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Central Bank Award Rodrigo Gómez, 2018

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Abstract

Due to the potential existence of an endogeneity issue, assessing exchange rate pass-through as a nonconditional phenomenon can lead to misleading conclusions. In this regard, this study estimates for two economies a dynamic stochastic general equilibrium model, aiming to analyze to what extent their coefficients of pass-through, which are a priori significantly different, are either driven by structural discrepancies or by differences in the shocks each economy faces. Evidence suggests that the later effect predominates.

About the author

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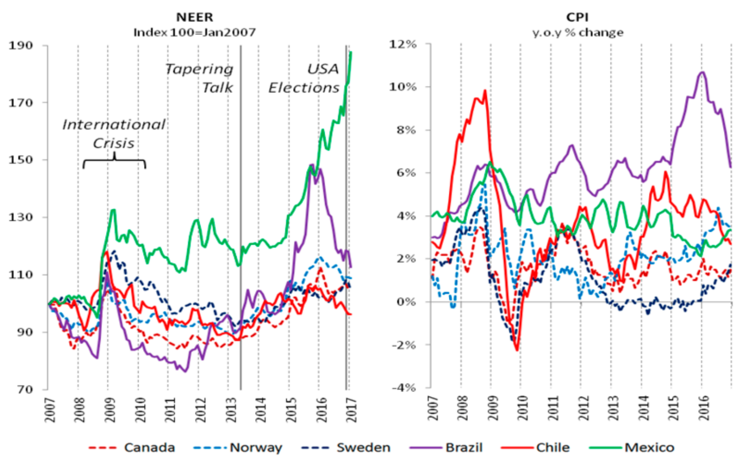
1. Introduction

Nominal exchange rates have recently undergone significant disturbances in both emerging and developed countries. Episodes like the International Crisis that began in 2008, the *tapering talk*,[1] and even election results–such as Brexit or presidential elections in the United States–have made currencies' relative prices change dramatically. In turn, price indexes in the economies affected have responded differently to these changes, either via different degrees of pass-through or with dissimilar lag levels, showing differences both between countries and temporarily within a single country. For example, during the international crisis, Mexico's exchange rate[2] climbed by 39% whilst inflation rose up to 6.5%; in contrast, the country's currency depreciated 36% during 2015 and 2016 while inflation never exceeded 3.4% in year-on-year terms, standing at 2.8% on average. Furthermore, the Brazilian real depreciated in nominal terms by 33% in 2015 while the country's inflation rate surpassed 10% year-on-year, thereby indicating a greater exchange rate pass-through (ERPT) to prices than that of the current Mexican economy.

Figure 1: Nominal Depreciation and Inflation



Source: Bruegel and International Financial Statistics - (IMF).

[1] Name given to a set of communications issued by the Federal Reserve as from May 2013 referring to the possibility of reducing its financial asset purchases. See, for example, Eichengreen and Gupta (2015) and Aizenman et al. (2016)

[2] Measured as the units in domestic currency relative to a currency basket consisting of the currencies of such economies with which there is commercial activity, weighted by trade flow.

Quantifying the degree to which exchange rate changes are passed through to prices and what factors determine such degree is pivotal for the monetary authority. In the case of a reduced pass-through, an economy may benefit from a flexible exchange rate, which acts as a shock buffer, whilst concerns about its repercussion on price levels are limited. This is even more relevant in countries having central banks that implement an inflation targeting policy, where the monetary policy is subject to meeting an inflation target.

Much work has been done to determine what factors influence the degree of ERPT.[3] The usual approach in literature consists in estimating reduced form equations where price change depends on exchange rates movements and other control variables suggested by theory. Next, coefficients related to the exchange rate are considered pass-through estimates and, then, it is analyzed how these estimates change in different contexts. In this regard, Calvo and Reinhart (2000) estimate bivariate vector autoregressive models (VAR) and compare the coefficients obtained for emerging and developed countries to contrast the hypothesis that the pass-through of the former is higher than that of the latter. Furthermore, Choudhri and Hakura (2006) estimate an equation where inflation is accounted for by an exchange rate change, inflation of trading partners and an autoregressive component and then recover the pass-through coefficients and estimate an equation where they are explained through different variables in order to analyze to what extent the hypothesis that a low inflation environment promotes lower ERPT to domestic prices (Taylor, 2000) is confirmed. A similar strategy is followed by Ca' Zorzi et al. (2007) and by Albagli et al. (2015), who calculate pass-through coefficients via VAR models focusing on the differences between emerging and developed countries. Contrary to earlier studies that consider the degree of pass-through as if it were an economy parameter—irrespective of economic conditions—, Caselli and Roitman (2016) estimate nonlinearities and asymmetries in the ERPT of 28 emerging economies and find significant evidence of nonlinearities in episodes of depreciation exceeding the 10% and 20% thresholds.

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[3]See Aron et al. (2014) for an excellent summary about the evolution of methodological techniques to measure ERPT.

Even though the papers abovementioned have contributed significantly to the study of this subject, the approach used considers exchange rate changes as exogenous and does not consider their causes, which could also be affecting prices and, therefore, implying an endogeneity problem in the exchange rate. To illustrate this, and following Shambaugh (2008), at times of high inflation, the amount of money increases, prices rise, and the exchange rate depreciates; this leads to a context of high ERPT coefficients, where purchasing power parity holds. In contrast, a fall in the domestic demand of a trading partner may reduce a country's domestic prices while at the same time depreciate its exchange rate (by reducing net exports). In this case, the pass-through to domestic prices would be lower and the purchasing power parity would still remain, given that the domestic currency depreciation and the decrease in foreign prices are offset in the pass-through to prices of imported goods. Thus, estimating the ERPT through reduced form equations poses two problems. Firstly, if the potential endogeneity of the exchange rate is not properly addressed, it could result in biased coefficients. Secondly, this approach provides little clarity about how the degree of pass-through changes in relation to the underlying shocks that generated it, thus it could confuse temporary changes or differences in the coefficients between countries with a temporary change or a variation between countries, respectively, in the distribution of shocks affecting their economies.

There are papers that consider this criticism and try to distinguish the degree of exchange rate pass-through to prices depending on the exogenous effect generating it; in other words, they consider it as a shock dependent phenomenon. They do this basically through two different approaches. On the one hand, the strategy implemented consists in using significance and sign restrictions in structural VAR models (SVAR) following the methodology of Blanchard and Quah (1989). For instance, Shambaugh (2008) exploits a country level panel data using long-run restrictions based on an IS-LM model, and Forbes et al. (2015) study United Kingdom experience using both short-run and long-run restrictions derived from a dynamic stochastic general equilibrium model (DSGE). On the other hand, a second approach implies estimating a DSGE model and recovering, by using impulse response functions, the ERPT coefficients for the different shocks considered in the model. This approach is followed by Bouakez and Rebei (2008), where they estimate a small open economy model with data for the Canadian economy, and in Shioji et al. (2009) with Japanese data.

This study shares the view of those studies that aim to identify ERPT determining factors but follows this last line of papers mentioned, where measuring is exempt from the criticism developed before. Particularly, the purpose of this research is to assess to what extent the difference in exchange rate pass-through to prices results from a difference in the parameters that structure the economy and/or a different distribution in the shocks such economy faces. To this end, a new Keynesian DSGE model will be estimated for two countries which, a priori, hold significantly different degrees of pass-through and, based on impulse response functions, the conditional ERPT coefficients will be recovered. This will allow making a comparison between different degrees of conditional pass-through within a single country and between both countries for pass-through generated by the same shock. Next, the history of underlying shocks will be analyzed and their distribution will be compared by studying how different the impacts each economy faced in different periods were and what degrees of ERPT are to be expected. Finally, as a counterfactual exercise, the models estimated will be used to simulate data on which pass-through coefficients will be calculated using the autoregressive vector methodology. This will allow making a direct comparison with estimates included in the literature for the countries under study, analyzing to what extent a different history of shock distribution affects estimates made as per the usual methodology.

Thus, the contribution of this paper to the ERPT literature is twofold. Firstly, it participates in the discussion about what factors determine the degree of ERPT by embarking on a dimension that has not been analyzed: shocks affecting an economy. Secondly, it contributes to empirical literature on the measurement of ERPT by providing estimates for the countries under study.

The study is structured as follows: Section 2 select the countries to be compared. Section 3 describes the model to be used, its estimation, and its goodness-of-fit. Section 4 analyzes conditional pass-through and relevant shocks to account for the outcome of the economies studied. Section 5 estimates VAR models with simulated data, comparing them to earlier literature results. Finally, Section 6 contains the main conclusions.

2. Selection of Countries

This section aims at choosing two countries which hold a priori significantly different pass-through to, then, analyze if such differences actually exist and if they are accounted for by the different shock distributions that affected each economy over the period under study. Given that the usual method to estimate ERPT coefficients uses VAR models, such method shall be used in this section.

Thus, a set of 23 small open economies applying an inflation targeting policy is considered and a VAR model is estimated for every country. The restriction in characteristics results from the fact that the same DSGE model will be used for both economies chosen; therefore, such a model must be adequate to capture the main features of those economies. According to earlier literature, endogenous variables included are gross domestic product, the multilateral nominal exchange rate, the consumer price index, and the monetary policy rate;[4] in turn, exogenous control variables are the oil price index, the Federal Reserve's benchmark interest rate, and the price index of trading partner countries.[5] Quarterly data from 2000Q1 to 2016Q2 is analyzed in this paper, subject to the availability of information. Given the unit root test results, variables are introduced in logarithmic differences with the exception of interest rates, which are included as percentage point differences. Optimal lag lengths are chosen as per the Schwarz-Bayesian and Hannan-Quinn information criterion.

Once regressions have been estimated, ERPT is defined as the ratio between the accumulated variation in prices and the accumulated variation in the exchange rate in relation to an exogenous shock in this last variable, identified as per a Cholesky ordering that respects the order in which variables were mentioned.

$$ERPT_t = \frac{\left(P_t^i - P_{t_0}^i\right)}{\left(NEER_t^i - NEER_{t_0}^i\right)},$$

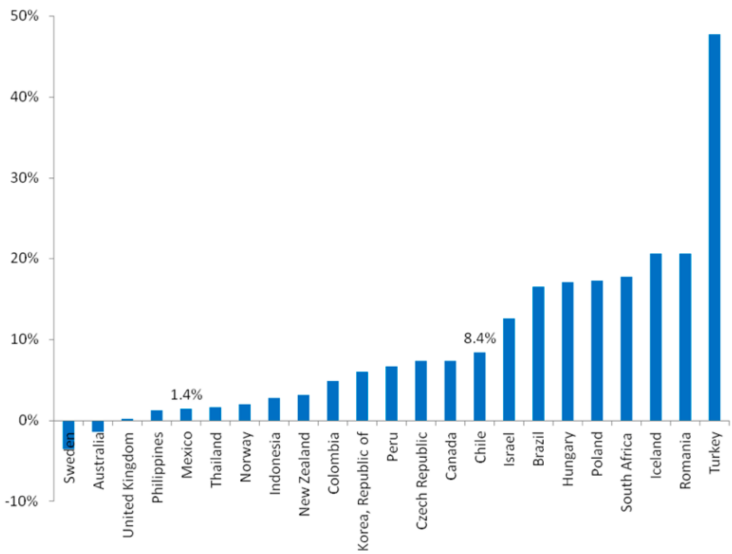
where variables are expressed in logarithms and *i* refers to the exchange rate shock. The different estimates are shown in Figure 2,

[4] The money market rate is used should the monetary policy rate be unavailable.
[5] Sources: International Financial Statistics, Bruegel, Federal Reserve Bank of St. Louis.

considering pass-through estimates at four quarters.[6]

On the basis of the results obtained, Chile and Mexico are chosen for analysis purposes. Such a choice is based on the fact that they both have different degrees of ERPT and because they share certain characteristics that make them suitable to be studied under the same model. They are both emerging countries and have small open economies. They are commodity exporters, have central banks applying an inflation targeting policy and have a high level of available information. In addition, for further control, Annex 1 contains ERPT existing estimates for the countries selected, which are in line with the results shown in Figure 2.

Figure 2 VAR ERPT - 4q



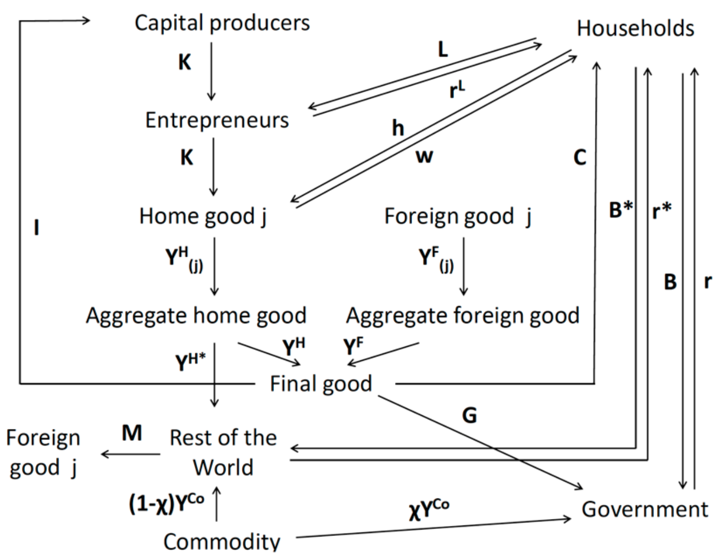
Source: Own estimates based on IFS, Bruegel and Federal Reserve Bank of St. Louis.

[6] For robustness control purposes, models with different Cholesky ordering schemes, alternative control variables and regular series instead of seasonally adjusted series are estimated. The results remain unchanged.

3.Model

The model developed in García-Cicco et al. (2014) will be used. This is a small open economy model with nominal and real rigidities. When processing home goods, work and capital are used and the resulting product is sold internally and externally. Firms related to this production set prices monopolistically and face price-stickiness à la Calvo as well as partial indexation. There also exist imported goods, the sale prices of which are subject to local currency pricing facing the same pricing problem domestic production does. Home and foreign goods are both used in the production of final goods, which are aimed to private and public consumption and the manufacturing of capital goods. Households maximize their utility based on decisions related to final consumption, labor, domestic and foreign debt, and loans to entrepreneurs, who finance the production of capital goods. At the same time, households supply labor monopolistically, facing wage-stickiness à la Calvo and wage-indexation. There is a commodity producing sector, a government that includes part of commodity production in its budget constraint, and a monetary authority that applies a monetary policy following a Taylor Rule. Finally, exogenous shocks are distributed in the model to capture domestic and external effects, both real and nominal.

Figure 3 Model Structure



3. 1 Model Structure

3.1.1 Households

There is a representative agent with defined preferences over consumption C_t and work h_t, and who regularly maximizes the following utility function:

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \upsilon_{t+s} \left[\log\left(C_{t+s} - \varsigma C_{t+s-1}\right) - \kappa \frac{h_{t+s}^{1+\phi}}{1+\phi} \right], \quad (1)$$

where $\beta \in (0,\ 1)$ is the intertemporal discount factor, ς, κ, and ϕ are parameters measuring consumption habits persistence, the relative importance between consumption and work and the inverse of elasticity of labor supply, respectively. In turn, υ_t represents a preferences shock, which follows an autoregressive process.

According to Schmitt-Grohé and Uribe (2005), labor is supplied monopolistically to a continuum of markets. Demand in each of such markets is given by:

$$h_t(i) = \left[\frac{W_t^n(i)}{W_t^n} \right]^{-\text{ú}_W} h_t^d,$$

depending negatively on the relative wage and positively on aggregate demand h_t^d. The election of wages is subject to a stickiness problem à la Calvo, where, for every period, an optimal wage is set for a fraction $\left(1-\theta_W\right)$ of labor markets while past wages in the remaining markets are adjusted based on a combination of past inflation and steady state inflation according to weights $\phi_W \in [0,\ 1]$ and $\left(1-\phi_W\right)$, respectively.

Households' income is applied for consumption, saving/indebtedness in bonds in domestic currency $\left(B_t\right)$ and foreign currency (B_t^*), contingent loans granted to the entrepreneur sector $\left(L_t\right)$, and the payment of lump-sum taxes $\left(T_t\right)$. Their income is derived from real wages $\left(W_t\right)$, loans and bonds yields, and dividends (Σ_t) from firms of which they hold full ownership. Thus, the budget constraint to which maximizing utility, in real terms, is defined as:

(2) $C_t + B_t + rer_t B_t^* + L_t + T_t = \int_0^1 W_t(i) h_t(i) di + r_t B_{t-1} + rer_t r_t^* B_{t-1}^* + r_t^L L_{t-1} + \Sigma_t .$

Real exchange rate rer_t indicates the number of final domestic goods necessary to purchase a foreign good, while gross yields on different financial assets are expressed in terms of their nominal counterparts according to:

$$r_t = R_{t-1}\pi_t^{-1}$$
$$r_t^* = R_{t-1}^*\xi_{t-1}\varpi_{t-1}(\pi_t^*)^{-1}$$
$$r_t^L = R_t^L\pi_t^{-1}$$

where gross domestic and foreign inflation rates are $\pi = P_t / P_{t-1}$ and $\pi^* = P_t^* / P_{t-1}^*$, respectively. According to a small economy context, international prices are supposed to follow an exogenous process. The international risk-free rate R_t^*, which is also assumed to change exogenously, is different from yields of assets denominated in foreign currency due to country premium ξ_t and shock ϖ_t. Regarding the latter, the purpose of including it is to capture deviations with respect to the uncovered interest rate parity condition. In turn, country premium is accounted for by the real saving/indebtedness level relative to the steady state level[7] and shock ζ_t which follows an autoregressive process.

$$\xi_t = \xi_{ss}\exp\left(\psi\frac{\frac{rer_t B_t^*}{A_{t-1}} - rer_{ss}b_{ss}^*}{rer_{ss}b_{ss}^*} + \frac{\zeta_t - \zeta_{ss}}{\zeta_{ss}}\right).$$

Considering the budget constraint and taking aggregate labor demand, the price level, interest rates, and aggregate variables as exogenous, households maximize their utility by choosing values of C_t, h_t, $W_t^t(i)$, B_t, B_t^*.

Finally, it should be mentioned that if the first-order conditions arising from the optimal election of debt in domestic and foreign currency are made equal, and following log-linearization, an uncovered interest rate

[7] To be more precise, the comparison uses the real indebtedness level adjusted by productivity. This is necessary because, as mentioned on the following pages, the model contains a permanent productivity shock A_t that generates a trend in all real variables thereby making the adjustment by productivity necessary to find a steady solution for the model.

parity (UIP) condition is obtained.

(3) $$R_t = R_t^* + \widehat{\xi}_t + \mathbb{E}_t\left[\pi_{t+1}^S\right] + \varpi_t,$$

where $\hat{x}_t = \log\left(\frac{x_t}{x_{ss}}\right)$.

3.1.2 Capital Producers

This industry has agents in perfect competition using a technology that includes depreciated capital (K) and investment (I) to generate new productive capital, facing investment adjustment costs (Γ).

(4) $$K_t = (1-\delta)K_{t-1} + \left[1 - \Gamma\left(\frac{I_t}{I_{t-1}}\right)\right] u_t I_t,$$

where:

$$\Gamma\left(\frac{I_t}{I_{t-1}}\right) = \frac{\gamma}{2}\left(\frac{I_t}{I_{t-1}} - a_{ss}\right)^2,$$

δ represents capital depreciation, γ measures investment adjustment costs, a_{ss} equals GDP growth under steady state, and u_t is a sector specific productivity shock. In every period, capital producers exchange depreciated capital and new capital with entrepreneurs at a price q_t, choosing the optimal investment level to maximize the following benefits function:

(5) $$\prod_t^K = q_t K_t - q_t(1-\delta)K_{t-1} - I_t \quad \forall t.$$

3.1.3 Entrepreneurs

Entrepreneurs are in charge of managing capital stock, being the link between capital producers and firms producing home goods. These agents rent capital stock to firms in every period at a gross rate r_t^K, and then sell the depreciated equipment to capital producers to then repurchase new capital to be rented in the following period. For this transaction to take place, entrepreneurs receive financing from households at a gross rate r_t^L. Hence, a sector representative agent chooses the optimal capital level to maximize the benefits given by

(6)
$$\prod_{t}^{E} = r_t^K K_{t-1} - q_t(1-\delta)K_{t-1} + L_t^K - q_t K_t - r_t^L L_{t-1}^K \quad \forall t.$$

3.1.4 Home Good j

As shown in the chart in the initial presentation of the model, firms in this sector produce different *j* types of a tradeable good using capital and work in their production function:

(7)
$$Y_t^H(j) = z_t K_{t-1}(j)^{\alpha} \left[A_t h_t^d(j)\right]^{1-\alpha},$$

where z_t and A_t (with $a_t = A_t / A_{t-1}$) symbolize a temporary and a permanent productivity shock, respectively, both common to the entire sector. Every firm has monopoly power on its good and faces a demand $X_t^H(j)$ defined by the aggregate home good producing sector, its decision variables being the level of prices and the optimal amount of input. Such variables are solved in two stages. Initially, the amount of capital and work is determined in the following cost minimization problem:

(8)
$$\min_{K_{t-1}(j),\, h_t^d(j)} W_{t+s} h_{t+s}^d(j) + r_{t+s}^K K_{t+s-1}(j)$$

subject to:

$$Y_{t+s}^H(j) = z_{t+s} K_{t+s-1}(j)^{\alpha} \left[A_{t+s} h_{t+s}^d(j)\right]^{1-\alpha} \quad \forall s.$$

In the second stage, and considering optimal marginal costs stemming from the resolution of 8, the optimal selection of prices is subject to a stickiness problem à la Calvo that is similar to that faced by households in their optimal wage decision.

3.1.5 Aggregate Home Good

This sector takes the production of firms *j* and, as evidenced by its name, it adds it into good Y_t^H, using constant elasticity of substitution technology:

(9)
$$Y_t^H = \left[\int_0^1 X_t^H(j)^{\frac{\text{Ú}_H - 1}{\text{Ú}_H}} dj\right]^{\frac{\text{Ú}_H}{\text{Ú}_H - 1}},$$

where $X_t^H(j)$ is the amount demanded to firm *j* and Ú_H measures the elasticity of substitution between the different varieties of home good *j*. Given that the aggregator sector competes perfectly, the maximization of benefits based on the optimal choice of $X_t^H(j)$ implies:

$$X_t^H(j) = \left(p_t^H(j)\right)^{-\acute{U}_H} Y_t^H \tag{10}$$

with $p_t^H(j) = P_t^H(j)/P_t^H$. Thus, the demand faced by the home good *j* producing firm is defined based on its price relative to that of the sector and an aggregate demand Y_t^H.

3.1.6 Foreign Good j

Foreign good *j* producing firms import a homogeneous good and sell it on the domestic market, defining total imports as follows:

$$M_t = \int_0^1 Y_t^F(j)\,dj. \tag{11}$$

The price in foreign currency for imports P_t^{F*} follows an exogenous process, while the sale price is defined monopolistically and its optimal election is subject to a price stickiness problem à la Calvo, similar to the one existing when determining wages and prices of home good *j*. It should be noted that by including price stickiness in this sector, the ERPT to prices of imported goods is not immediate and its pace is partially determined by Calvo's parameter θ_F and by the type of price indexing of the sector, defined by φ_F.

3.1.7 Aggregate Foreign Good

Imported goods are aggregated in the same manner home goods are, hence:

$$Y_t^F = \left[\int_0^1 X_t^F(j)^{\frac{\acute{U}_F - 1}{\acute{U}_F}}\,dj\right]^{\frac{\acute{U}_F}{\acute{U}_F - 1}}, \tag{12}$$

where $X_t^F(j)$ is the demand for imported good *j* and $\acute{U}_F$ is the constant elasticity of substitution between the different varieties of the imported good. Like its domestic counterpart, this sector operates in perfect competition, and the first-order condition provides for the following optimal demand for imported good *j* is:

(13) $$X_t^F(j) = \left(p_t^F(j)\right)^{-\text{Ú}_F} Y_t^F,$$

where $p_t^F(j) = P_t^F(j) / P_t^F$ and Y_t^F is the final aggregate demand for imports.

3.1.8 Final Good

A representative firm of the final good producing sector ends the production chain of goods demanding for aggregate home and foreign goods in the amounts X_t^H and X_t^F, respectively, and combining them according to the technology:

(14) $$Y_t^C = \left[(1-o)^{1/\eta}\left(X_t^H\right)^{\eta-1/\eta} + o^{1/\eta}\left(X_t^F\right)^{\eta-1/\eta}\right]^{\eta/\eta-1},$$

where $o \in [0, 1]$ and $(1-o)$ are the shares of the foreign and the home good, respectively, and η is the elasticity of substitution between them. In a context of perfect competition, firms take prices of inputs as given and choose X_t^H and X_t^F to maximize their benefits, which results in optimal demands:

(15) $$X_t^H = \left(p_t^H\right)^{-\eta} Y_t^C (1-o),$$

(16) $$X_t^F = \left(p_t^F\right)^{-\eta} Y_t^C o,$$

where $p_t^H = P_t^H / P_t$ and $p_t^F = P_t^F / P_t$.

3.1.9 Commodities

The production of commodities Y_t^{Co} follows an exogenous process that is cointegrated with the permanent productivity shock A_t. The entire production is assumed to be exported at an international price P_t^{Co*}; additionally, its real foreign price $p_t^{Co*} = P_t^{Co*} / P_t^*$ also follows an exogenous process.[8] A fraction $\chi \in [0, 1]$ of sales is owned by the government, while the remainder is taken by foreign agents. In terms of the final goods, revenue reported by this sector is $p_t^{Co} Y_t^{Co}$, where $p_t^{Co} = P_t^{Co*} S_t / P_t$, and S_t is the nominal exchange rate expressed as

[8] In the Mexican case, given that not the entire production is exported, the oil balance of trade is considered in its calibration. See Annex 2.

domestic currency relative to the foreign currency.

It should be noted that this sector's modeling is compatible with the export of commodities in both Chile and Mexico. In the former, copper is the main commodity exported and its ownership is shared by the government, through the public company Codelco, and the foreign private sector. In the case of Mexico, oil is the main commodity exported and it belongs to the government through company Pemex.[9]

3.1.10 Fiscal Policy

The government consumes an exogenous amount G_t of the final good, issues debt denominated in domestic currency (B_t), collects taxes and makes transfers (T_t), and receives a share of the production of commodities; thus, its budget constraint in terms of the final good is:

(17)
$$G_t + r_t B_{t-1} = T_t + B_t + \chi p_t^{Co} Y_t^{Co}.$$

3.1.11 Monetary Policy

In line with the fact that the countries under study apply inflation targeting regimes, the monetary policy is assumed to follow a Taylor-type rule:

(18)
$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}}\right)^{\rho R} \left[\left(\frac{\pi_t}{\pi_{ss}}\right)^{\alpha_\pi} \left(\frac{Y_t/Y_{t-1}}{a_{t-1}}\right)^{\alpha_y}\right]^{1-\rho R} \exp\left(\varepsilon_t^R\right),$$

where π_{ss} is the inflation target, while deviations from the rule, that is, monetary policy shocks, are captured by ε_t^R.

[9] An incipient process of openness to private capital for oil exploitation (see CRS Report 2015) began in Mexico as from July 2015. Given that the period under study is–as mentioned before–2003Q1-2016Q2, oil is assumed to be owned by the government on a permanent basis.

3.1.12 Rest of the World

Apart from the fraction of commodity production that is directed abroad, a share of the production of the aggregate home good is exported according to demand:

$$X_t^{H*} = o^* \left(\frac{P_t^{H*}}{P_t^*} \right)^{-\eta^*} Y_t^*,$$

where o^* is a parameter that represents the share of exports in terms of the product of the rest of the world Y_t^*; the latter follows an exogenous process. The law of one price is assumed to be applied to home goods; thus, $P_t^H = P_t^{H*} S_t$, and, therefore, it is possible to express the demand for exports as follows:

(19) $$X_t^{H*} = o^* \left(\frac{p_t^H}{rer_t} \right)^{-\eta^*} Y_t^*.$$

3.1.13 Aggregation and Market Clearing

Matching specific sectors' demand and supply provides the following equations:

$$\begin{aligned} Y_t^H(j) &= X_t^H(j) \\ Y_t^F(j) &= X_t^F(j) \\ Y_t^H &= X_t^H + X_t^{H*} \\ Y_t^F &= X_t^F \\ Y_t^C &= C_t + I_t + G_t \end{aligned}$$

If the relation of the economy with the external sector is aggregated, $GDP(Y_t)$ and the balance of trade (TB_t), may be defined–both in units of the final good–as:

(20) $$Y_t \equiv C_t + I_t + G_t + X_t^{H*} + Y_t^{Co} - M_t,$$

(21) $$TB_t \equiv p_t^H X_t^{H*} + rer_t p_t^{Co*} Y_t^{Co} - rer_t M_t.$$

Thus, the definition of the GDP deflator P_t^Y is implicitly defined as

(22) $$p_t^Y Y_t = C_t + I_t + G_t + TB_t,$$

where $p_t^Y = \frac{P_t^Y}{p_t}$. Finally, the position of the net foreign debt is

(23) $$rer_t B_t^* = rer_t r_t^* B_{t-1}^* - \left(TB_t - (1-\chi) rer_t p_t^{Co*} Y_t^{Co}\right).$$

3.1.14 Driving Forces

Those variables that evolve exogenously satisfy the following process

$$log\left(\frac{\mu_t}{\mu_{ss}}\right) = \rho_\mu log\left(\frac{\mu_{t-1}}{\mu_{ss}}\right) + e_t^\mu, \quad \rho_\mu \in [0,1) \text{ and } \mu_{ss} > 0.$$

being $\mu = \{v, u, z, a, \zeta, R^*, \pi^*, p^{Co*}, y^{Co}, y^*, g, \acute{U}^R, \varpi\}$, where μ_{ss} identifies the variable in its steady state value and e_t^μ are iid shocks (independent and identically distributed).[10]

Thus, the model proposed has seven domestic shocks and six external shocks. The former includes the preferences, investment, temporary technology, permanent technology, commodity production, public spending, and monetary policy rate shocks. In turn, the shocks to country premium, foreign interest rate, deviation from the uncovered interest parity (UIP), international inflation, commodity relative price, and international aggregate demand make up the set of external shocks.

3.2 Parametrization

The empirical strategy used employs calibrated parameters, parameters solved based on steady state equilibrium conditions, and standard Bayesian estimation. The parameters that were calibrated come primarily from two sources: sample means from the period used for the Bayesian estimation and earlier studies. Annex 2 shows the values of such parameters and their source, for Chile and Mexico.

Regarding the estimation, standard Bayesian techniques were used based on the model resolution with a log-linear approximation around the steady state. Fourteen observable variables were used. Out of the national account series, per capita investment (I), private consumption (C), GDP (Y), and public expenditure (G) are included. In order to capture the price dynamics, consumer price index (CPI)

[10] It is worth pointing out that y^{Co}, y^*, and g are presented in lower case letters. See Annex 6 to account for the transformation made.

inflation (π), the evolution of real wages (π^{W}), and the price of the main commodity exported expressed in relation to foreign prices (p^{Co*})[11] are also used as inputs. The remaining domestic variables included are the production of commodities (Y^{Co}), the monetary policy interest rate (R), the country premium measured by the EMBI+Country (ξ), and the multilateral nominal exchange rate depreciation (π^{S}). The external variables used are the Libor interest rate (R^{*}), GDP (Y^{*}), and CPI inflation (π^{*}) of trading partners, both trade-weighted. Both interest rates and the country premium were considered on a quarterly basis. Finally, to be in line with the model, all variables were transformed into logarithms and subsequently expressed in deviations from their mean.[12]

In the case of Chile, the 2001Q3-2016Q2 period was considered, while in the case of Mexico the period analyzed extended from 2003Q1 to 2016Q2. In this way, the initial quarter coincides with the stabilization of the inflation target for each country.

Regarding the priors imputed, the same distributions were used for both countries. Even though not using specific priors for each country results in a potential loss of information about the real distribution of parameters, using the same distributions guarantees not generating differences in later estimates that are not accounted for by differences in time series. In any case, the values used are not too different from the priors used in earlier studies, especially in García-Cicco et al. (2014), and Medina and Soto (2007) for Chile; and in Adame et al. (2013) for Mexico. Finally, iid measurement errors were also added for each of the observable variables, with a variance that is proportional to that of the associated variable. Estimation results are described in annexes 4 and 5.

Considering the results obtained, the differences estimated for the values of the parameters related to price stickiness should be underscored. Particularly, Chile has greater indexing to past inflation for both home and imported goods and higher chances of optimal periodic domestic price adjustment, thereby indicating a more flexible

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[11] Copper in the case of Chile and oil in the case of Mexico, deflated by the index used for construction of π^{*}.

[12] For further detailed information on the origin and treatment of the observable variables used in the estimation, see Annex 3.

price system. This scenario is not repeated in the labor market, where both countries have a high stickiness level in optimal wage setting with the difference that, in the case of Mexico, it has a greater wage indexation to past inflation.

The similarity in the values estimated for such parameters governing the monetary policy in both countries should also be mentioned, where a significant autoregressive component and a clear preponderance of the inflation target over that of GDP are evident, as is expected for inflation targeting regimes.

As a goodness-of-fit measure of the model used, Table 1 compares the second-order moments that arise from the model and those arising from the data, for such observable variables included in the estimation. It may be seen that improvement is still possible in terms of adjustment in the case of country premium and investment growth, where the model generates more volatility and persistence than the time series observed, and in the persistence of the real wage evolution. It is particularly relevant to analyze the fit of the final good inflation and that of the exchange rate depreciation, both key in this analysis. Regarding inflation, more volatility and persistence is observed in Chile than in Mexico, both in terms of what was estimated and what was computed based on the observed time series; however, it should be noted that there are still chances of improvement in the estimate of Mexico's inflation. With regard to nominal depreciation, both the model and the data indicate—for both countries—high volatility and persistence close to zero.

Table 1: Selected Second Order Moments

		Chile				Mexico			
		Standard deviation		Autocorrelation coefficient		Standard deviation		Autocorrelation coefficient	
		Model	Data	Model	Data	Model	Data	Model	Data
MPR	R	0.55	0.41	0.92	0.88	0.44	0.48	0.88	0.95
Country premium	ξ	0.26	0.15	0.93	0.83	0.54	0.17	0.97	0.78
Inflation	π	0.69	0.7	0.67	0.57	0.55	0.33	0.62	0.08
Foreign interest rate	R^*	0.39	0.43	0.97	0.97	0.48	0.44	0.98	0.98
Foreign inflation	π^*	1.3	1.3	0.44	0.44	0.37	0.37	0.38	0.38
Commodity relative price	p^{Co*}	36.43	45.44	0.93	0.95	35.37	35.14	0.88	0.88
Commodity production	Y^{Co}	4.22	4.27	0.65	0.66	3.56	3.83	0.89	0.9
Foreign GDP	Y^*	1.98	1.45	0.91	0.83	1.27	1.49	0.88	0.91
Government expenditure	G	1.89	1.92	0.66	0.67	1.01	0.99	0.61	0.61
NEER depreciation	π^*	4.93	4.27	–0.04	0.15	4.51	4.37	–0.05	0.04
GDP growth	g^Y	1.12	1.04	0.33	0.19	0.94	0.97	0.43	0.47
C growth	g^C	0.6	0.75	0.79	0.93	1.25	1.3	0.37	0.44
I growth	g^I	4.6	4.03	0.62	0.21	2.47	1.82	0.72	0.51
W growth	g^W	0.61	0.6	0.39	0.31	0.89	0.99	0.18	–0.4

Note: Unconditional moments computed at the posterior mean. Standard deviations are presented as percentage points.

4. Conditional Exchange Rate Pass-through

4.1 Selection of Shocks

Once the model for both economies has been estimated, the next logical step to obtain conditional pass-through coefficients is to identify what shocks mainly account for exchange rate fluctuations. This allows shortening the analysis and is also a first approach to see whether the different shock distributions faced by each country could explain differences in ERPT. To this end, the unconditional variance decomposition is used, which breaks down the variance of variables according to the contribution made by each shock.

Table 2: Variance Decomposition

$$\mu = \{v, u, z, a, \zeta, R^*, \pi^*, p^{Co*}, y^{Co}, y^*, g, \text{Ú}^R, \varpi\}$$

		v	u	z	a	ζ	R^*	π^*
Chile	R	2.72	28.56	19.02	0.61	0.32	19.94	2.93
	π	1.17	21.22	56.96	0.97	0.17	6.92	1.04
	π^S	0.1	1.72	0.57	0.32	1.46	17.78	29.23
Mexico	R	8.11	9.23	35.17	5.6	0.77	8.2	0.03
	π	4.5	4.51	70.86	2.82	0.4	3.04	0.01
	π^S	0.65	3.64	3.53	4	3.39	11.97	1.89

		p^{Co*}	y^{Co}	y^*	g	Ú^R	ϖ
Chile	R	4.61	0.07	0.29	0.03	11.65	9.25
	π	1.36	0.01	0.23	0.05	5.01	4.9
	π^S	1.5	0.01	0.1	0	4.87	42.35
Mexico	R	1.92	0.02	1.28	0.02	15.89	13.77
	π	0.59	0.01	0.32	0.01	5.73	7.2
	π^S	1.69	0.02	1.79	0	8.65	58.79

Note: Each column shows, in this order, the preferences, investment, temporary technology, permanent technology, country premium, international interest rate, international inflation, commodity relative price, commodity production, international aggregate demand, public expenditure, monetary policy rate, and UIP deviations shocks.

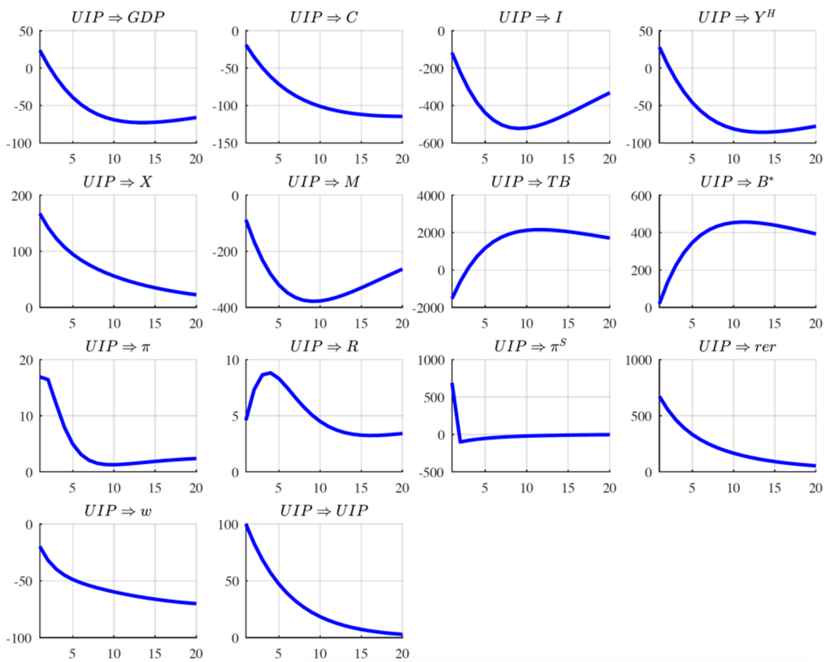
Table 2 shows that, in the Chilean case, changes in the exchange rate result mainly from uncovered interest rate parity shocks, disturbances in external prices, international interest rate shocks, and, to a lesser extent, deviations from the monetary policy rule. In Mexico, however, uncovered interest rate parity shocks account for almost 60% of the exchange rate variance; in addition, the international and the domestic interest rate play a nontrivial role in its determination. As expected, inflation volatility is partially determined by those effects that influence the exchange rate, particularly, transitory technology disturbances explain a major fraction of price variability. Finally, it should be noted that those shocks having greater influence on the exchange rate variance account for around 15% of inflation volatility, thereby measuring the impact ERPT has on prices evolution.

The unconditional decomposition then allows limiting the universe of disturbances considered to the set composed by uncovered interest rate parity, foreign prices, monetary policy rate, and international interest rate shocks. To better understand why such disturbances could generate unequal degrees of pass-through, it is necessary to analyze the transmission channels through which they operate.

4.2 Model Dynamics

Figure 4 illustrates how a UIP shock (see equation 3) impacts on the model's variables. It may be seen that deviations from the interest rate parity work mainly through two channels: on the one hand, they increase the financing cost—both internally and externally—and, on the other hand, they generate hikes in the exchange rate. Regarding the first channel, higher financing costs passes consumption and investment to the future, depressing activity in the present. This would have a negative impact on the level of prices. As far as the second effect is concerned, a UIP shock implies a rise in the nominal exchange rate, which takes place with the traditional overshooting, resulting from the slower pace of price adjustment. This results in a rise in the real exchange rate, which boosts the price of imports and exports thereby generating an expansionary effect on GDP which, in turn, reinforces inflationary pressures caused by the rise in the real exchange rate. Considering both effects, as a whole, Figure 4 shows that the global effect on prices is positive. Thus, the UIP shock exerts pressure on the exchange rate and the prices of the final product in the same direction leading to a positive ERPT.

Figure 4: Impulse Responses to a UIP Shock

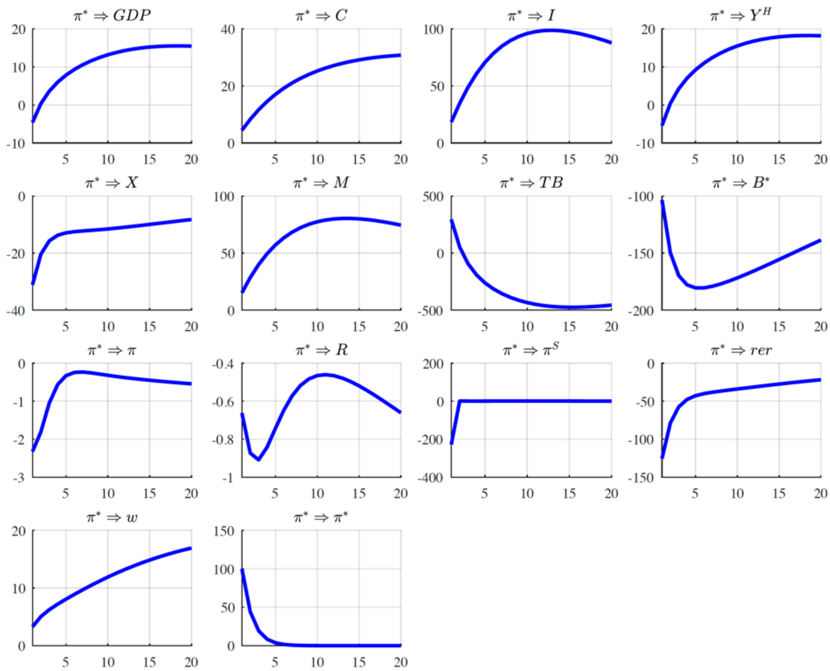


Note: Variables included are GDP, consumption, investment, home good production, exports, imports, balance of trade, foreign debt, inflation of the final good, monetary policy rate, exchange rate depreciation, real exchange rate, wages, and the variable being shocked. The shock was normalized to represent a 1 pp deviation, and responses of the variables are expressed in percentage deviations (basis points) in relation to their steady state. Impulse–response functions shown herein correspond to the Chilean case; however, the dynamics are similar for Mexico.]

In second place of importance when determining the exchange rate comes the variation in external prices, which impacts on the model, again, mainly through two channels. Initially, focus is placed on how the nominal exchange rate overreacts to the initial shock, thereby placing the real exchange rate below its steady state value. In the absence of this real appreciation, the rise in international prices would cause an increase in marginal costs in the importing industry and in the demand for exports, both recording inflationary effects. However, given that the reduction in the exchange rate more than offsets the international inflation shock, the real exchange rate appreciates and the commercial channel acts in the opposite manner, exerting deflationary pressures.

The increase in foreign prices implies, in the financial channel, a lower real foreign interest rate (see equation 23), thus a lesser repayment cost of foreign debt; therefore, such stock falls dramatically and the country premium is thus reduced. It should be noted that a reduction in the country risk requires an exchange rate appreciation to keep the interest rate parity; therefore, movements in these variables are mutually validated.

Figure 5: Impulse Responses to a Foreign Prices Shock

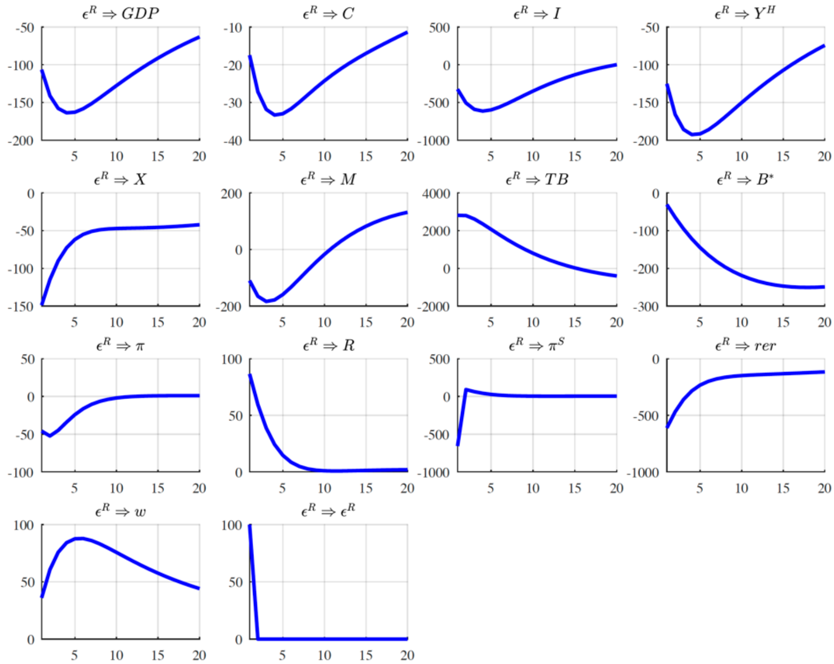


Note: See Figure 4

Regarding how changes in the monetary policy rate (without being driven by the Taylor rule considered) operate, Figure 6 shows how an increase in the interest rate has a contractionary effect on the economy. This takes place both because of the intertemporal pass-through of agents' consumption (Euler equation) and because of a rise in the cost of capital. Another significant effect stemming from the rise in the monetary policy rate is the imbalance in the interest rate parity, where domestic assets have a risk-adjusted yield that is higher than the yield expected from foreign assets. Such imbalance implies the subsequent appreciation of the exchange rate. Given that both the contractionary effect on activity and an appreciated exchange rate lead to negative inflation, this shock implies, once again, a positive

ERPT.

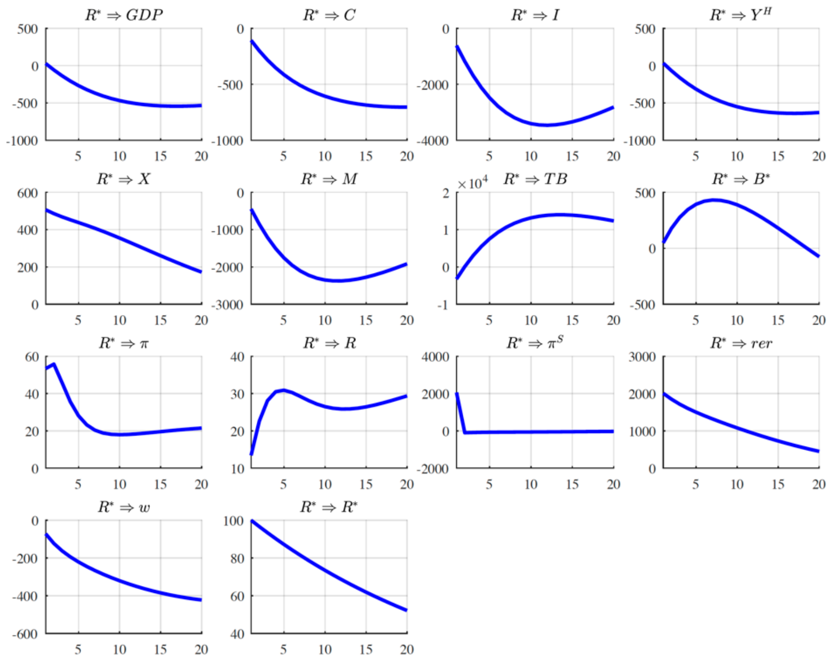
Figure 6: Impulse Responses to a Monetary Policy Rate Shock



Note: See Figure 4

Finally, the impact of a change in the international interest rate is analyzed here. On the one hand, it has the opposite effect on the UIP than the one generated by a rise in the monetary policy rate; this leads to the depreciation of the nominal exchange rate. Given that the foreign economy is not modeled here, there are no direct contractionary effects on the trade channel. However, the initial rise in the real exchange rate generates an upward pressure on import and export prices. It may be seen that the pass-through will exceed zero if there is an international interest rate positive shock.

Figure 7: Impulse Responses to a Foreign Interest Rate Shock



Note: See Figure 4

4.3 Conditional Pass-through Computation

Once the relevant shocks and their implied dynamics have been analyzed, and having projected conditional coefficients of ERPT exceeding zero for all of them, it is necessary to calculate the magnitude of such pass-through. To that end, the conditional ERPT is defined as follows:

$$ERPT_t^i = \frac{\sum_{j=1}^{t} IRF_j^{\pi,i}}{\sum_{j=1}^{t} IRF_j^{\pi^S,i}}, \qquad (24)$$

where the numerator and the denominator represent the cumulative deviation of inflation and of the exchange rate depreciation, respectively, relative to their steady state values in the presence of shock *i*. Given that the model is solved through a log-linear approximation, variables are expressed in logarithms and, therefore, their addition approaches the cumulative percentage deviation. Thus, the conditional ERPT expresses the percentage change in the level of prices as a ratio of the percentage change in the nominal exchange rate, without considering such own steady state variations.

Figure 8: Conditional ERPT for Selected Shocks

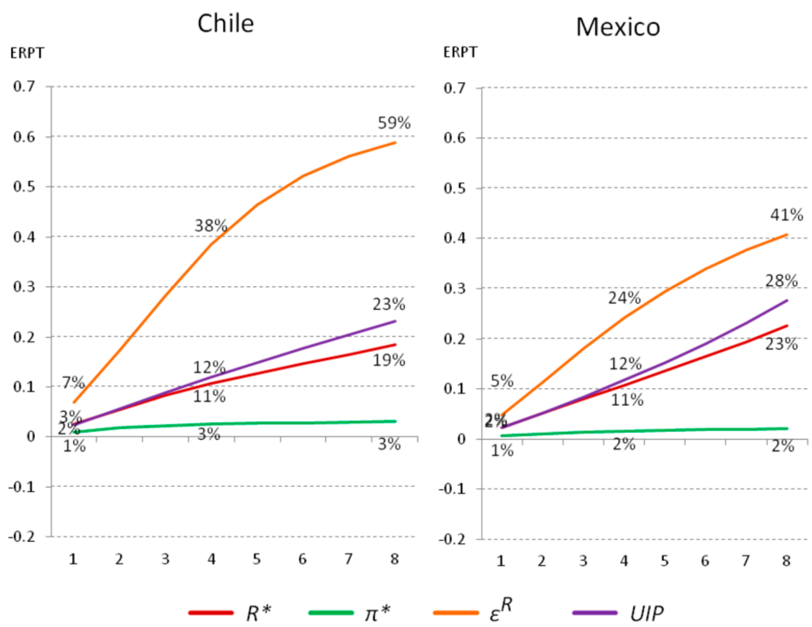


Figure 8 shows the conditional pass-through for the subset of shocks analyzed for both countries. First, it may be seen that there exist different degrees of conditional ERPT both within Mexico and within Chile, and that such differences are more evident when longer horizons are considered. Secondly, the similarity in the degree of the existing conditional pass-through in both countries should be noted, even if different horizons are taken into account. The hierarchy order for both Chile and Mexico is estimated to be the same, albeit in different degrees: an almost null pass-through for the international price shock, a rising pass-through reaching up to around 20% or 30% for UIP shocks and for the international interest rate shocks, and a higher one that, after eight quarters, amounts to around 40% for Mexico and 60% for Chile and which corresponds to the monetary policy shock. Save for this last effect, a high level of similarity is observed in the computation of coefficients, especially in those having more impact on determining the exchange rate, ergo, those associated to external price fluctuations and deviations from the UIP.

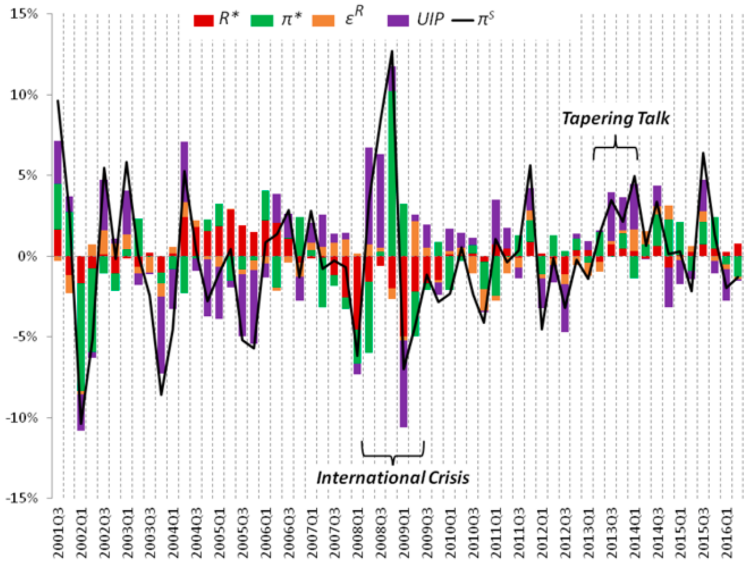
The results included herein measure the relevance of considering ERPT as a conditional phenomenon. In the case of the two countries under study, the same price response would not be expected upon a rise in the exchange rate caused by a fall in the monetary policy rate or by a rise in prices in the economies of their trading partners. Therefore, a similar response by the monetary authorities would not be optimal.

The fact that conditional pass-through coefficients within countries are not identical also helps explaining why prices would seem to suffer a greater impact in view of nominal depreciations in some episodes and a lesser effect in some others.

4.4 Historical Variance Decomposition

In order to better understand the relative significance of the different shocks in time, historical variance decompositions are presented here. Figure 9 describes the history of shocks that affected the exchange rate in Chile based on the identification proposed in this study. It may be observed that different disturbances in the relative value of currency were influenced by different shocks. To illustrate this, note that the depreciation associated to the international crisis during the 2008–2009 period was initially related to deviations from the uncovered interest rate parity and then to reductions in external prices, while lower depreciation that was linked to the tapering talk episodes is identified with deviations from the UIP and positive monetary shocks. Considering the different degrees of conditional pass-through estimated, a higher inflation response would be expected for every percentage point of depreciation of the exchange rate in the recent episode.

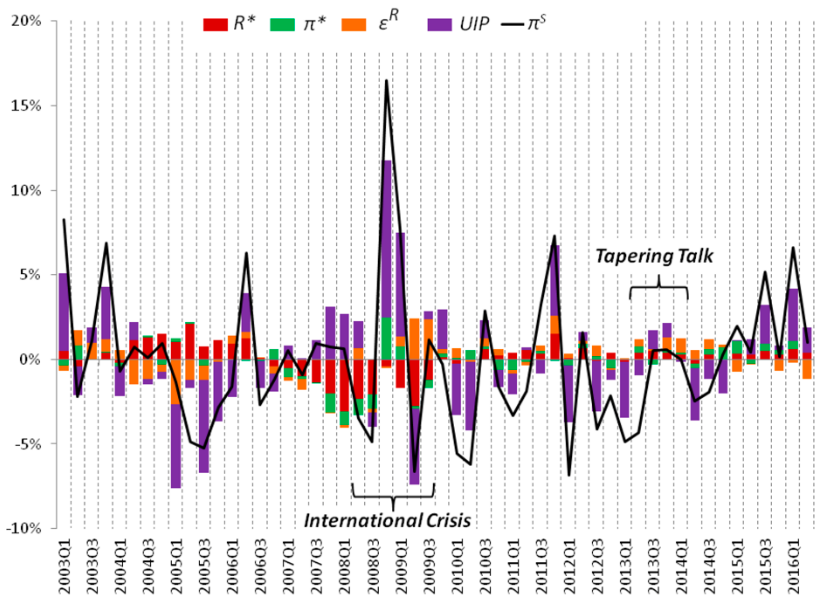
Figure 9: Historical Decomposition of Exchange Rate Depreciation in Chile



Note: Historical decomposition computed at the posterior distribution means.

In the case of Mexico, Figure 10 indicates that, both during the international crisis and during the tapering talk episodes, exchange rate depreciations (a slowdown in the appreciation that began in 2012 was observed in the last episode) were mainly induced by deviations from the interest rate parity. However, a significant share corresponding to the reduction of external prices was observed in 2008-2009, similar to that of Chile; in turn, in 2013, a monetary policy rate reduction that was not accounted for by the variables included in the Taylor rule was observed. This would suggest a higher degree of ERPT in the latest episode.

Figure 10: Historical Decomposition of Exchange Rate Depreciation in Mexico



Note: Historical decomposition computed at the posterior distribution means.

The historical variance decomposition shows that exchange rates in the economies under review suffered different shocks along their recent history; therefore, ERPT unconditional metrics could be suggesting conclusions that are not accurate for specific episodes, this being a key issue for the monetary authority.

Furthermore, even in periods characterized by global trends—such as the effects from the international crisis and the tapering talk on emerging countries—where it would make sense to think about different economies with nominal depreciations explained by common causes (flight to quality), it may be seen that different channels lead to such depreciations and, therefore, different inflationary behaviors would be expected.

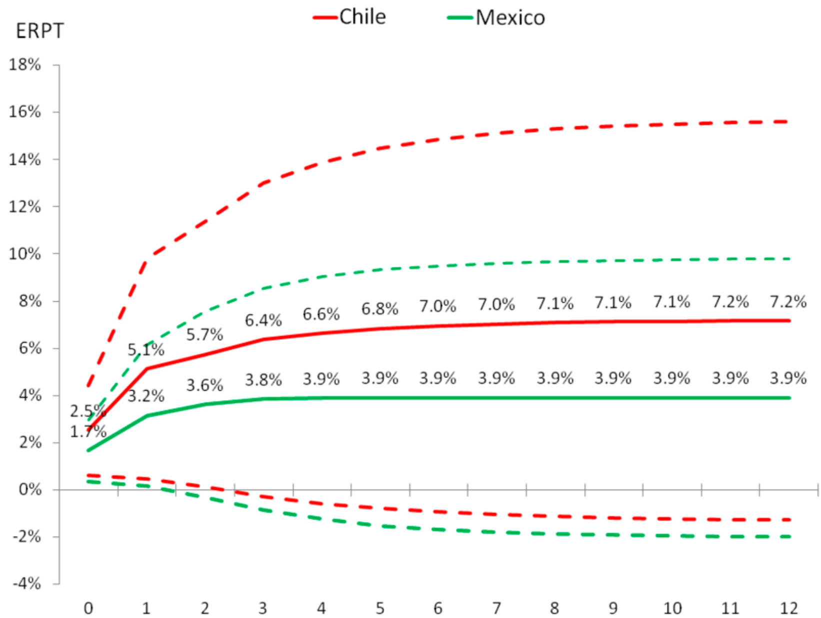
5. Back in VAR

The purpose of this section is to analyze to what extent the pass-through coefficients estimated as per the VAR methodology (those presented in Section 2) are affected by the specific history of the shocks faced by each country. The introduction of this study mentions how common it has been for literature to estimate reduced form equations and identify ERPT with the coefficients related to such regressions. Then, when comparing the pass-through of different countries, such methodology implied not considering the history of shocks recorded by each economy and, therefore, assigning the differences found to variables of different natures (region, development level, inflation level, and so on). This section is aimed at using, as per the traditional methodology found in literature, the VAR models to estimate the ERPT, but using simulated data from the model. These series are generated by a random shock distribution; therefore, they allow analyzing how the variables in both economies would have behaved should they have faced similar shocks.[13] In this way, by using simulated series to estimate VAR models, the pass-through coefficients obtained may be compared to those included in Section 2. Unlike the latter, the coefficients to be obtained do not consider the specific history of disturbances over the period under study but a random shock distribution, thereby allowing a comparison that explains the relevance of shocks when determining the pass-through coefficients as per the vector autoregressive methodology.

Particularly, 5,000 samples of size $n = 70$ are simulated in order to be coherent with the period analyzed. Next, a VAR model that is equal to the one described in Section 2 is estimated; hence, an ERPT distribution is obtained for each country and horizon. Figure 11 presents the results.

[13] Although it is a random shock distribution—and, given the number of samples, both countries would be expected to suffer, on average, the same shocks–it should be noted that the variance parameters and the autoregressive coefficients estimated for the shocks of each country in particular remain present. Therefore, the relevance of shocks in determining the different variables is not expected to be the same from one country to the other.

Figure 11: VAR ERPT with Simulated Data



Note: The dotted lines represent one standard deviation confidence intervals.

Going back to the values obtained in the initial estimates of Section 2, where the pass-through in Chile was 8.4 pp over four quarters whilst it was only 1.4 pp in Mexico, and especially considering the estimates of previous papers (see Annex 1), a clear contrast with the coefficients estimated herein may be observed. In fact, if we control for the particular shocks suffered by each economy, the degrees of pass-through in the economies studied are not significantly different in any of the horizons considered. Consequently, the relevance of shock distribution to account for a specific pass-through is clear to see.

6. Conclusion

This paper starts from the premise that the study of exchange rate pass-through to prices via reduced form equations, due to a potential endogeneity problem, could lead to wrong conclusions. Hence, the purpose here has been to analyze two countries with supposedly different degrees of ERPT and assess to what extent the shocks suffered by such countries would be affecting aggregate measurements.

The main results of the analysis indicate that: *1)* if the most relevant shocks to explain the exchange rate are considered, the degree of conditional pass-through is the same for both countries, with the exception of that related to the monetary policy rate; *2)* there are nontrivial differences in the degrees of conditional pass-through to the different shocks generating them; *3)* the historical distribution of shocks is different for each country; while the exchange rate in Mexico is more influenced by UIP shocks, in the case of Chile this variable is influenced by a combination of such movements and disturbances in prices of its trading partners; and *4)* the historical distribution of shocks within each country is not homogeneous in time; therefore, different inflationary consequences are to be expected in different episodes.

Regarding the unconditional measurement bias, given that conditional pass-through does not change significantly from one country to another but it does change according to the related shock, and the fact that the distribution of disturbances faced by each country is different, evidence would suggest that the differences in unconditional ERPT measurements are mainly accounted for by the history of shocks related to the time series used and not by economies' structural factors.

Finally, and for the purpose of comparing the results obtained herein to the unconditional measurements, series of simulated data were used to estimate unconditional pass-through coefficients via VAR models. The results show that when coefficients for Chile and Mexico are estimated with this methodology, they are not significantly different, thereby reinforcing the conclusion aforementioned

7. Annexes

Annex 1. Review of ERPT Estimates

Table A.1: Review of erpt Estimate for Chile

Reference	Period	Methodology	ERPT coefficient
Albagli, Naudon and Vergara (2015)	2000-2015	VAR	4 q: 19%
BBVA (2015)	2000-2015	VAR	4 q: 14%
IMF (2016)	20002015	Single equation	4 q: 6%, 8 q:12%
Pérez-Ruiz (2016)	2003-2015	VAR	4 q: 9%, 8 q:11%
Sansone (2016)	2008-2013	Partial equilibrium	Accumulated: 9%-20%*

Coefficients depend on elasticities used.

Table A.2: Review of erpt Estimate for Mexico

Reference	Period	Methodology	ERPT coefficient
Albagli, Naudon and Vergara (2015)	2000-2015	VAR	4 q: 4%
BBVA (2015)	2000-2015	VAR	4 q: 4%
Capistrán, Ibarra-Ramírez and Ramos-Francia (2012)	2001-2010	VAR	4 q: Nonsignificant
Cortés-Espada (2013)	2001-2012	VAR	4 q: Nonsignificant
Lopez-Villavicencio and Mignon (2016)	1994-2015	Single equation	1 q: 1.3%
Peón and Rodríguez-Brindis (2014)	2001-2013	VAR	Accumulated: 2.2%

Annex 2. Calibrated Parameters

Table A.3: Calibrated Parameters

Parameter	Description	Value	Source
		Chile	
ϕ	Labor supply elasticity	1	Adolfson et al. (2007)
0	Share of foreign good in final good	0.37	Imports over absorption, 2001q3-2016q2 average
α	Capital share in production	0.33	Medina and Soto (2007)
Ú$_{H}$	E. o. S. in aggregate home good	11	Medina and Soto (2007)
χ	Government share in commodity production	0.55	c+(1−c)*t, c=CODELCO/total=0.31 (2001-2015 average), and tax=0.35
δ	Capital depreciation	0.015	Medina and Soto (2007)
Ú$_{F}$	E. o. S. in aggregate foreign good	11	Medina and Soto (2007)
Ú$_{W}$	E. o. S. in labor demand	11	Medina and Soto (2007)
p^{R*}	Autocorrelation R^*	0.966	AR(1) coefficient, sample period
$p^{\pi*}$	Autocorrelation π^*	0.4411	AR(1) coefficient, sample period
$p^{p^{Co*}}$	Autocorrelation p^{Co*}	0.9275	AR(1) coefficient, sample period
$p^{y^{Co}}$	Autocorrelation y^{Co}	0.654	AR(1) coefficient, sample period
p^{y*}	Autocorrelation y^*	0.912	AR(1) coefficient, sample period
p^{y^g}	Autocorrelation g	0.664	AR(1) coefficient, sample period
σ^{R*}	Standard deviation of shock to R^*	0.001	AR(1) standard error, 2001Q3-2016Q2
$\sigma^{\pi*}$	Standard deviation of shock to π^*	0.0117	AR(1) standard error, 2001Q3-2016Q2
$\sigma^{p^{Co*}}$	A Standard deviation of shock to p^{Co*}	0.1362	AR(1) standard error, 2001Q3-2016Q2
$\sigma^{y^{Co}}$	Standard deviation of shock to y^{Co}	0.032	AR(1) standard error, 2001Q3-2016Q2
σ^{y*}	Standard deviation of shock to y^*	0.008	AR(1) standard error, 2001Q3-2016Q2
σ^{y^g}	Standard deviation of shock to g	0.014	AR(1) standard error, 2001Q3-2016Q2
ξ	Country premium in SS	$1.0145^{0.25}$	EMBI+Chile, 2001Q3-2016Q2 average
a	Long run growth	$1.02538^{0.25}$	Quarterly year over year GDP per capita change, 2001Q3-2016Q2 average

Parameter	Description	Value	Source
R	Monetary policy rate in SS	$1.0394^{0.25}$	Monetary policy rate, 2001Q3-2016Q2 average
π	Inflation in SS	$1.03^{0.25}$	Inflation target
R^*	International interest rate in SS	$1.0173^{0.25}$	Libor rate, 2001Q3-2016Q2 average
s^{TB}	Trade balance to GDP in SS	0.042	(Exports–imports)/GDP, 2001Q3-2016Q2 average
s^G	Government expenditure in SS	0.117	Government expenditure/GDP, 2001Q3-2016Q2 average
$s^{Y^{Co}}$	Commodity products to GDP in SS	0.134	Cooper production/GDP, 2001Q3-2016Q2 average
p^H	Home good relative price in SS	1	Normalization
		Mexico	
ϕ	Labor supply elasticity	1	Adolfson et al. (2007)
0	Share of foreign good in final good	0.3	Imports over absorption, 2001Q3-2016Q2 average
α	Capital share in production	0.34	García-Verdú (2005)
Ú$_H$	E. o. S. in aggregate home good	11	Adame et al. (2013)
χ	Government share in commodity production	1	Pemex
δ	Capital depreciation	0.02	Adame et al. (2013)
Ú$_F$	E. o. S. in aggregate foreign good	11	Adame et al. (2013)
Ú$_W$	E. o. S. in labor demand	11	Adame et al. (2013)
p^{R^*}	Autocorrelation R^*	0.979	AR(1) coefficient, sample period
p^{π^*}	Autocorrelation π^*	0.377	AR(1) coefficient, sample period
$p^{p^{Co*}}$	Autocorrelation p^{Co*}	0.881	AR(1) coefficient, sample period
$p^{y^{Co}}$	Autocorrelation y^{Co}	0.887	AR(1) coefficient, sample period
p^{y^*}	Autocorrelation y^*	0.884	AR(1) coefficient, sample period
p^{y^g}	Autocorrelation g	0.612	AR(1) coefficient, sample period
σ^{R^*}	Standard deviation of shock to R^*	0.001	AR(1) standard error, 2003Q1-2016Q2
σ^{π^*}	Standard deviation of shock to π^*	0.003	AR(1) standard error, 2003Q1-2016Q2
$\sigma^{p^{Co*}}$	A Standard deviation of shock to p^{Co*}	0.168	AR(1) standard error, 2003Q1-2016Q2
$\sigma^{y^{Co}}$	Standard deviation	0.016	AR(1) standard error,

Parameter	Description	Value	Source
	of shock to y^{Co}		2003Q1-2016Q2
σ^{y^*}	Standard deviation of shock to y^*	0.006	AR(1) standard error, 2003Q1-2016Q2
σ^{y^g}	Standard deviation of shock to g	0.008	AR(1) standard error, 2003Q1-2016Q2
ξ	Country premium in SS	$1.0204^{0.25}$	EMBI+Mexico, 2003Q1-2016Q2 average
a	Long run growth	$1.0048^{0.25}$	Quarterly year over year GDP per capita change, 2003Q1-2016Q2 average
R	Monetary policy rate in SS	$1.0606^{0.25}$	Monetary policy rate, 2003Q1-2016Q2 average
π	Inflation in SS	$1.03^{0.25}$	Inflation target
R^*	International interest rate in SS	$1.017^{0.25}$	Libor rate, 2003Q1-2016Q2 average
S^{TB}	Trade balance to GDP in SS	0.001	(Exports–imports)/GDP, 2003Q1-2016Q2 average
S^G	Government expenditure in SS	0.111	Government expenditure/GDP, 2003Q1-2016Q2 average
$S^{Y^{Co}}$	Commodity products to GDP in SS	0.011	Pemex trade balance/GDP, 2003Q1-2016Q2 average
p^H	Home good relative price in SS	1	Normalization
h	Hours worked in SS	0.3	Normalization

Annex 3. Variables' Sources and Treatment

Table A.4: Observable Variables

Variable	Source	Original Variable	Treatment
		Chile	
Investment growth	Banco Central de Chile	Gross fixed capital formation, billions of chained pesos, seasonally adjusted, quarterly	*1)* PC, *2)* Log-diff, *3)* DM
Consumption growth	Banco Central de Chile	Private consumption, millions of pesos at 2008 prices, quarterly	*1)* PC, *2)* SA, *3)* Log-diff, *4)* DM
Government expenditure	Banco Central de Chile	Government consumption, millions of pesos at 2008 prices, quarterly	*1)* PC, *2)* SA, *3)* Ln, *4)* DT, DM
GDP growth	Banco Central de Chile	GDP, millions of chained pesos, seasonally adjusted, quarterly	*1)* PC, *2)* Log-diff, *3)* DM
Inflation	Banco Central de Chile	CPI general index, monthly	*1)* QA, *2)* SA, *3)* Log-diff, *4)* DM
Wage growth	ine	Remunerations general index, real, monthly	*1)* QA, *2)* SA, *3)* Log-diff, *4)* DM
Commodity production	Banco Central de Chile	Copper mining, chained volume at previous year prices, seasonally adjusted, quarterly	*1)* Ln, *2)* DT, DM
Commodity relative price	Banco Central de Chile	Copper price (USD per pound, LME)	*1)* QA, *2)* Deflated by π^*, *3)* Ln, *4)* DM
Monetary policy rate	Banco Central de Chile	Monetary policy reference rate, monthly average	*1)* QA, *2)* QR, *3)* Ln, *4)* DM
Country premium	Banco Central de Chile	Spread – EMBI Chile, monthly average, basis points	*1)* QA, *2)* QR, *3)* Ln, *4)* DM
NEER depreciation	Banco Central de Chile	Multilateral exchange rate, monthly average	*1)* QA, *2)* Log-diff, *3)* DM
Foreign interest rate	Federal Reserve Bank of St. Louis-FRED	Libor rate, monthly average	*1)* QA, *2)* QR, *3)* Ln, *4)* DM
Foreign GDP	IMF-IFS and Banco Central de Chile	Trading partners real GDP (IFS), REER weights (Banco Central de Chile), annual	*1)* Trading partners real GDP growth weighted by noncopper trade flow, *2)* SA, *3)* Ln, *4)* DT, DM

Variable	Source	Original Variable	Treatment
Foreign inflation	Banco Central de Chile	External prices index (EPI), observed dollar (pesos/dollar) (OD), multilateral exchange rate (MER), monthly	*1)* EPI*OD/MER, *2)* QA, *3)* Log-diff, *4)* DM
Population	US Census Bureau	Population older than 16 years, annual.	Expressed on quarterly basis via linear expansion

Note: PC=per capita, SA=x12 seasonally adjusted, QA=quarterly average, QR= rate expressed on quarterly basis, Ln= natural logarithm, Log-diff= logarithmic difference between the variable and its one-period lag, DM=deviation from mean, and DT=deviation from trend.

Table A.4 (cont.) : Observable Variables

Variable	Source	Original Variable	Treatment
		Mexico	
Investment growth	INEGI	Gross fixed capital formation, millions of pesos at 2008 prices, seasonally adjusted, quarterly	*1)* PC, *2)* Log-diff, *3)* DM
Consumption growth	INEGI	Private consumption, millions of pesos at 2008 prices, seasonally adjusted, quarterly	*1)* PC, *2)* Log-diff, *3)* DM
Government expenditure	INEGI	Government consumption, millions of pesos at 2008 prices, seasonally adjusted, quarterly	*1)* PC, *2)* Ln, *3)* DT, DM
GDP growth	INEGI	GDP, millions of pesos at 2008 prices, seasonally adjusted, quarterly	*1)* PC, *2)* Log-diff, *3)* DM
Inflation	Banco de México	CPI general index, monthly	*1)* QA, *2)* SA, *3)* Log-diff, *4)* DM
Wage growth	Inegi, Banco de México, and Federal Reserve Bank of St. Louis-FRED	Manufacturing industry remuneration in USD per hour (W), monthly Exchange rate peso/dollar (ER), monthly. CPI general index (π), monthly	*1)* W*ER/ π *2)* QA, *3)* SA, *4)* Log-diff, *5)* DM
Commodity production	INEGI	Liquid hydrocarbons production, raw oil, thousand barrels per day, monthly	*1)* QA, *2)* Ln, *3)* DT, DM

Variable	Source	Original Variable	Treatment
Commodity relative price	Federal Reserve Bank of St. Louis-FRED	Crude oil prices: West Texas Intermediate (WTI) - Cushing, Oklahoma, dollars per barrel, monthly.	*1)* QA, *2)* Deflated by π^*, *3)* Ln, *4)* DM
Monetary policy rate	Banco de México	Interbank Equilibrium Interest Rate (TIIE) at 91 days, annual rate, monthly	*1)* QA, *2)* QR, *3)* Ln, *4)* DM
Country premium	Banco Central de Reserva del Perú	Spread – EMBIG Mexico, daily, basis points	*1)* QA, *2)* QR, *3)* Ln, *4)* DM
NEER depreciation	Banco de México	World, currency per US dollar index (E*), pesos per US dollar index (E), monthly	*1)* E/E*, *2)* QA, *3)* Log-diff, *4)* DM
Foreign interest rate	Federal Reserve Bank of St. Louis-FRED	Libor rate, monthly average	*1)* QA, *2)* QR, *3)* Ln, *4)* DM
Foreign GDP	Inegi and IMF-IFS	Trading partners real GDP (IFS), oil exports and nonoil imports (Inegi), quarterly	*1)* Trading partners real GDP growth weighted by nonoil trade flow (51 countries), *2)* SA, *3)* Ln, *4)* DT, DM
Foreign inflation	Banco de México	External prices index (111 countries), monthly	*1)* QA, *2)* SA, *3)* Log-diff, *4)* DM
Population	US Census Bureau	Population older than 16 years, annual.	Expressed on quarterly basis via linear expansion

Note: PC=per capita, SA=x12 seasonally adjusted, QA=quarterly average, QR= rate expressed on quarterly basis, Ln= natural logarithm, Log-diff= logarithmic difference between the variable and its one-period lag, DM=deviation from mean, and DT=deviation from trend.

Annex 4. Estimated Parameters

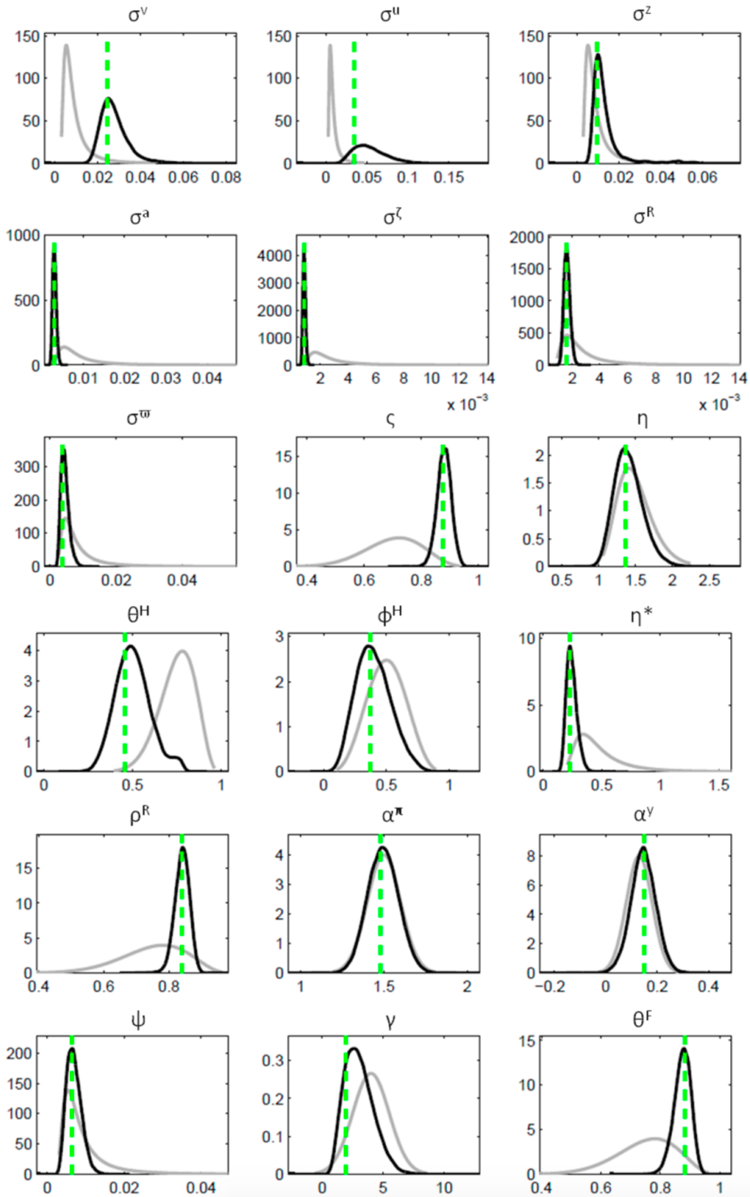
Table A.5: Estimated Parameters

Parameter	Description	Distribution	Mean	Standard error	Chile	Mexico
ς	Consumption habits	Beta	0.7	0.1	0.88	0.567
η	E. o. S. between x_t^H and x_t^F	Inverted gamma	1.5	0.25	1.405	1.307
η^*	Demand elasticity for exports	Inverted gamma	0.5	0.3	0.243	0.197
α^π	Inflation weight in MPR	Normal	1.5	0.1	1.494	1.549
α^y	Production weight in MPR	Normal	0.13	0.05	0.145	0.148
ρ^R	R_{t-1} weight in MPR	Beta	0.75	0.1	0.84	0.8
ψ	Country premium elasticity	Beta	0.01	0.013	0.007	0.004
γ	Investment adjustment costs	Beta	4	1.5	3.019	2.911
θ^H	Calvo probability home goods	Beta	0.75	0.1	0.501	0.722
ϕ^H	Indexation to π_{t-1} in home goods	Beta	0.5	0.15	0.396	0.267
θ^F	Calvo probability foreign goods	Beta	0.75	0.1	0.874	0.865
ϕ^F	Indexation to π_{t-1} in foreign goods	Beta	0.5	0.15	0.457	0.36
θ^W	Calvo probability wages	Beta	0.75	0.1	0.963	0.953
ϕ^W	Indexation to π_{t-1} in foreign wages	Beta	0.5	0.15	0.411	0.672
ρ^v	Autocorrelation of preference shock	Beta	0.75	0.1	0.867	0.692
ρ^u	Autocorrelation of investment shock	Beta	0.75	0.1	0.703	0.716
ρ^z	Autocorrelation of temporary technology shock	Beta	0.75	0.1	0.762	0.568
ρ^α	Autocorrelation of permanent technology shock	Beta	0.38	0.1	0.344	0.197
ρ^ς	Autocorrelation of country	Beta	0.75	0.1	0.83	0.859

Parameter	Description	Distribution	Mean	Standard error	Chile	Mexico
	premium shock					
ρ^{ϖ}	Autocorrelation of UIP shock	Beta	0.75	0.1	0.829	0.864
σ^{v}	Standard deviation of preference shock	Inverted gamma	0.01	0.013	0.028	0.025
σ^{u}	Standard deviation of investment shock	Inverted gamma	0.01	0.013	0.053	0.021
σ^{z}	Standard deviation of temporary technology shock	Inverted gamma	0.01	0.013	0.013	0.029
σ^{α}	Standard deviation of permanent technology shock	Inverted gamma	0.01	0.013	0.003	0.008
σ^{ζ}	Standard deviation of country premium shock	Inverted gamma	0.003	0.004	0.001	0.001
σ^{R}	Standard deviation of MPR shock	Inverted gamma	0.003	0.004	0.002	0.002
σ^{ϖ}	Standard deviation of UIP shock	Inverted gamma	0.01	∞	0.005	0.004

Annex 5. Priors and Posteriors

Figure 12: Priors and Posteriors – Chile



Note: Horizontal and vertical axis represent the prior range distribution and the cumulative density, respectively. The grey, black and green lines indicate the prior density, posterior density, and posterior mode, respectively.

Figure 12 (Continued): Priors and Posteriors – Chile

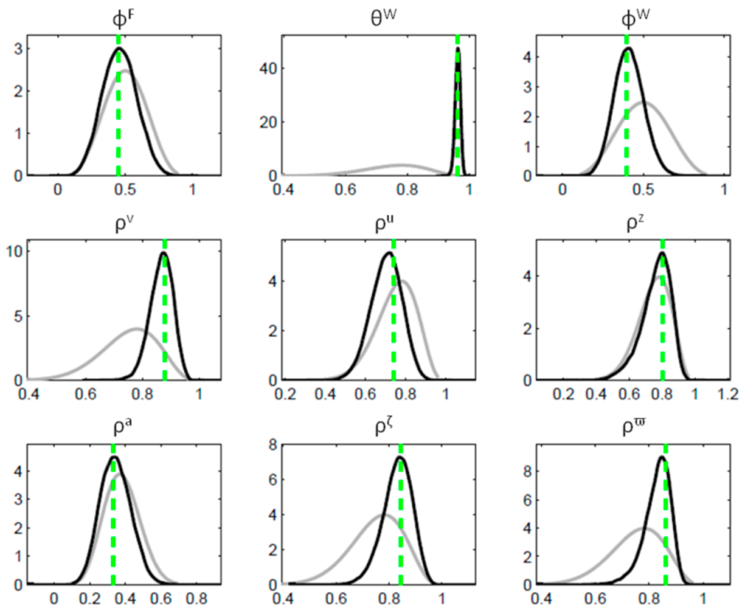
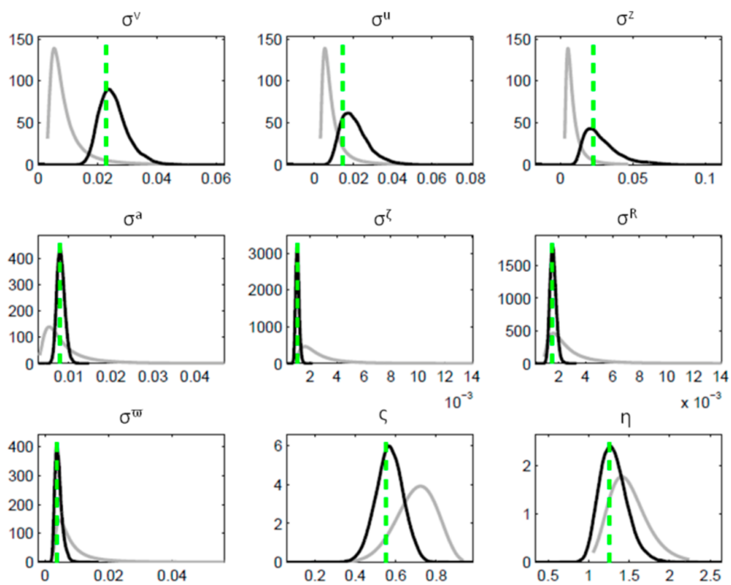
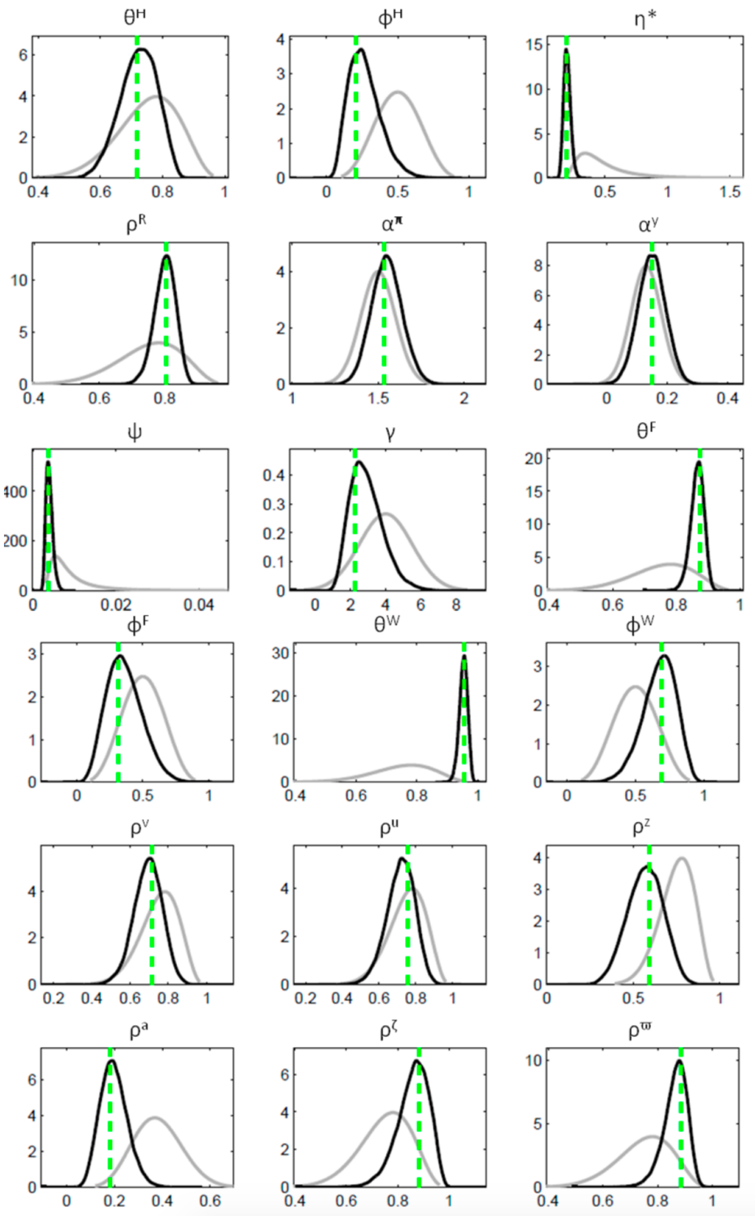


Figure 13: Priors and Posteriors – Mexico



Note: See Figure 12.

Figure 13 (Continued): Priors and Posteriors - Mexico



Note: See Figure 12.

Annex 6. Equilibrium Conditions

The model presented includes a permanent productivity shock, A_t, which implies nonstationarity for those nonprices uppercase variables. In order to achieve a stationary version of this model, such variables are divided by A_{t-1}, with the exception of Lagrange multiplier Λ, which is multiplied by A_{t-1}, since it contains an inverse trend to that of A_t. Transformed variables are presented in lowercase.

The rational expectations equilibrium of the model, in its stationary version, is conformed by the set of sequences:

$$\{\lambda_t, c_t, h_t, h_t^d, w_t, \tilde{w}_t, mc_t^W, f_t^W, \Delta_t^W, i_t, k_t, r_t^K, q_t, y_t, y_t^C, y_t^F, y_t^H, x_t^F, x_t^H, x_t^{H*}, R_t,$$
$$xi_t, r_t^L, \pi_t, \pi_t^S, rer_t, p_t^H, \tilde{p}_t^H, p_t^F, \tilde{p}_t^F, p_t^Y, mc_t^H, f_t^H, \Delta_t^H, mc_t^F, f_t^F, \Delta_t^F, b_t^*, m_t, tb_t\}_{t=0}^{\infty},$$

such that for given initial values and the following exogenous sequences:

$$\{v_t, u_t, z_t, a_t, \zeta_t, R_t^*, \pi_t^*, p_t^{Co*}, y_t^{Co}, y_t^*, g_t, \text{Ú}_t^R, \varpi_t\}_{t=0}^{\infty},$$

the following conditions are satisfied:

A.1 $$\lambda_t = \left(c_t + \varsigma \frac{c_{t-1}}{a_{t-1}}\right)^{-1} - \beta\varsigma \mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\left(c_{t+1}a_t - \varsigma c_t\right)^{-1}\right]$$

A.2 $$w_t mc_t^W = \kappa \frac{h_t^{\phi}}{\lambda_t}$$

A.3 $$\lambda_t = \frac{\beta}{a_t} R_t \mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\frac{\lambda_{t+1}}{\pi_{t+1}}\right]$$

A.4 $$\lambda_t = \frac{\beta}{a_t} R_t^* \xi_t \mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\frac{\pi_{t+1}^S \lambda_{t+1}}{\pi_{t+1}}\right]$$

A.5 $$y_t^C = \left[(1-o)^{\frac{1}{\eta}}\left(x_t^H\right)^{\frac{\eta-1}{\eta}} + o^{\frac{1}{\eta}}\left(x_t^F\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

A.6 $$x_t^F = o\left(p_t^F\right)^{-\eta} y_t^C$$

A.7 $$x_t^H = (1-o)\left(p_t^H\right)^{-\eta} y_t^C$$

A.8 $$mc_t^H = \frac{\left(r_t^K\right)^{\alpha} w_t^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}\left(p_t^H\right) z_t a_t^{1-\alpha}}$$

A.9
$$f_t^H = \left(\tilde{p}_t^H\right)^{-\text{Ú}_H} y_t^H mc_t^H + \\ +\beta\theta_H \mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{\pi_t^{\phi H}\pi_{ss}^{1-\phi H}}{\pi_{t+1}}\right)^{-\text{Ú}_H}\left(\frac{\tilde{p}_t^H}{\tilde{p}_{t+1}^H}\right)^{-\text{Ú}_H}\left(\frac{p_t^H}{p_{t+1}^H}\right)^{-1-\text{Ú}_H} f_{t+1}^H\right]$$

A.10
$$f_t^H = \left(\tilde{p}_t^H\right)^{1-\text{Ú}_H} y_t^H \left(\frac{\text{Ú}_H - 1}{\text{Ú}_H}\right) + \\ +\beta\theta_H \mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{\pi_t^{\phi H}\pi_{ss}^{1-\phi H}}{\pi_{t+1}}\right)^{-\text{Ú}_H}\left(\frac{\tilde{p}_t^H}{\tilde{p}_{t+1}^H}\right)^{1-\text{Ú}_H}\left(\frac{p_t^H}{p_{t+1}^H}\right)^{-\text{Ú}_H} f_{t+1}^H\right]$$

A.11
$$x_t^{H*} = o^*\left(\frac{p_t^H}{rer_t}\right)^{-\eta^*} y_t^*$$

A.12
$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}}\right)^{\rho R}\left[\left(\frac{\pi_t}{\pi_{ss}}\right)^{\alpha_\pi}\left(\frac{y_t}{y_{t-1}}\right)^{\alpha_y}\right]^{1-\rho_R} \exp\left(\varepsilon_t^R\right)$$

A.13
$$y_t^H \Delta_t^H = z_t\left(\frac{k_{t-1}}{a_{t-1}}\right)^{\alpha}\left(a_t h_t^d\right)^{1-\alpha}$$

A.14
$$1 = \theta_H\left(\frac{p_{t-1}^H}{p_t^H}\frac{\pi_{t-1}^{\phi H}\pi_{ss}^{1-\phi H}}{\pi_t}\right)^{1-\text{Ú}_H} + \left(1-\theta_H\right)\left(\tilde{p}_t^H\right)^{1-\text{Ú}_H}$$

A.15
$$y_t^H = x_t^H + x_t^{H*}$$

A.16
$$y_t^C = c_t + i_t + g_t$$

A.17
$$\frac{rer_t}{rer_{t-1}} = \frac{\pi_t^S \pi^*}{\pi_t}$$

A.18
$$y_t = c_t + i_t + g_t + x_t^{H*} + y_t^{Co} - m_t$$

A.19
$$tb_t = p_t^H x_t^{H*} + rer_t p_t^{Co*} y_t^{Co} - rer_t m_t$$

A.20
$$rer_t b_t^* = rer_t \frac{b_{t-1}^*}{a_{t-1}\pi_t^*} R_{t-1}^* \xi_{t-1} \varpi_{t-1} - \left(tb_t - (1-\chi) rer_t p_t^{Co*} y_t^{Co}\right)$$

A.21
$$\xi_t = \xi_{ss}\exp\left(\psi\frac{rer_t b_t^* - rer_{ss} b_{ss}^*}{rer_{ss} b_{ss}^*} + \frac{\zeta_t - \zeta_{ss}}{\zeta_{ss}}\right)$$

A.22
$$\Delta_t^H = \left(1-\theta_H\right)\left(\tilde{p}_t^H\right)^{-\text{Ú}_H} + \theta_H\left(\frac{p_{t-1}^H}{p_t^H}\frac{\pi_{t-1}^{\phi H}\pi_{ss}^{1-\phi H}}{\pi_t}\right)^{-\text{Ú}_H}\Delta_{t-1}^H$$

A.23 $$k_t = (1-\delta)\frac{k_{t-1}}{a_{t-1}} + \left[1 - \frac{\gamma}{2}\left(\frac{i_t}{i_{t-1}} a_{t-1} - a_{ss}\right)^2\right] u_t i_t$$

A.24 $$\lambda_t = \frac{\beta}{a_t}\mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\lambda_{t+1} r^L_{t+1}\right]$$

A.25 $$\frac{k_{t-1}}{h^d_t} = a_{t-1}\frac{\alpha}{1-\alpha}\frac{w_t}{r^K_t}$$

A.26 $$\frac{1}{q_t} = u_t\left[1 - \frac{\gamma}{2}\left(\frac{i_t}{i_{t-1}} a_{t-1} - a_{ss}\right)^2 - \gamma\left(\frac{i_t}{i_{t-1}} a_{t-1} - a_{ss}\right)\frac{i_t}{i_{t-1}} a_{t-1}\right] + \\ + \frac{\beta\gamma}{a_t}\mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\frac{\lambda_{t+1}}{\lambda_t}\frac{q_{t+1}}{q_t} u_{t+1}\left(\frac{i_{t+1}}{i_t} a_t - a_{ss}\right)\left(\frac{i_{t+1}}{i_t} a_t\right)^2\right]$$

A.27 $$p^Y_t y_t = c_t + i_t + g_t + tb_t$$

A.28 $$1 = \theta_F\left(\frac{p^F_{t-1}}{p^F_t}\frac{\pi^{\phi_F}_{t-1}\pi^{1-\phi_F}_{ss}}{\pi_t}\right)^{1-\text{Ú}_F} + (1-\theta_F)\left(\tilde{p}^F_t\right)^{1-\text{Ú}_F}$$

A.29 $$y^F_t = x^F_t$$

A.30 $$m_t = y^F_t \Delta^F_t$$

A.31 $$\Delta^F_t = (1-\theta_F)\left(\tilde{p}^F_t\right)^{-\text{Ú}_F} + \theta_F\left(\frac{p^F_{t-1}}{p^F_t}\frac{\pi^{\phi_F}_{t-1}\pi^{1-\phi_F}_{ss}}{\pi_t}\right)^{-\text{Ú}_F}\Delta_{t-1}$$

A.32 $$mc^F_t = \frac{rer_t}{p^F_t}$$

A.33 $$f^F_t = \left(\tilde{p}^F_t\right)^{-\text{Ú}_F} y^F_t mc^F_t + \\ + \beta\theta_F\mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{\pi^{\phi_F}_t\pi^{1-\phi_F}_{ss}}{\pi_{t+1}}\right)^{-\text{Ú}_F}\left(\frac{\tilde{p}^F_t}{\tilde{p}^F_{t+1}}\right)^{-\text{Ú}_F}\left(\frac{p^F_t}{p^F_{t+1}}\right)^{-1-\text{Ú}_F} f^F_{t+1}\right]$$

A.34 $$f^F_t = \left(\tilde{p}^F_t\right)^{1-\text{Ú}_F} y^F_t\left(\frac{\text{Ú}_F - 1}{\text{Ú}_F}\right) + \\ + \beta\theta_F\mathbb{E}_t\left[\frac{v_{t+1}}{v_t}\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{\pi^{\phi_F}_t\pi^{1-\phi_F}_{ss}}{\pi_{t+1}}\right)^{1-\text{Ú}_F}\left(\frac{\tilde{p}^F_t}{\tilde{p}^F_{t+1}}\right)^{1-\text{Ú}_F}\left(\frac{p^F_t}{p^F_{t+1}}\right)^{-\text{Ú}_F} f^F_{t+1}\right]$$

A.35 $$r^L_t = \frac{r^K_t + q_t(1-\delta)}{q_{t-1}}$$

A.36 $$f_t^W = \tilde{w}_t^{-\text{Ú}_W} h_t^d mc_t^W + \\ +\beta\theta_W \mathbb{E}_t \left[\frac{v_{t+1}}{v_t} \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\pi_t^{\phi_W} \pi_{ss}^{1-\phi_W}}{\pi_{t+1}} \right)^{-\text{Ú}_W} \left(\frac{\tilde{w}_t}{\tilde{w}_{t+1}} \right)^{-\text{Ú}_W} \left(\frac{w_t}{w_{t+1}} \right)^{-1-\text{Ú}_W} f_{t+1}^W \right]$$

A.37 $$f_t^W = \tilde{w}_t^{1-\text{Ú}_W} h_t^d \left(\frac{\text{Ú}_W - 1}{\text{Ú}_W} \right) + \\ +\beta\theta_W \mathbb{E}_t \left[\frac{v_{t+1}}{v_t} \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\pi_t^{\phi_W} \pi_{ss}^{1-\phi_W}}{\pi_{t+1}} \right)^{1-\text{Ú}_W} \left(\frac{\tilde{w}_t}{\tilde{w}_{t+1}} \right)^{1-\text{Ú}_W} \left(\frac{w_t}{w_{t+1}} \right)^{-\text{Ú}_W} f_{t+1}^W \right]$$

A.38 $$1 = (1-\theta_W)\tilde{w}_t^{1-\text{Ú}_W} + \theta_W \left(\frac{w_{t-1}}{w_t} \frac{\pi_{t-1}^{\phi_W} \pi_{ss}^{1-\phi_W}}{\pi_t} \right)^{1-\text{Ú}_W}$$

A.39 $$\Delta_t^W = (1-\theta_W)\tilde{w}_t^{-\text{Ú}_W} + \theta_W \left(\frac{w_{t-1}}{w_t} \frac{\pi_{t-1}^{\phi_W} \pi_{ss}^{1-\phi_W}}{\pi_t} \right)^{-\text{Ú}_W} \Delta_{t-1}^W$$

A.40 $$h_t = h_t^d \Delta_t^W$$

Finally, the exogenous processes satisfy

$$\log\left(\frac{\mu_t}{\mu_{ss}} \right) = \rho_\mu \log(\mu_t - 1) + e_t^\mu, \qquad \rho_\mu \in [0, 1) \text{ and } \mu_{ss} > 0, \text{ for}$$

$\mu = v, u, z, a, \zeta, R^*, \pi^*, p^{Co*}, y^{Co}, y^*, g, \text{Ú}^R, \varpi,$ where e_t^μ are i.i.d. shocks.

8.References

Adame, Francisco, Jessica Roldán-Peña, and Miguel Zerecero (2013), *Financial Considerations in a Small Open Economy Model for Mexico*, Banco Central de México.

Adolfson, Malin, Stefan Laséen, Jesper Lindé, and Mattias Villani (2007), “Bayesian Estimation of an Open Economy DSGE Model with Incomplete Pass-through”, *Journal of International Economics*, Vol. 72, No. 2, pp. 481-511, <https://doi.org/10.1016/j.jinteco.2007.01.003>.

Aizenman, Joshua, Mahir Binici, and Michael M. Hutchison. (2016), “The Transmission of Federal Reserve Tapering News to Emerging Financial Markets,” *International Journal of Central Banking*, June, pp. 317-356.

Albagli, Elías, Alberto Naudon, and Rodrigo Vergara (2015) *Inflation Dynamics in LATAM: A Comparison with Global Trends and Implications for Monetary Policy*, Documentos de Política Económica, No. 58, Banco Central de Chile.

Aron, Janine, Ronald Macdonald, and John Muellbauer (2014), “Exchange Rate Pass-through in Developing and Emerging Markets: A Survey of Conceptual, Methodological and Policy Issues, and Selected Empirical Findings,” *Journal of Development Studies* Vol. 50, No. 1, pp. 101-143, <https://doi.org/10.1080/00220388.2013.847180>.

Blanchard, Olivier, and Danny Quah (1989), “The Dynamic Effects of Aggregate Demand and Supply Disturbances,” *The American Economic Review,* Vol. 79, No. 4, pp. 655-673, <https://www.jstor.org/stable/1827924>.

Bouakez, Hafedh, and Nooman Rebei (2008), “Has Exchange Rate Pass-through Really Declined? Evidence from Canada,” *Journal of International Economics*, Vol. 75, No. 2, pp. 249-267, <https://doi.org/10.1016/j.jinteco.2007.12.004>.

Ca’ Zorzi, Michele, Elke Hahn, and Marcelo Sánchez (2007), *Exchange Rate Pass-through in Emerging Markets*, Working Paper Series, No. 739, European Central Bank.

Calvo, Guillermo, and Carmen Reinhart (2000), *Fixing for your Life*, NBER Working Paper, No. 8006, November, <DOI: 10.3386/w8006>.

Caselli, Francesca G., and Agustin Roitman (2016), *Non-linear Exchange Rate Pass-through in Emerging Markets*, IMF Working Paper, No. WP/16/1, International Monetary Fund.

Choudhri, Ehsan, and Dalia S. Hakura (2006), “Exchange Rate Pass-through to Domestic Prices: Does the Inflationary Environment Matter?,” *Journal of International Money and Finance*, Vol. 25, No. 4, June, pp. 614-639, <https://doi.org/10.1016/j.jimonfin.2005.11.009>.

Eichengreen, Barry, and Poonam Gupta (2015), “Tapering Talk: The Impact of Expectations of Reduced Federal Reserve Security Purchases on Emerging Markets,” *Emerging Markets Review*, Vol 25, pp. 1-15, <https://doi.org/10.1016/j.ememar.2015.07.002>.

Forbes, Kristin, Ida Hjortsoe, and Tsvetelina Nenova, T. (2015), *The Shocks Matter: New Evidence on Exchange Rate Pass-through,* Discussion Paper, No. 43, Bank of England.

García-Cicco, Javier, Markus Kirchner, and Santiago Justel (2014), *Financial Frictions and the Transmission of Foreign Shocks in Chile,* Documentos de Trabajo, No. 722, February, Banco Central de Chile.

García Verdú, Rodrigo (2005), "Factor Shares From Household Survey Data," Working Papers 2005-05, Banco de México, <https://ideas.repec.org/p/bdm/wpaper/2005-05.html>

Guillermo Peón, Sylvia Beatriz, and Rodríguez Brindis, Martín Alberto, (2014), "Analyzing the Exchange Rate Pass-through in Mexico: Evidence Post Inflation Targeting Implementation," Revista ESPE - Ensayos sobre Política Económica, Banco de la Republica de Colombia, vol. 32 (74), pages 18-35, June, <https://ideas.repec.org/a/bdr/ensayo/v32y2014i74p18-35.html>

Medina, Juan, and Claudio Soto (2007), The Chilean Business Cycles Through the Lens of a Stochastic General Equilibrium Model, Documentos de Trabajo, No. 457, December, Banco Central de Chile

Pérez-Ruiz, Esther (2016), *Outside the Band: Depreciation and Inflation Dynamics in Chile,* IMF Working Paper, No. WP/16/129, International Monetary Fund.

Ribando Seelke, Clare, Michael Ratner, M. Angeles Villareal, and Phillip Brown, (2015), *Mexico’s Oil and Gas Sector: Background, Reform Efforts, and Implications for the United States*, Congressional Research Service Report, September.

Sansone, Andrés (2016), *Traspaso de tipo de cambio a precios en*

Chile: el rol de los insumos importados y del margen de distribución, Documentos de Trabajo, No. 775, January, Banco Central de Chile

Schmitt-Grohé, Stephanie and Martin Uribe (2005), *Optimal Fiscal and Monetary Policy in a Medium–Scale Macroeconomic Model: Expanded Version,* NBER Working Paper, No. 11417, June, <DOI: 10.3386/w11417>.

Shambaugh, Jay (2008), A New Look at Pass-through, *Journal of International Money and Finance,* Vol. 27, No. 4, June, pp. 560-591, <https://doi.org/10.1016/j.jimonfin.2008.01.009>.

Shioji, Etsuro, Vu Tuan Khai, and Hiroko Takeuchi (2009), *Shocks and Incomplete Exchange Rate Pass-through in Japan: Evidence from an Open Economy DSGE Model*, paper presented at the Far East and South Asia Meeting of the Econometric Society, University of Tokyo.

Taylor, John B. (2000), "Low Inflation, Pass-through, and the Pricing Power of Firms," *European Economic Review,* Vol. 44, No.7, June, pp. 1389-1408, <https://doi.org/10.1016/S0014-2921(00)00037-4>.

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