic activity)} \rightarrow \text{d(Monetary policy)} \rightarrow \text{dln(CPI)} \rightarrow \text{dln(Exchange Rate)} \qquad \text{Ord. 4}$$

Here, the exchange rate is placed at 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 exchange rate can respond to various shocks. However, Faruqee (2006) warns that although this restriction may be valid for many prices, it may not be appropriate for others.

Figure 4 provide a comparison of the IRF to the different price desegregations to exchange rate shocks across the different orderings. As it 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 4

Exchange rate pass-through – Full Sample
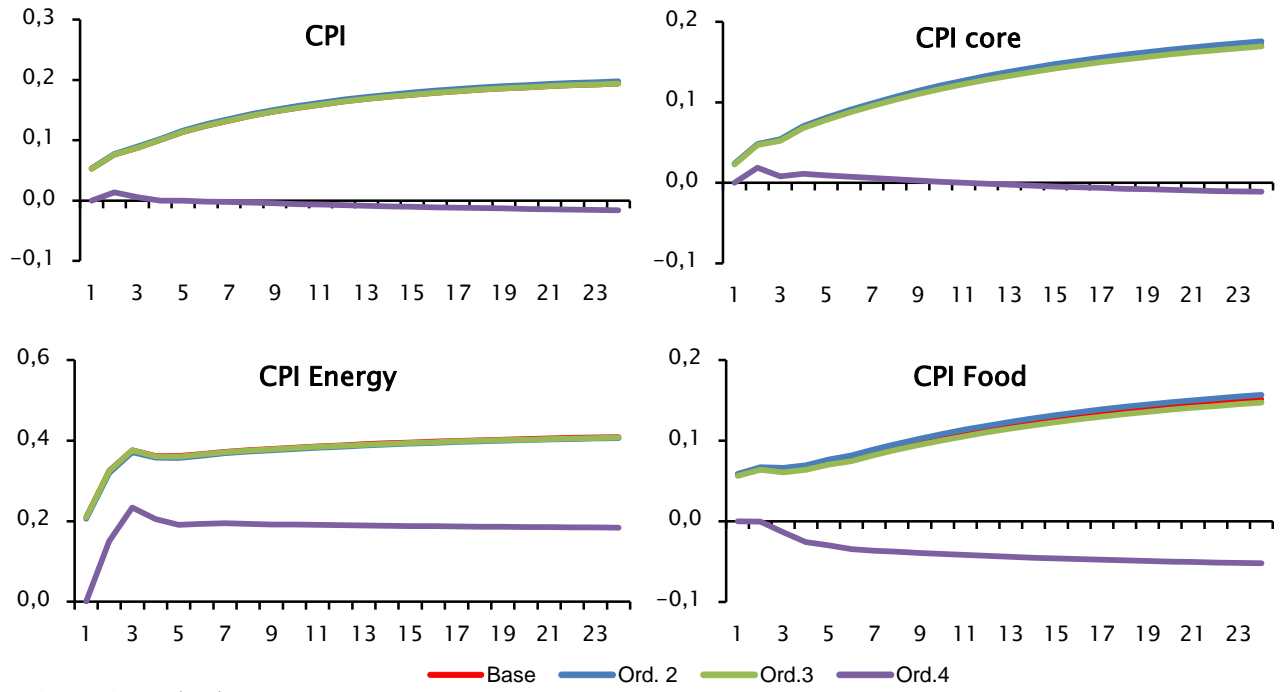
Source: Own estimations.

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