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Fiscal Policy with a Flexible Exchange Rate: Why Are We Still Using It?

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We analyze why it is useful to conduct fiscal policy in a context of flexible exchange rates. By estimating a structural model, we find that although external financial shocks are dominant, the exchange rate remains vital for adjusting the economy to massive negative external shocks. One way to enhance this depreciation is through an expansionary fiscal policy that produces inflation and speeds up the adjustment of the economy. The Schmitt-Grohé-Uribe effect is key to understanding why an expansionary fiscal policy can depreciate, rather than appreciate, the local currency: overspending leads to an increase in the risk premium. However, if this depreciation does not occur, the economy falls into a deep recession, regardless of the policy applied.
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I. Introduction

The impact of fiscal policy—specifically, public spending—is again in the academic debate with the fiscal programs implemented to address the COVID-19 pandemic. In this article, we explore a classic question of international finance: why, in situations of severe economic crisis, do governments of open economies choose to increase spending despite having a flexible exchange rate system? The traditional Mundell-Fleming model recommends against it: an increase in public spending is offset by the negative effects of an appreciation in the local currency on net exports after an increase in the interest rate. In contrast, under a flexible exchange rate, monetary policy should be the appropriate tool to stabilize the business cycle in open economies. For example, Edwards and Yeyati (2005) find not only that a more rigid exchange rate regime increases the impact of terms-of-trade shocks, but also that a flexible exchange rate is associated with faster growth.

The literature on this subject is vast and spans a wide range of themes and methodologies. For instance, Ilzetzki, Mendoza, and Végh (2013) arrive at a similar result to Mundell (1963) and Fleming (1962). Using a large quarterly sample of 44 countries since 1960, they categorically find that the expenditure multiplier is zero in economies with flexible exchange rates. However, while countries tend to follow the recommendation of the Mundell-Fleming model on average, they tend to abandon it in critical circumstances and implement massive fiscal programs. Understanding why they do so is crucial in the current juncture.

We explore this issue by empirically questioning the central result that an increase in public spending produces a fall in the exchange rate. Ravn, Schmitt-Grohé, and Uribe (2012) find evidence using vector autoregressive (VAR) models that in industrialized countries, an increase in public spending produces a depreciation of the currency. Monacelli, and Perotti (2008,2010) and Müller (2008) find similar evidence for the United States and other developed countries. Thus, we argue that if increased spending produces a currency depreciation, then it could have a similar or complementary impact to monetary policy, providing a relevant instrument in times of severe difficulty.

Although this article is essentially empirical, we develop a structural model to make the estimates. Because we have rather short samples for each country and heterogeneous data quality, we use Bayesian econometrics to limit the parameters to values that are compatible with the previous evidence and economic theory. The model has several standard features, including price and wage rigidity, restricted agents, use of endogenous capital, diminishing returns to scale in the short term, and adjustment costs at different levels, as well as both internal and external shocks for a sample of countries with different characteristics. This imposes a strong challenge: omitting certain structures or overemphasizing others may ultimately bias the result in favor of the study's central hypothesis. We therefore introduce a wide range of elements that have been developed in recent years to understand the effects and dynamics of the exchange rate on the economy. The elements necessary to make realistic estimates with the structural model can be classified into five groups.

First, the literature on international finance—since the Asian crisis of the 1990s—introduces financial elements to explain the connections between the fluctuations of the economic cycle and the exchange rate. One strand of this literature focuses on explaining the mismatches that occur in domestic firms and banks when they contract foreign debt denominated in foreign currency—the so-called original sin and its balance-sheet effect (see, for example, the pioneering work of Céspedes, Chang and Velasco (2004)). Gertler, Gilchrist and Natalucci (2007) merge internal financial frictions with original sin, deriving the traditional financial accelerator but for an open economy. In another strand of this literature, Schmitt-Grohé, and Uribe (2003) model the risk premium of a small open economy in terms of foreign debt, an exercise initially undertaken for methodological reasons to close small open economy models. The importance of this approach is that the authors compact much of the default literature into a single parameter.

This is an extreme simplification, but it is useful for the empirical analysis of the business cycle in open economies. Both of these strands have a direct consequence for our study. An excess of domestic debt, caused by high public expenditure, will tend to produce a depreciation of the local currency—not an appreciation. We introduce both elements into the model to measure their relative importance, although ultimately the final effect will depend on empirical evidence, especially if the Schmitt-Grohé-Uribe effect has some significance beyond being an arbitrary mechanism to ensure stationarity.

Second, in recent years the identification of external shocks has gone far beyond the terms of trade, commodity prices, and the growth of the world economy, challenging the stabilizing role of a flexible exchange rate and ultimately questioning traditional macroeconomic policy itself in open economies. According to Gabaix and Maggiori (2015), Itskhoki and Mukhin (2019), and other recent studies, the exchange rate responds mostly to capital flows, which in turn respond to imbalances in imperfect or segmented financial markets—that is, by definition there is no international risk-sharing—that alter the risk of having different currencies. This explains the disconnection of the real exchange rate from internal determinants and the correlation between the real and nominal rates, and it undermines the role of this variable as a shock absorber.

In addition, Bräuning and Ivashina (2020) argue that even a flexible exchange rate does not allow for an independent national monetary policy—known in the literature as the trilemma framework—since credit to open economies is basically in dollars and their monetary policy is therefore subordinated to the U.S. Federal Reserve, international banks, and increased risk appetite[1]. The policy implications are strong: open economies are at the mercy of global financial cycles unless the capital account is managed with macroprudential policies.

All of this literature not only denies the use of fiscal policy, but also minimizes the importance of monetary policy when a flexible exchange rate is chosen. The growing relevance of international financial markets is undeniable and makes alternatives to a flexible exchange rate unfeasible. Indeed, a fixed exchange rate is impracticable for small open economies because of speculative market behavior against local currencies. Thus, according this literature (see Razin (2014), chapter 8),we must rule out an active fiscal policy in this last context, while under a flexible exchange rate the domestic monetary policy is almost testimonial. Since we already directly consider the role of domestic financial frictions and country risk, we introduced a third shock in addition to the U.S. federal funds rate—namely, a liquidity shock in the uncovered interest rate parity (UIP)—to measure whether these shocks really overshadow the policy options that we analyze in this study,

[1] See also Miranda-Agrippino and Rey (2020); Di Giovanni and others (2017); Bruno and Shin (2015); Bekaert and others (2013); and Rey (2013).

as recent literature finds and predicts.

Third, a vital question in our study is how to model export prices to measure autonomous changes in the exchange rate or changes induced by monetary or fiscal policy (or both). In the Mundell-Fleming model and its more modern versions (Svensson and van Wijnbergen (1989); Obstfeld and Rogoff (1995), the price of exports is fixed for the domestic economy, so the adjustment is direct: a depreciation immediately increases competitiveness. While this assumption is reasonable for large exporting economies, it does not seem to be appropriate for small economies facing prices that are fixed in dollars in international markets and that are also independent of the currency in the destination market, as proposed by Devereux and Engel (2003). Gopinath et al (2020) raise exactly this point, leaving the weight of adjustment to imports.

In this regard, we consider two groups of countries, one with significant foreign trade (namely, Mexico and Canada), and one with smaller economies (Chile, Colombia, New Zealand, and Australia). We assume that the first group can set prices, while in the second group the price of export products is fixed in dollars. We also undertake a second breakdown of our results into emerging economies (Chile, Colombia, and Mexico) and developed countries (Australia, Canada, and New Zealand), which extends the validity of our results to a wide group of cases. To draw conclusions from the estimates for the different countries, we average the impulse response functions of the different country groups.

Fourth, we incorporate the "delayed portfolio adjustment" assumption proposed by Bacchetta and van Wincoop (2019). This allows us to solve a series of puzzles that arise in open economy models when trying to explain the dynamics between the exchange rate and the interest rate, which is an important focus of our study. We assume that the real exchange rate has the persistence to produce a delayed overshooting—which modifies another classic mechanism in the open macroeconomics literature: namely, Dornbusch´s (1976) overshooting. Hence, the dynamics of the exchange rate—and therefore the return on local bonds—is determined more by expectations in the near than in the distant future. The magnitude of persistence is estimated directly from the data.

Fifth, using fiscal policy appears as an alternative when there are severe crises rather than normal fluctuations. This point is related to the debate on the type of shock produced by fluctuations in small and open economies: namely, transitory versus permanent shocks[2]. We take an intermediate path to these two approaches. While we explore the results of our estimates based on different types of external and domestic shocks (monetary, fiscal, productivity, etc.) that are both transitory

[2]See, for instance, the classic debate between García-Cicco, Pancrazi, and Uribe (2010) and Aguiar and Gopinath (2007).

and isolated, one of the main results is obtained with a shock defined as severe, that is, an external shock of long duration that compresses four key variables: commodity prices, the federal funds rate, external growth, and external changes in liquidity.

The importance of this composite shock is that in times of global turmoil, the synchronization between the dominant economic blocks increases due to a reduction of financial integration (see Kalemli-Ozcan, Papaioannou and Peydró (2013), causing open economies to face difficulties on different fronts. This causes several types of shock to act simultaneously, and it is artificial to try to omit the connection between them. For example, external growth and commodity prices are tightly connected to mismatches on the balance sheets of foreign investors, which trigger capital flows and changes in the real exchange rate. In this regard, authors such as Fernández, Schmitt-Grohé and Uribe (2020) find evidence that the movements of relevant external variables are related to each other. We thus carry out our simulations assuming various alternative scenarios for economic policy—including a zero lower bound—and the reaction of the exchange rate considering these possible connections.

Our results confirm that the flexible exchange rate regime is a great absorber of external shocks—as pointed out by Schmitt-Grohé, and Uribe (2016)—especially in the case of financial shocks. This verifies the evidence presented by authors such as Canova (2005). Moreover, from this perspective, the real exchange rate is not disconnected from the domestic economy, but rather is making the necessary adjustment to return the economy to full employment through higher inflation. We also find that the stabilizing reactions of monetary policy and fiscal policy are complementary within this adjustment made by the real exchange rate. Even if traditional monetary policy ceases to function and a zero lower bound is reached, monetary policy could be replaced by fiscal policy. Contrary to Mundell-Fleming's prediction, an expansionary fiscal policy can lead to a depreciation of the local currency, due to an increase in the risk premium. Depreciation causes inflation, and key relative prices fall, which drives up spending and leads the economy to full employment. This would largely explain why governments in critical circumstances consider fiscal policy to be a valid tool despite having a flexible exchange rate system.

However, we also find that the potential benefits of using fiscal policy depend crucially on how strongly the local currency depreciates against the dominant currency, the U.S. dollar. In the absence of a strong depreciation, the economy inevitably enters a recession, regardless of the policy implemented.

The paper is organized as follows: section II presents the model, section III analyzes the empirical results, and section IV discusses the policy implications.

II. Model

A. Households

The model considers a continuum of family units, indexed by $i \in [0,1]$. There are two types of families: a fraction $(1-\lambda_c)$ of families has access to the national and international capital market, and a fraction λ_c is restricted to income from work. The preferences of the first families are given by a separable utility function:

$$\max_{\left\{C_t^o(i), B_{t+1}^o(i), B_{t+1}^{o^*}(i)\right\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t^o(i)-\gamma C_{t-1}^o\right)^{1-\sigma}-1}{1-\sigma} - \frac{N_t^o(i)^{\varphi}}{\varphi}, \tag{1}$$

where C_t^o is consumption, N_t^o is the labor supply, σ measures relative risk aversion, $\varphi - 1$ measures the disutility of working and is the inverse of the elasticities of hours worked to the real wage, and γ measures exogenous habit formation, which depends on the lagged aggregate consumption of Ricardian families.

The budget constraint is given by:

$$P_t C_t^o(i) \leq W_t N_t^o(i) + B_t^o(i) - S_t B_t^{o^*}(i) + D_t^o - T_t - \frac{B_{t+1}^o(i)}{R_t} + \frac{S_t B_{t+1}^{o^*}(i)}{\Phi_t R_t^*}, \tag{2}$$

where W_t is the wage rate, B_t^o and $B_t^{o^*}$ are domestic and external debt of households, S_t is the nominal exchange rate, D_t^o corresponds to dividends, Φ_t is the country risk premium function, and T_t, R_t, and R_t^* are lump-sum taxes, the gross domestic interest rate, and the gross foreign interest rate, respectively. We assume that the log of this last variable follows a first-order autoregressive, or $AR(1)$, process with a shock $u_t^{R^*} \sim N(0, \sigma_{R^*}^2)$. Moreover, in the log-linear model, we also include a demand shock, $u_t^D \sim N(0, \sigma_D^2)$, in the Euler equation to improve the model fit to the data.

Households are not price takers in the labor market; we assume that there is a union that acts as a wage setter on behalf of each family to negotiate with the firms that produce non-commodity goods. Wages are staggered à la Calvo (1983):

(3)

$$\max_{\left\{\widetilde{W}_t\right\}_{k=0}^{\infty}} E_t \sum_{k=0}^{\infty} \theta_W^k \left\{ \Lambda_{t,t+k} \left[\frac{\widetilde{W}_t \Pi_{l=1}^k (1+\pi_{t+l-1})^{\delta_W}}{P_{t+k}} - \left(N_{t+k}^o(i)\right)^{\varphi-1} \left(C_t^o(i) - \gamma C_{t-1}^o\right)^{\sigma} \right] N_{t+k}^o(i) \right\},$$

subject to:

$$N^o_{t+k}(i) = \left(\frac{\widetilde{W}_t}{W_{t+k}}\right)^{-\epsilon_W} \int_0^1 N_{t+k}(j)dj, \tag{4}$$

where θ_w is the probability that a given wage can be re-optimized in any particular period, δ_w measures the level of indexation, $\Lambda_{t,t+k}$ is the stochastic discount factor, and ϵ_w is the elasticity of substitution between any two households. The first two parameters are estimated, and the third is calibrated according to information from each country[3].

Restricted families are subject to the following budget constraint:

$$P_t C^r_t(i) \leq W_t N^r_t(i) - T_t. \tag{5}$$

B. *Firms*

We assume two types of firms, those producing intermediate goods, which are not competitive, and those producing capital or investment goods, which are competitive.

Intermediate goods. Firms that produce intermediate goods—indexed by $j \in [0, 1]$—have a Cobb-Douglas production function with diminishing returns to scale in the short term, which depends on three inputs—namely, capital utilization, $\widetilde{K}_t(j)$; labor, $N_t(j)$; and imported inputs, $M_t(j)$:

$$Y_t(j) = A_t(j)\widetilde{K}^{\alpha_1}_t(j)N^{\phi_{01}\alpha_2}_t(j)M^{\phi_{02}\alpha_3}_t(j), \tag{6}$$

where $A_t(j)$ is total factor productivity (TFP), and its log is modeled as an $AR(1)$ process with a shock $u^A_t \sim N(0, \sigma^2_A)$.

The introduction of diminishing returns to scale captures the fact that small open economies face more constraints than large economies with large capital stocks. However, the values of the parameters ϕ_{01} and ϕ_{02} depend finally on estimation and can take a value of one. In this case, equation (6) becomes a function with constant returns to scale.

As mentioned, the firms that produce intermediate goods are not competitive. To make the estimation as simple as possible, we assume that firms set prices in

[3]For details on the calibration of ϵ_w, see Appendix A.2.The labor markup

a similar way to wage setting, and prices are staggered à la Calvo (1983):

(7)

$$\max_{\left\{\widetilde{P}_t(j)\right\}_{k=0}^{\infty}} E_t \sum_{k=0}^{\infty} \theta_D^k \left\{\Lambda_{t,t+k} \left[Y_{t+k}(j)\widetilde{P}_t(j)\Pi_{l=1}^k \left(1+\pi_{t+l-1}\right)^{\delta_D} - MC_{t+k}\left(Y_{t+k}(j)\right)\right]\right\},$$

subject to:

$$Y_{t+k}(j) = \left(\frac{\widetilde{P}_t\left(j\right)}{P_{t+k}}\right)^{-\epsilon_D} Y_{t+k}, \tag{8}$$

where θ_D is the probability that a given price can be re-optimized in any particular period, δ_D measures the level of indexation, $\Lambda_{t,t+k}$ is the stochastic discount factor, ϵ_D is the elasticity of substitution between any two firms, and MC_{t+k} is marginal cost. As in the case of wages, the first two parameters are estimated, and the third is calibrated according to information for each country, which was obtained from De Loecker and Eeckhout (2018).

To improve the empirical adjustment of the macroeconomic model—and parallel to the Euler equation for consumption—we also include a supply shock $u_t^s \sim N(0, \sigma_s^2)$ in the Phillips curve of the log-linear model. For the same reasons, we assume that there are lags in conditional demand and in the response of each demand to input prices. In the log-linear model, the lags for the conditional demand for imports and labor are measured by parameters Ω_M and Ω_N, respectively. In a similar fashion, the parameters that measure this lower response to input prices are ξ_{01} and ξ_{02} for the conditional demand for imports and labor, respectively.

As usual, there is an aggregator that competitively produces an aggregate good from intermediate goods, which is used for consumption, investment, exports, etc.

Investment goods. In contrast, only competitive firms, indexed by $l \in [0,1]$, are involved in the production of capital. In this regard, we assume a remarkably simple form of capital accumulation, in which these firms maximize the benefits of leasing capital subject to market prices, adjustment costs, and depreciation at every moment in time. These firms decide not only the quantity of capital to build, but also the intensity of its use, measured by the variable $\mu_t(l)$. Thus, the capital stock used by firms that produce investment goods is $\widetilde{K}_t(l) = \mu_t(l)K_t(l)$. We define investment and adjustment costs as $I_t(l)$ and $\phi_t(l)$, with the standard properties that $\phi_t(\delta) = \delta$ and $\phi_t'(\delta) = 1.0$, respectively. The maximization problem of capital-producing firms is then

$$\max_{\{I_t(l),\mu_t(l)\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left(Z_t \mu_t(l) K_t(l) - P_t I_t(l) \right), \tag{9}$$

subject to:

$$K_{t+1}(l) = (1 - \delta_t(l)) K_t(l) + \phi \left(\frac{I_t(l)}{K_t(l)} \right) K_t(l), \textit{ and} \tag{10}$$

$$\delta_t(l) = \delta + \xi \left(\frac{\mu(l)^{\eta^{MU}+1} - 1}{\eta^{MU} + 1} \right), \tag{11}$$

where Z_t, P_t, and $\Lambda_{0,t}$ are the capital rental price, the investment price, and the stochastic discount rate, respectively; and $\delta_t(l)$ is the depreciation rate of the capital stock, which depends on capital utilization $\mu_t(l)$ (see equation 11). We arbitrarily set the parameter ξ such that $\mu = 1$ in steady state (see subsection Appendix A.2.National account variables, equations (A2.7) and (A2.8)).

We introduce this last element so that in the case of a negative shock that reduces imports, GDP does not increase due to our accounting definition of GDP: output minus imports (see equation 22). Thus, the lower use of capital outweighs the purely accounting effect of using fewer imports in the production of goods. The importance of this effect is estimated through the parameter η^{MU}.

Also relevant in the estimates, it is the parameters AC that measure the response of investment to Tobin's Q in real terms or Q_t^T, this parameter is the inverse of the adjustment costs. For the same reasons that we included shocks in the Euler and Phillips equations, the log-linear model includes a shock in the investment equation, $u_t^I \sim N(0, \sigma_I^2)$, where this variable is determined by Tobin's Q.

C. *Exports*

Export modeling considers two possibilities: small open economies (SOE), where the price of non-commodity exports is fixed in dollars, and other larger open economies (LOE), which can fix the price of their non-commodity exports in local currency.

Small open economies. Non-commodity exports are:

$$X_t^D = \left(X_{t-1}^D\right)^{\Omega_X} \left(\left(\frac{P_t^X}{P_t^*}\right)^{-\eta^d} GDP_t^*\right)^{1-\Omega_X} e^{u_t^{X_D}},\ u_t^{X_D} \sim N(0, \sigma_{X_D}^2), \tag{12}$$

where P_t^X is the dollar price of domestic exports and P_t^* is the international price level (specifically, the U.S. consumer price index). The parameter η^d—the price elasticity of demand—was also calibrated based on market power information obtained from De Loecker and Eeckhout (2018), taking the average of China, the United States, Europe, and Japan. We assume that prices in dollars are fixed à la Calvo (1983), but for the sake of simplicity, we do not repeat the pricing equations (they are similar to equations 7 and 8). Then, we model the log of the external GDP as an $AR(1)$ process with a shock $u_t^{GDP^*} \sim N(0, \sigma_{GDP^*}^2)$.

Unlike domestic prices and wages, the Phillips curve associated with the P_t^X price is partially calibrated according to values used in the literature to model the international inflation rate. The parameters associated with this calibrated Phillips curve are δ_X, an indexation measure; θ_X, the probability that a given price can be re-optimized in any particular period; and ϵ_X, the elasticity of substitution between any two firms. The values are equal to 0.45, 0.75, and 3.1, respectively. The criteria for choosing these values were the following: for indexation, we averaged the value used in several works, which estimate this parameter between 0.2 and 1.0 (see subsection Appendix A.2.Indexation in the Phillips curve for details); for the probability of changing prices, we used a standard value of average price rigidity used in many models; and for the substitution elasticity, we averaged the markups for China, the United States, Europe, and Japan, as reported by De Loecker and Eeckhout (2018). However, the marginal costs—expressed in real dollar terms—and the parameters associated with economies of scale are specific to each open economy.

Total exports for SOEs are:

$$X_t = \frac{E_t P_t^X}{P_t^*} X_t^D + E_t P_t^{CM} X_t^{CM}, \tag{13}$$

where E_t is the real exchange rate, P_t^{CM} is the commodity price in real terms, and X_t^{CM} is commodity exports. In the log-linear version of the model, we approximate P_t^X / P_t^* for the differences $(\pi_t^X - \pi_t^*)$, where π_t^X is obtained as explained in the paragraph above and π_t^* corresponds to U.S. inflation. For simplicity, we assume that this variable can be modelled as an $AR(1)$ process with a shock $u_t^{\pi^*} \sim N(0, \sigma_{\pi^*}^2)$.

While the price of domestic exports in SOEs is fixed in dollars—and thus determines their demand in international markets—the total value of exports remains dependent on the real exchange rate (see equation (13)). To close the export block, we assume that commodity exports depend on the commodity price:

(14)
$$X_t^{CM} = \left(X_{t-1}^{CM}\right)^{\Omega_{XCM}} \left[\left(P_t^{CM}\right)^{\phi_{XCM}}\right]^{1-\Omega_{XCM}} e^{u_t^{PCM}},\ u_t^{PCM} \sim N\left(0, \sigma_{PCM}^2\right).$$

We assume that the commodity export price is fixed in dollar terms. We maintain this assumption for the larger economies as well, so the commodity supply depends on the international price in dollars expressed in real terms (equation 13 and 16).

Larger open economies. In this case, the price is fixed domestically, so non-commodity exports depend directly on the real exchange rate, that is, the comparison between the price in local currency and its price in dollars:

$$X_t^D = \left(X_{t-1}^D\right)^{\Omega_X} \left(E_t^\eta GDP_t^*\right)^{1-\Omega_X} e^{u_t^{X_D}},\ u_t^{X_D} \sim N\left(0, \sigma_{X_D}^2\right), \tag{15}$$

However, the real exchange rate does not affect the real value of non-commodity exports in the LOE case. Rather, it affects only the quantity of these products supplied, so total LOE exports are:

$$X_t = X_t^D + E_t P_t^{CM} X_t^{CM}. \tag{16}$$

D. Government and Monetary Policy

In relation to fiscal policy, we focus on public spending, G_t. We assume that there is a long-term level, G, which can be interpreted in different ways, such as a fiscal rule that fixes spending according to permanent tax revenues or a more general policy that seeks to keep the ratio of this spending to GDP constant. Deviations from this long-term expenditure are financed by changes in public debt (both domestic and foreign), and we model these deviations as temporary shocks, u_t^G:

$$G_t = G^{1-\rho_G} \left(G_{t-1}\right)^{\rho_G} e^{u_t^G},\ u_t^G \sim N\left(0, \sigma_G^2\right). \tag{17}$$

The fiscal budget constraint is defined as:

$$P_tG_t \leq \frac{S_tB^{G^*}_{t+1}}{\Phi_tR^*_t} + \frac{B^o_{t+1}}{R_t} + T_t - B^o_t - S_tB^{G^*}_t, \tag{18}$$

where $B^o_t = \int_{\lambda_c}^1 B^o_t(i)di$. In the case of monetary policy, we assume a simple Taylor rule, which depends on the inflation rate, Π, and GDP and which also considers the level of the exchange rate, E_t, and its volatility, $\triangle E_t$:

$$R_t = R^{\Omega_R}_{t-1}\left[\Pi^{\psi_R}_t GDP^{\psi_y}_t E^{\psi_{01}}_t \left(\triangle E_t\right)^{\psi_{02}}\right]^{1-\Omega_R} e^{u^{MP}_t},\ u^{MP}_t \sim N(0,\sigma^2_{MP}). \tag{19}$$

The importance of all these parameters depends on the values obtained in the model estimates. However, ψ_π must be greater than one to ensure a unique sticky-price equilibrium.

E. Equilibrium

We assume that commodity exports affect the market for non-commodity goods in the equilibrium condition:

$$Y_t = C_t + I_t + G_t + X_t, \tag{20}$$

where $Y_t = \int Y_t(j)dj$, $I_t = \int I_t(l)dl$, $C_t = \int_0^{\lambda_c} C^r_t(i)di + \int_{\lambda_c}^1 C^o_t(i)di$, and $N_t = \int N_t(j)dj = \int_0^{\lambda_c} N^r_t(i)di + \int_{\lambda_c}^1 N^o_t(i)di$. The rationale behind this simplifying assumption is that commodity production is not an isolated enclave and, therefore, needs the rest of the economy's resources. Then, once we sum the restrictions from restricted and unrestricted households, government, and firms, we get the total restriction of the economy:

$$\underbrace{\frac{S_tB^*_{t+1}}{\Phi R^*_t} - S_tB^*_t}_{Foreign\ Debt} \geq \underbrace{\underbrace{P_tC_t + P_tI_t + P_tG_t}_{Domestic} + \underbrace{S_tM_t}_{Imports}}_{Expenditure} - \underbrace{P_tY_t}_{Output}. \tag{21}$$

We use the definition of national accounts—that is, at constant prices, assuming $P_t = 1.0$—to measure real GDP:

$$GDP_t = Y_t - M_t. \tag{22}$$

Finally, the model is completed with the definition of the sticky-price equilibrium, which we estimate and simulate in the next section. It is expressed in real terms by using P_t and P_t^*, which are the domestic and external price level, respectively.

DEFINITION 1: *Sticky-price equilibrium. A sticky-price equilibrium is a set of prices in real terms:*

$$\left\{ \frac{W_t}{P_t}, E_t, Q_t^T, P_t^{CM}, \frac{Z_t}{P_t}, \frac{R_t P_t}{P_{t+1}}, \frac{R_t^* P_t^*}{P_{t+1}^*}, \frac{P_t^X}{P_t^*} \right\}_{t=0}^{\infty},$$

such that a fraction $(1-\lambda_c)\theta_W$ *of households maximizes utility, a fraction* θ_D *of intermediate-good producers maximizes profits in the domestic market, a fraction* θ_X *of non-commodity exporters maximizes profits in foreign markets, all capital producers maximize profits, markets clear, and the current account restriction is fulfilled. Agents who cannot optimize at a specific point in time use either a simple rule for consumption (equation 5) for a fraction* λ_c *of restricted households or Phillips curves to update wages and prices (or both) and then make work and production decisions, respectively.*

In this definition of equilibrium, agents take as given the technological constraint, external activity, domestic and external financial frictions (including the country risk premium), government expenditure, initial debt, initial capital, and all shocks.

F. Expenditure, exchange rate, and risk premium

As in Schmitt-Grohé, and Uribe (2003), we close the model by assuming that the country risk premium function, Φ_t, depends on the country's total external debt over real GDP—that is, b_{t+1}^*/GDP_t, where $b_t^* = S_t B_t^*/P_t$ and $B_t^* = B_t^{o^*} + B_t^{G^*}$, $B_t^{o^*} = \int_{\lambda_c}^1 B_t^{o^*}(i)di$ —as follows:

$$\Phi_t = \Phi \left(\underbrace{\frac{b_{t+1}^*}{GDP_t}}_{\substack{Schmitt-Grohe \\ Uribe\, effect}}, \underbrace{\frac{b_{t+1}^*}{Q_t^T K_{t+1}} \frac{E_t}{E_{t+1}}}_{\substack{Financial \\ Accelerator \\ effect}}, \underbrace{e^{u_t^L}}_{\substack{Liquidity \\ Shock}} \right) \tag{23}$$

The second term in the risk premium—that is, $\left(b^*_{t+1}/Q^T_t K_{t+1}\right)(E_t/E_{t+1})$—corresponds to the financial accelerator proposed by Gertler, Gilchrist and Natalucci (2007) for a small open economy, where Q^T_t is Tobin's Q ratio. This term connects the exchange rate with financial distress—measured by the value of external debt, including expectations of real exchange rate depreciation—relative to the value of capital—as a measure of the collateral for the economy. Both effects produce an upward-sloping supply of funds, indicating that the economy faces financial frictions in the external credit markets. We measure the Schmitt-Grohé-Uribe effect and the financial accelerator effect by ϕ_{RP01} and ϕ_{RP02}, respectively, in the log-linear model.

Additionally, an international liquidity shock—$u^L_t \sim N(0, \sigma^2_L)$—is introduced to measure capital flows, as explained in the introduction of this article. This shock shifts the supply of funds. In the log-linear version of the model, the contemporary real exchange rate depends on a lag in order to include a gradual portfolio adjustment in the UIP equation, which is measured by the parameter Ω_E.

Once the model and equilibrium are defined, we can examine in detail the connection between domestic and imported expenditure, the exchange rate, and the effects on the real exchange rate explained in equation (23). To do this, we focus on the marginal relationship between domestic and external debt. If we omit the model uncertainty for a moment, without significantly sacrificing detail in the analysis, and express all these variables in real terms, this marginal condition can be written as:

$$1 = \frac{E_{t+1}}{E_t}\frac{\widetilde{R}^*_t}{\widetilde{R}_t}. \tag{24}$$

According to equations (21) and (23), an increase in expenditure causes a direct increase in foreign debt, assuming constant output. Thus, when government spending increases, there are two opposite effects on the real exchange rate. On the one hand, the greater demand for inputs raises marginal costs and inflation and consequently increases the real interest rate $\widetilde{R}_t$ (equation 19), which tends to appreciate the local currency. On the other, the risk premium and the financial accelerator increase (equations 21 and 23). These last elements increase $\widetilde{R}^*_t$—that is, the real interest rate adjusted by the risk premium—and with this the real exchange rate also rises or, equivalently, the local currency tends to depreciate.

We can say that the Mundell-Fleming prediction of an appreciation of the real exchange rate when spending rises is not clear in our model. Empirically determining the final sign of this effect on the real exchange rate is one of the main focuses of this study, which we analyze in detail in the following section.

III. Results

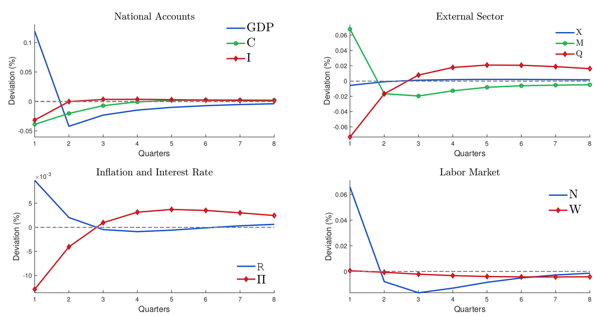
The model estimates were made with six open economies with different characteristics: namely, Australia, Canada, Chile, Colombia, Mexico, and New Zealand. The sample in each case depends on the availability of data, as explained in Appendix A.1. The estimates were made with Bayesian econometrics, defining priors for each of the parameters that determine the model dynamics based on a first-order approximation of the model with 10^6 simulations to achieve appropriate convergence in all cases. The rest of the parameters—associated with the non-stochastic steady state—were calibrated (see Appendix A.2 for details).

All the estimated parameters and the visual criteria for checking the convergence of the estimated model for each country are reported in Appendix A.3 and Appendix A.4, respectively. With regard to the latter, most of the parameter values are within the ranges found in the literature, so in this section we emphasize only the parameters that are most relevant for analyzing our hypothesis[4]. As discussed in the introduction, the effects of fiscal and monetary policy on the economy under a flexible exchange rate scheme depend on many factors. To them sort out, we first analyze the effects of fiscal and monetary policy, arranging them by type of country: small, larger, emerging, and developed open economies (see Appendix A.1 for the criteria used to classify the different countries). The results—calculated as average impulse responses—are presented in figure 1 for a fiscal policy shock of 1% of fiscal spending and figure 2 for a monetary policy shock of a 100-basis-point decrease in the interest rate.

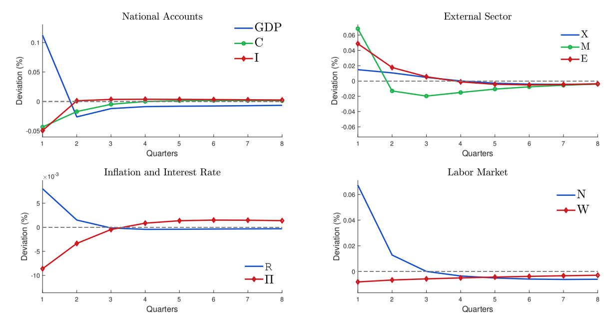
The different impulse responses shown in figure 1 have the expected shape, with one important exception discussed in the following paragraph. First, we focus on the standard effect found: a 1% shock in fiscal spending produces an increase in GDP by a similar percentage, which confirms a low multiplier. This effect is explained by a sequence of events that weaken the fiscal multiplier. The sequence begins with an increase in the interest rate in an attempt to reduce inflation. For this to be effective, the increase in the interest rate must be able to reduce consumption and investment, and the labor market must be depressed so that real wages - and rental price of capital as well - and thus marginal costs fall throughout the quarters, which finally causes inflation to decline. So far—including the initial positive effects on employment—the results are as expected for a closed economy with a significant crowding-out effect as a result of the Taylor rule.

[4]We also estimated a Markov-switching dynamic stochastic general equilibrium (MSDSGE) model to try to associate different states with the parameters of equation (23). However, there were no substantial differences for any given parameter in the two different states previously defined as crisis and not crisis.

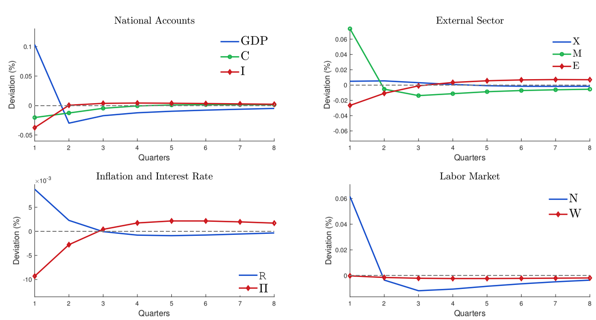
FIGURE 1. FISCAL POLICY IN OPEN ECONOMIES: A POSITIVE FISCAL EXPENDITURE SHOCK OF 1%



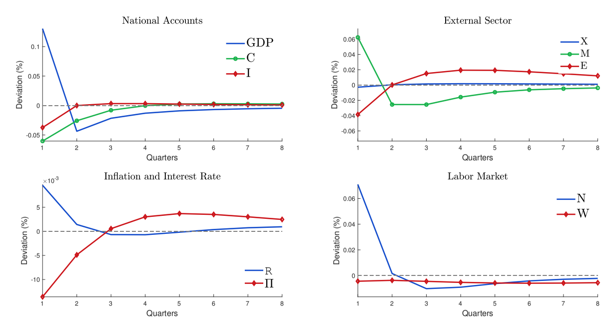
(a) SMALL OPEN ECONOMIES



(b) LARGE OPEN ECONOMIES



(c) EMERGING ECONOMIES



(d) DEVELOPED ECONOMIES

Source: Authors' calculations, based on the model presented in section II.

Note: GDP: gross domestic output; C: consumption; I: investment; X: exports; M: imports; E: real exchange rate; N: employment; W: wage; Π: inflation rate; and R: nominal interest rate. Impulse responses are the average of the impulse responses of the countries in each sample. See Appendix A.1 for country group definitions.

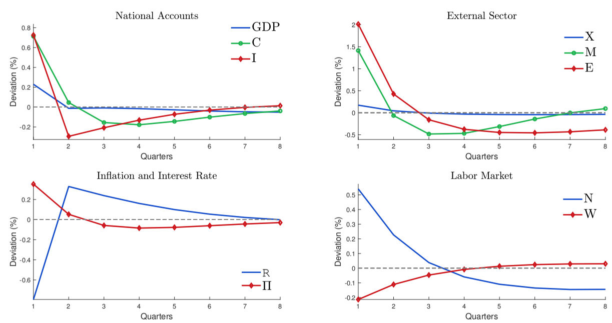
However, the action in the external sector is different from the standard view. One of the crucial predictions of the Mundell-Fleming model is that an increase in spending will appreciate the local currency, reduce exports, and increase imports. This is not what occurs in figure 1. For larger open economies, in particular, the domestic currency depreciates—that is, the exchange rate rises—rather than appreciates. Imports, rather than falling, rise—driven by rising GDP—and exports increase less than imports, but ultimately rise. In the other three cases in figure 1, the local currency appreciates, but only on impact—more strongly in small open economies and less for emerging economies. Imports rise unambiguously in all cases, while exports show only marginal changes and in both directions, although in the case of large open economies—where prices are not fixed in dollars—the reaction of exports is greater. Nevertheless, in all these cases the appreciation of the local currency is only initial, after which the currencies rapidly depreciate for many periods, affecting imports, which also fall rapidly as the quarters pass.

The fiscal policy results are repeated to some extent with the monetary policy shock (see figure 2). The results are expected for all sectors, but it again is not definitive in the external sector as the Mundell Fleming model would predict. Although an expansionary monetary policy depreciates the local currency on impact, exports only increase marginally, and imports rise—again driven by GDP growth. Only as the exchange rate falls do imports decrease, and exports gradually return to the steady state.

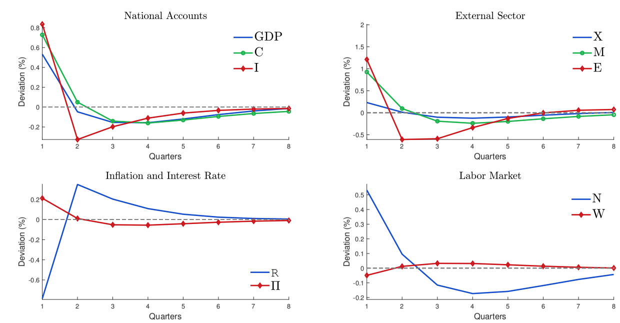
While the persistence of the exchange rate effect is explained by the delayed portfolio adjustment (as confirmed by posterior estimates of Ω_E between 0.17 and 0.40; see Appendix A.4, Table A.4.1), the change in sign of the exchange rate trajectory is related to the Schmitt-Grohé-Uribe and financial accelerator effects. In the case of fiscal policy, excess government spending translates into an increase in foreign debt, causing the local currency tends to depreciate over time. In the case of monetary policy, however, the drop in the interest rate is reversed by the increase in inflation. This causes private spending to fall in subsequent quarters, causing the external debt of the economy to contract and, ultimately, the local currency to appreciate.

Our next step is to analyze whether the Schmitt-Grohé-Uribe effect or the financial accelerator effect is dominant in determining the path of the real exchange rate or whether they are equally relevant. Figure 3 shows simulations of a 1% public spending shock in which the two effects are isolated and then also combined, for the same four sets of countries used above. In all cases, the Schmitt-Grohé-Uribe effect outweighs the financial accelerator effect, to a greater or lesser extent. The real exchange rate tends to rise definitively under the former, while the depreciation is only marginal under the latter.

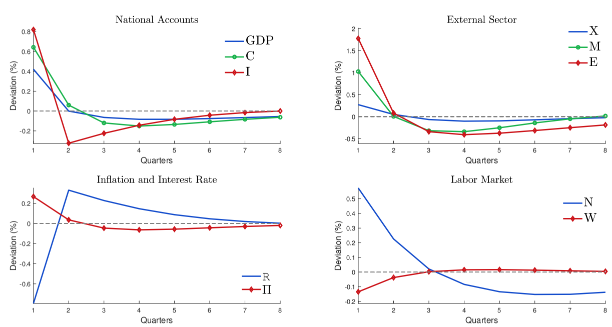
Figure 2. Monetary Policy in Open Economies: Unexpected Fall in the Interest Rate of 100 Basis Points



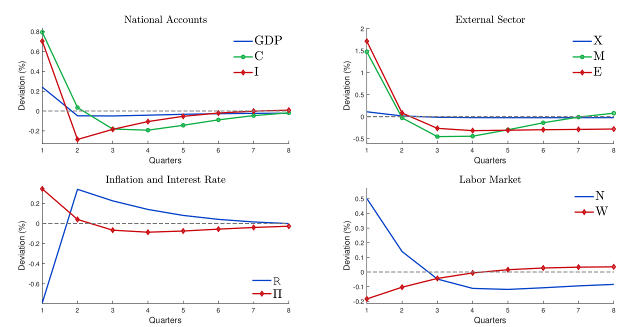
(a) Small Open Economies



(b) Large Open Economies



(c) Emerging Economies



(d) Developed Economies

Source: Authors' calculations, based on the model presented in section II.

Note: GDP: gross domestic output; C: consumption; I: investment; X: exports; M: imports; E: real exchange rate; N: employment; W: wage; Π: inflation rate; and R: nominal interest rate. Impulse responses are the average of the impulse responses of the countries in each sample. See Appendix A.1 for country group definitions.

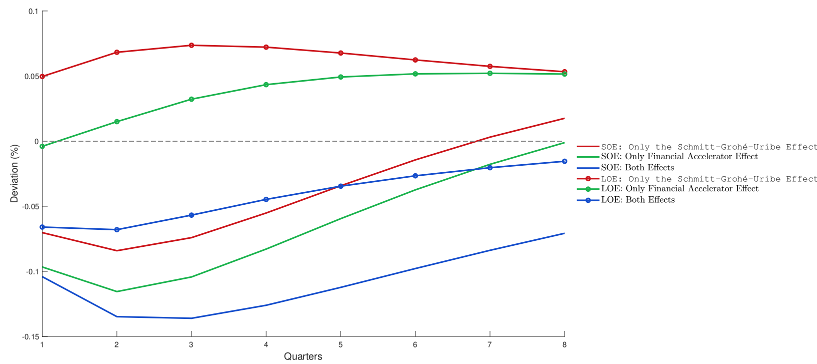
Although the estimated parameters are similar, with both ϕ_{RP01} and ϕ_{RP02} between 0.3 and 0.6 (see Appendix A.4, Table A.4.1), the variables associated with these parameters are of a different nature. Indeed, if we divide the numerator and the denominator of the financial accelerator by GDP, then we can express both the debt and the capital stock value in terms of GDP. By doing so, we can observe that a change in debt is smaller in the case of the financial accelerator effect than in the Schmitt-Grohé-Uribe effect, because in the first case we are subtracting, in the linearized log version, the value of the capital stock. Therefore, the increase in the debt-to-GDP ratio is stronger in the Schmitt-Grohé-Uribe effect despite the fact that both effects have similar values in their respective parameters.

The recent literature explains the possible disconnection of the exchange rate from domestic variables as deriving from external financial shocks. We explore the decomposition of historical variance by aggregating all model shocks into two classifications: domestic and external (figure 4). We then measure the impacts of external shocks on four key variables: GDP, the real exchange rate, exports, and imports (figure 5).

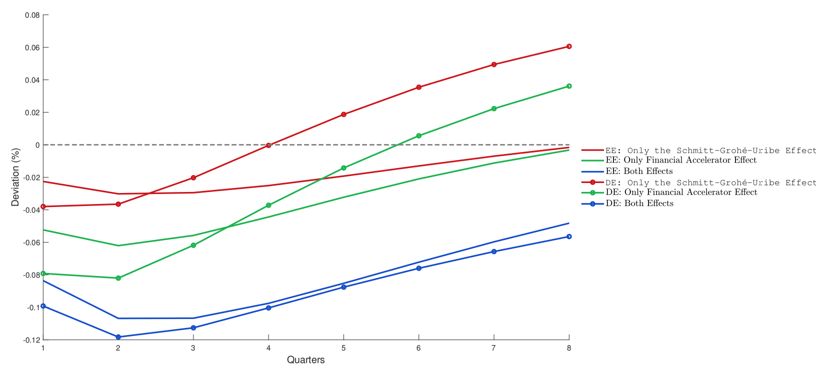
Figure 4 indicates that GDP is basically explained by domestic shocks, while the real exchange rate is explained by external shocks. The effects of external shocks seem to be so decisive in explaining the real exchange rate that a first reading of the results in light of figure 4 overshadows the results of the previous figures. To continue to unravel the results of the model estimates, figure 5 shows the effect of the external shocks on key variables. A first interpretation of the evidence suggests that external liquidity shocks and federal funds rate shocks essentially explain most of the movements in the real exchange rate. This result supports the assertion that, in principle, the real exchange rate could be more connected to external variables and less to domestic variables.

Nevertheless, a second interpretation is possible: the real exchange rate fully absorbs external shocks, so that, in the end, only domestic shocks affect GDP. Both interpretations call into question the performance of macroeconomic policy in stabilizing the economy. Under the first interpretation, the role of monetary and fiscal policy is completely overshadowed by external capital markets and U.S. monetary policy, which is the global financial cycle hypothesis. The second interpretation similarly minimizes the role of policy because it is enough for the exchange rate to be adjusted in the right direction, with no need for central bank and/or government intervention.

FIGURE 3. EFFECT OF A 1% POSITIVE SHOCK ON PUBLIC SPENDING ON THE REAL EXCHANGE RATE



(a) SMALL OPEN ECONOMY (SOE) VS LARGE OPEN ECONOMY (LOE)



(b) EMERGING ECONOMIES (EE) VS DEVELOPED ECONOMIES(DE)

Source: Authors' calculations, based on the model presented in section II.

Note: See Appendix A.1 for country group definitions. Impulse responses are the average of the impulse responses of each country.

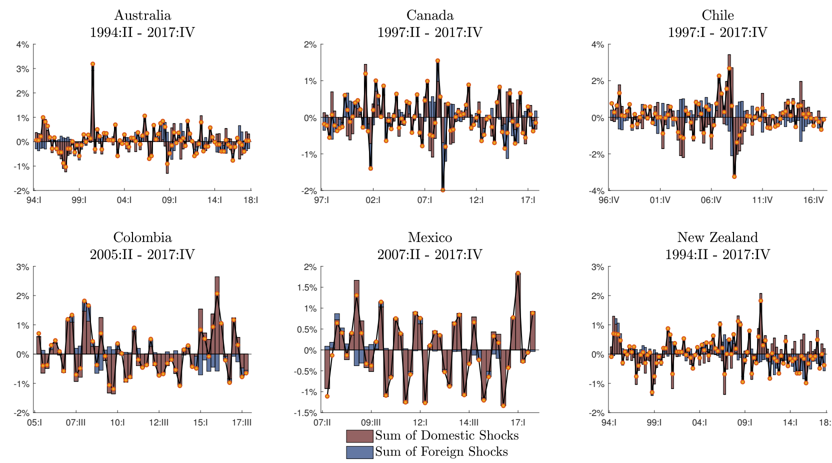
In addition, a disaggregated analysis of the effects of the shocks on the economy faces important challenges, even if some results are consistent with previous studies. For instance, the unimportance of terms-of-trade shocks in figure 4 is consistent with the results obtained by Schmitt-Grohé and Uribe (2018). Undoubtedly, a first reading of our results would also indicate the importance of financial shocks over real shocks in determining the dynamics of the real exchange rate, as many studies find. However, our results are not always consistent with the literature. For example, our estimates also indicate the low importance of foreign GDP shocks, a result that contradicts Fernández, Schmitt-Grohé and Uribe (2017).

The challenge of analyzing external disturbances is to recognize that they are generally not isolated phenomena and, in some particular circumstances, last several periods longer than normal fluctuations. Indeed, the crises facing open economies are complex events in which several external variables simultaneously record sharp movements. For open economies, changes in the dominant economies—namely, the United States, Europe, and China—translate into simultaneous changes in both real variables (terms of trade and growth) and financial variables (risk premium, capital flow, and interest rates), as has been recognized by several authors. For instance, Fernández, Schmitt-Grohé and Uribe (2020) find that world shocks that affect commodity prices and the world interest rate explain more than half of the variance of output growth, on average, across countries between 1960 and 2018.

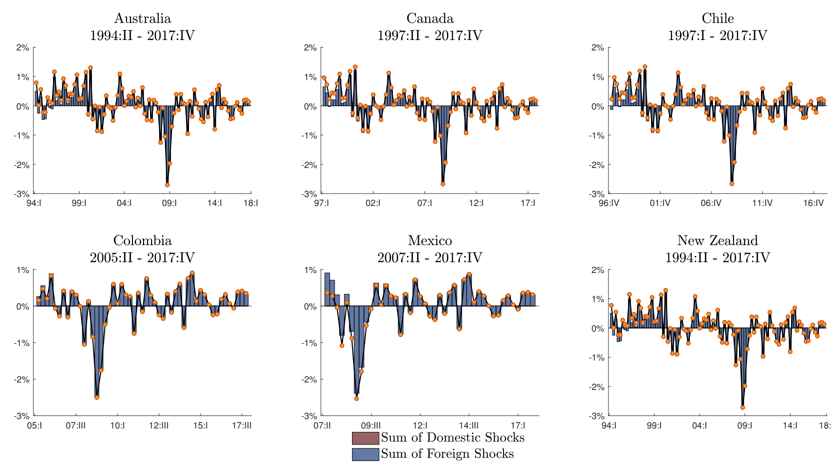
Most likely, common factors are triggered that end up changing the balances in various markets. For example, the financial decisions of foreign investors that trigger capital flows, identified in our model by financial shock, may be the result of a combination of changes affecting, among other variables, external growth, commodity prices, and the federal funding rate. It is difficult to think of these elements working separately, especially when financial integration falls sharply. In fact, in normal times it is possible that the synchronization of the business cycle across countries is weakened by access to credit, as observed by Kalemli-Ozcan, Papaioannou and Peydró (2013). It is also possible that in normal times, the connections among all the variables mentioned above are more evident in emerging economies than in developed countries, because of the former's more limited access to international financial markets. However, in generalized crises such as the Great Recession of 2008 and the COVID-19 pandemic, in which the financial markets would have been paralyzed without the intervention of the government and the central bank, the international synchronization reappears and intensifies for any open economy.

To address this last point and incorporate the results of our estimates, which seem to be consistent with sometimes contradictory interpretations of the perfor-

Figure 4. Historical Variance Decomposition by Country



(a) Gross Domestic Product



(b) Real Exchange Rate

Source: Authors' calculations, based on the model presented in section II.

Note: See Appendix A.1 for the definition of all domestic and external shocks. The different sample periods reflect data availability.

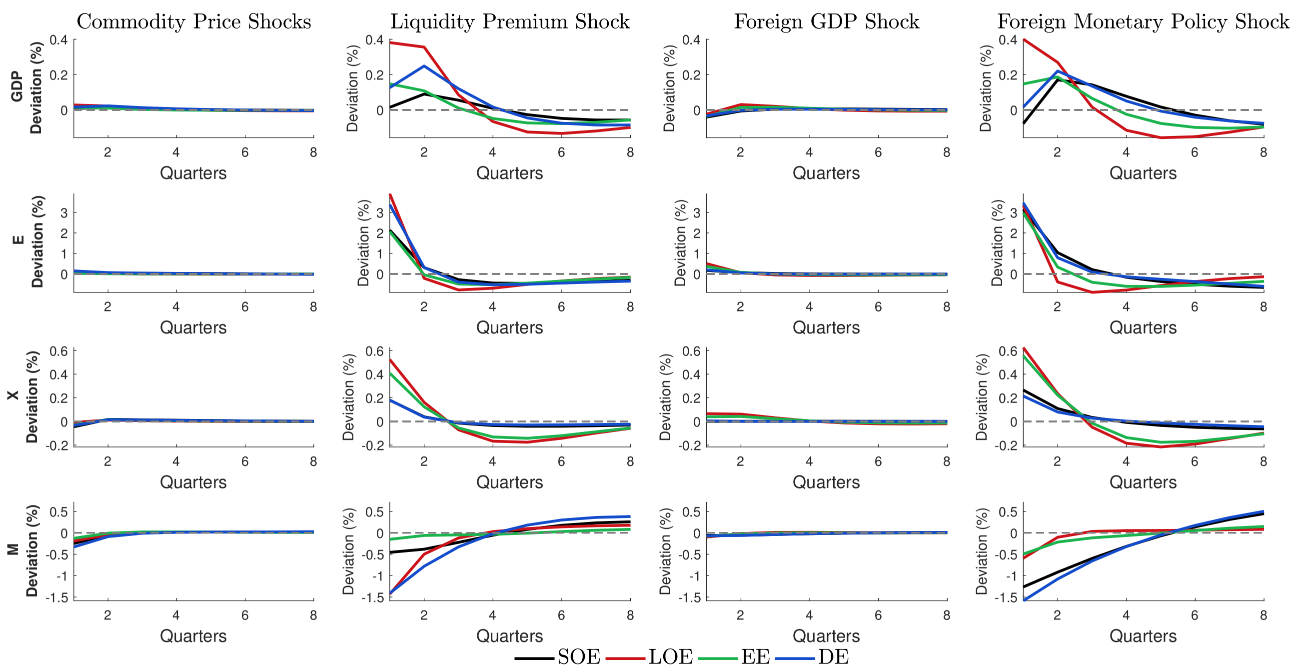
mance of fiscal and monetary policies, we defined a composite shock that combines the difficulties faced by open economies in a crisis triggered by external factors and that lasts four quarters, contrary to standard simulations that focus on shocks that last one quarter and then quickly disappear. In other words, we are interested in fluctuations that are an intermediate between high frequency cyclical fluctuations and super cycles. These are negative shocks whose effects can extend over a number of years, which is why they are defined as severe and the government intervenes, but not decades as the effects of super commodity cycles. Examples of shocks with these characteristics include the international financial crisis of 2008 and the COVID-19 crisis (see table 1).

Rather than looking for correlations between variables or developing a complete model for the world in these circumstances, we take the effective values the COVID-19 crisis as an example, considering only the external effects and leaving aside the domestic effects. The simulations do not seek to replicate this crises in particular, but to isolate the external elements that directly affect the exchange rate. We then performed different simulations that allow us to consider all the elements at stake and to determine their relative importance. That is, in the model we replaced the structural shocks that were used for the estimates with simultaneous shocks and with longer shocks for all countries considered in this study.

For a properly defined compound shock, we consider three groups of scenarios: (i) a benchmark scenario in which the real exchange rate is adjusted naturally and the Taylor rule is working; (ii) alternative scenarios with either a monetary policy shock (100 basis points) or a government spending shock (1%), in which the Taylor rule stops working; and (iii) and alternative scenarios in which the exchange rate cannot rise. The constant exchange rate represents a case in which the economy that issues the dominant currency performs worse, for some reason, than open economies, so the local currency cannot depreciate.

Figures 6–9 shows the results of the simulations. First, in the benchmark case, the crisis is faced with a fall in the interest rate, since the Taylor rule is operating (black lines in all figures), which depreciates the local currency in real terms. The crucial connection of this with the rest of the economy is that inflation increases (figures 6, 8, and 9) or, as we analyze later (see figure 7), decreases less than in the case of no real depreciation of the local currency (yellow lines in all figures). This tends to put downward pressure on key relative prices in the economy: namely, real wages, the real interest rate, and the rental price of capital. As a result, expenditure falls less, and the economy quickly returns to full employment.

Figure 5. Effects of External Shocks on the Economy: 1% Increase



Source: Authors' calculations, based on the model presented in section II.

Note: SOE: small open economy; LOE: large open economy; EE: emerging economy; and DE: developed open economy. *GDP*: gross domestic output; X: exports; M: imports; and E: real exchange rate. See Appendix A.1 for definitions. Impulse responses are the average of the impulse responses of each country.

Table 1—Compound Shocks for Severe Crisis in Open Economies

	Australia		Canada		Chile	
	COVID-19	IFC 2008	COVID-19	IFC 2008	COVID-19	IFC 2008
UIP shocks	6.2	9.05	2.23	5.36	4.38	9.34
Quarterly foreign GDP growth	–0.7	0.11	–0.94	–0.19	–0.58	0.27
Federal funds rate	–0.3	–0.46	–0.32	–0.46	–0.32	–0.46
Commodity price	–9.9	–12.71	–33.05	–42.85	–2.87	–32.98
	Colombia		Mexico		New Zealand	
	COVID-19	IFC 2008	COVID-19	IFC 2008	COVID-19	IFC 2008
UIP shocks	3.31	4.23	2.95	3.27	5.37	11.16
Quarterly foreign GDP growth	–0.75	–0.02	–0.90	–0.15	–0.75	0.13
Federal funds rate	–0.32	–0.46	–0.32	–0.46	–0.32	–0.46
Commodity price	–33.05	–42.85	–33.05	–42.85	–4.07	–23.12

Source: Three-month or 90-day rates: FRED and Central Bank of Chile; CPI, real effective exchange rate, WTI oil price, copper price, iron ore price, and coal price: FRED; Trade weights: BIS; and ANZ Commodity price index: ANZ.
Note: For the COVID-19 crisis, the calculation compares the first two quarters of 2019 and 2020, in percentage terms. For the 2008 international financial crisis (IFC), it compares the first quarter of 2007 and 2009, because the crisis materialized in these countries mainly in 2009. UIP shocks are the errors of the uncovered interest rate parity. External GDP growth for each country is the weighted average of the GDP growth of China, Japan, Europe, and the United States. The commodity price corresponds to oil for Canada, Colombia, and Mexico; copper for Chile; coal and iron ore for Australia; and the ANZ Commodity Price Index for New Zealand.

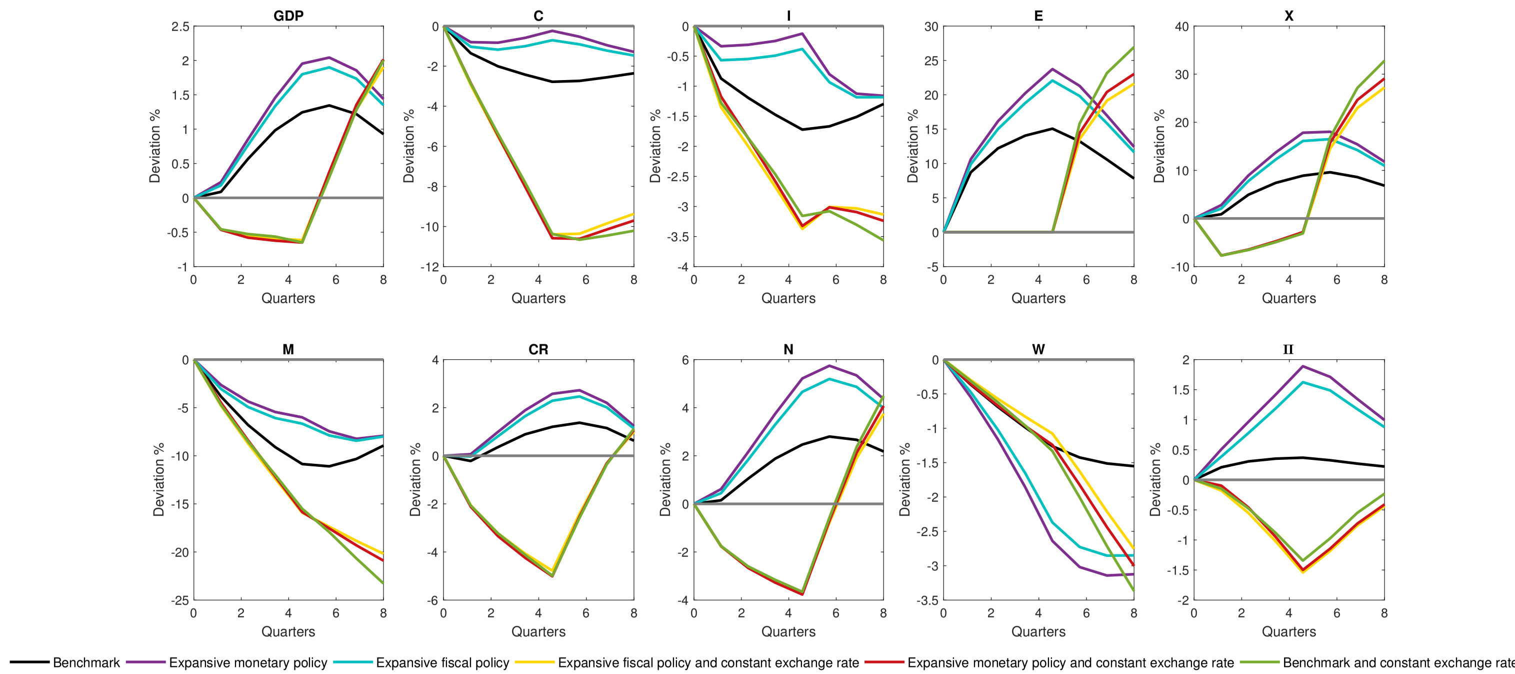
Second, if the currency depreciates, fiscal policy turns out to be as effective as monetary policy. When the Taylor rule stops working, fiscal policy is somewhat less effective than a discretionary monetary policy that reduces the interest rate—the differences between the purple and cyan lines in all the figures. Also, fiscal policy is more effective than the Taylor rule in the benchmark case. Indeed, in three out of four cases (figures 6, 8, and 9), expansionary fiscal policy succeeds in increasing inflation along with the depreciation of the local currency. The additional inflationary effect causes a further drop in key relative prices, leading to a lower reduction in spending than in the benchmark case. In the case of figure 7, although inflation falls, the reduction is less than in the benchmark case. The importance of this finding is that, for instance, when the monetary policy rate is at the zero lower bound—that is, when the monetary authorities do not have the option of further reducing the interest rate—fiscal policy is a valid tool. This policy operates through the Schmitt-Grohé-Uribe effect: more fiscal spending puts pressure on the risk premium, reinforcing the depreciation of the local currency and, therefore, generating more inflation.

Third, with regard to the nature of the adjustment in open economies, exports either fall or increase only marginally on impact, although their value rises due to the depreciation of the local currency in the case of small open economies (figure 6). Thus, part of the adjustment is achieved through a contraction of expenditures: namely, imports, consumption, and investment. At the same time, if discretionary fiscal or monetary policy is able to produce more inflation and, hence, a strong drop in real wages (see figures 6, 8, and 9), then employment does not decrease. Otherwise, employment tends to fall, as shown in figure 7. This happens in large open economies for two reasons: inflation falls, and nominal wages are less rigid than in other groups of countries (see table A.4.1).

Fourth, considering the nature of the shock, the shock-absorbing role of the real exchange rate is fundamental to push the economy out of an external crisis. Without that effect—regardless of the type of country or policy considered—the economy falls into a severe recession, as shown in all four figures (the yellow, green, and red lines). In other words, without the depreciation of the local currency, the economy either falls into deflation (figures 6, 8, and 9) or the deflation is more pronounced (figure 7). As we have pointed out, depreciation enhances people's expectations about inflation, in the event of a massive negative shock. In the absence of this effect, an expansionary macroeconomic policy may not work in the open economies under study. This negative scenario for macroeconomic stabilization could occur, for instance, if the dominant currency, the U.S. dollar, weakens in international markets. We also stress that this last scenario does not correspond to an appreciation caused by massive and exogenous capital inflows, which correspond to a positive external shock.

Finally, one of the assumptions of the model is that fiscal spending is not transferred to either consumption or private investment. In an economic crisis, however, the government transfers resources directly to the private sector, either to support the most vulnerable families or to directly subsidize investment and boost activity. However, the simulations did not indicate different impacts on the economy if some of the spending is transferred to private consumption or investment, as some authors find for a close economy (for example, Kaplan and Violante (2018)). In our model, this happens basically because the transfers do not substantially change agents' marginal spending decisions and, hence, the level of foreign debt, so there is no significant impact on the depreciation of the local currency. We leave to future research the task of adequately introducing heterogeneous agents in order to re-evaluate this last result.

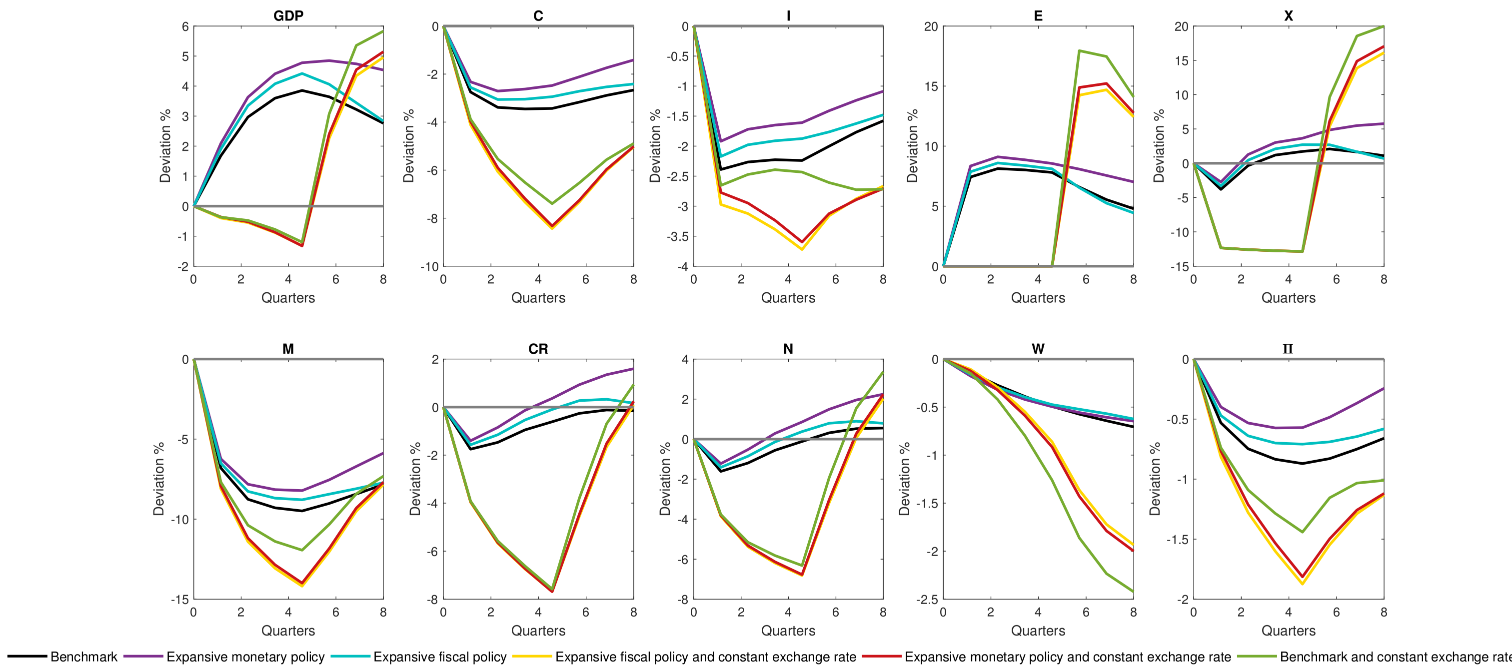
Figure 6. Effect of a Severe External Shock on Small Open Economies



Source: Authors' calculations, based on the model presented in section II.

Note: For country classifications, see Appendix A.1. Impulse responses are the average of the impulse responses of each country. C: consumption; I: private investment; E: real exchange rate; X: total exports; M: total imports; C^R: restricted consumption; N: employment; W: real wage; and Π: inflation rate.

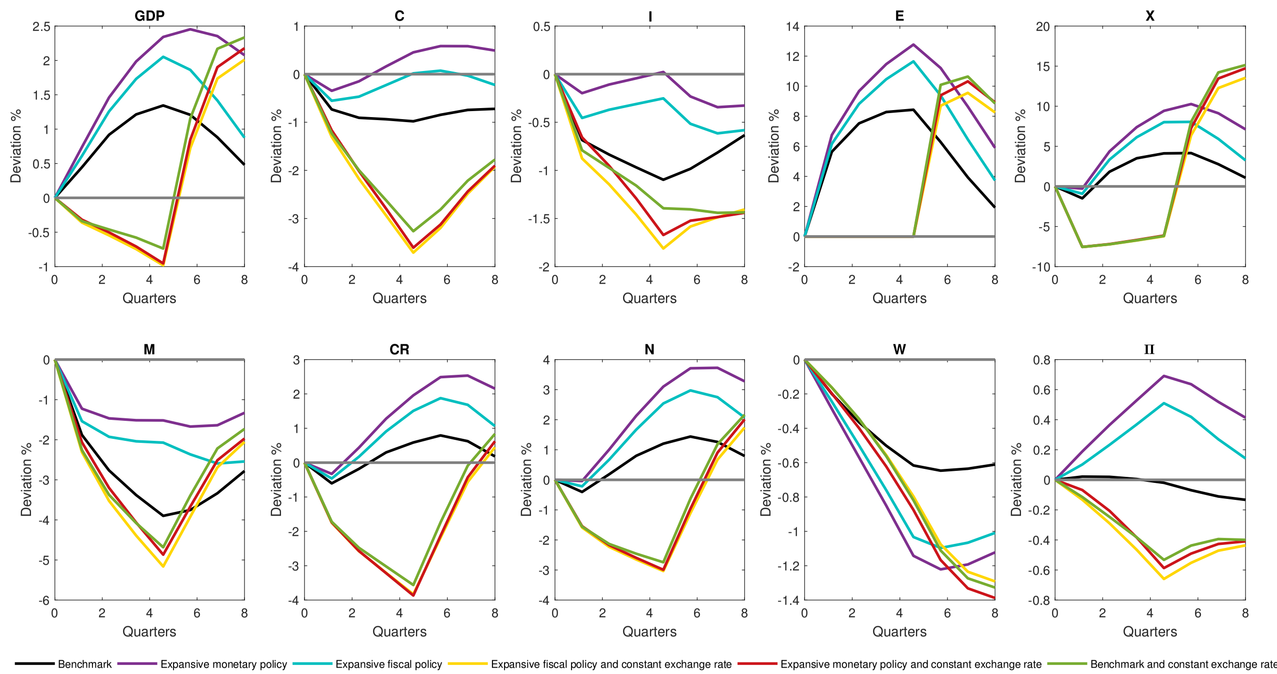
Figure 7. Effect of a Severe External Shock on Large Open Economies



Source: Authors' calculations, based on the model presented in section II.

Note: For country classifications, see Appendix A.1. Impulse responses are the average of the impulse responses of each country. C: consumption; I: private investment; E: real exchange rate; X: total exports; M: total imports; C^R: restricted consumption; N: employment; W: real wage; and Π: inflation rate.

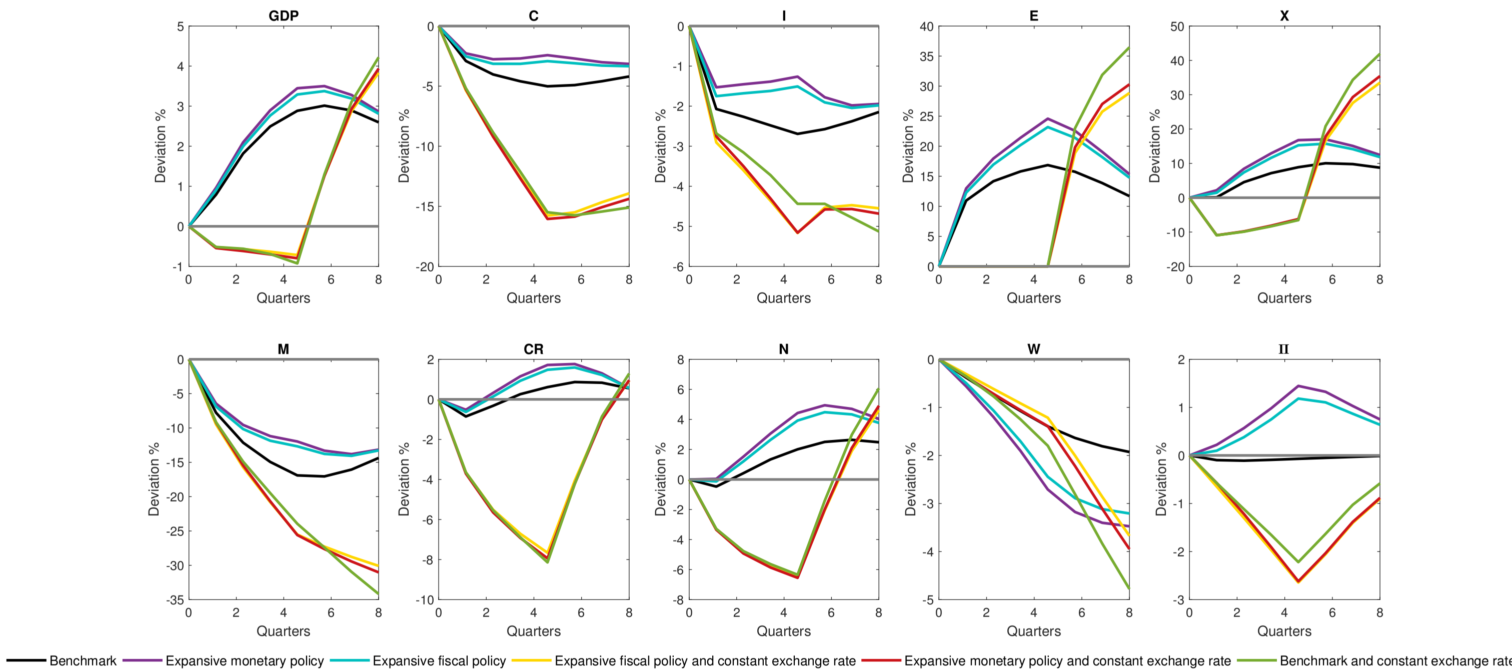
Figure 8. Effect of a Severe External Shock on Emerging Economies



Source: Authors' calculations, based on the model presented in section II.

Note: For country classifications, see Appendix A.1. Impulse responses are the average of the impulse responses of each country. C: consumption; I: private investment; E: real exchange rate; X: total exports; M: total imports; C^R: restricted consumption; N: employment; W: real wage; and Π: inflation rate.

Figure 9. Effect of a Severe External Shock on Developed Open Economies



Source: Authors' calculations, based on the model presented in section II.

Note: For country classifications, see Appendix A.1. Impulse responses are the average of the impulse responses of each country. C: consumption; I: private investment; E: real exchange rate; X: total exports; M: total imports; C^R: restricted consumption; N: employment; W: real wage; and Π: inflation rate.

IV. Conclusion

In this study, we answer the question of why it is useful to use fiscal policy in an economy with a flexible exchange rate in a context of financial shocks that tend to disconnect the trajectory of the real exchange rate from domestic variables. Our results indicate that although financial shocks are apparently dominant—relative to shocks in the terms of trade and global growth—in explaining the trajectory of the real exchange rate, these financial shocks do not overshadow either the real exchange rate's function of absorbing external shocks or the complementary role of fiscal and monetary policy in stabilizing the economy. In fact, we found that an increase in fiscal spending causes a real depreciation of the local currency, rather than an appreciation, in case of severe shocks. The crucial connection with the rest of the economy is that inflation increases or decreases less than in the case where there is no real depreciation of the local currency. This leads to appropriate adjustment, putting downward pressure on key prices and boosting spending to achieve full employment.

Behind this last result is the inclusion and estimation of the Schmitt-Grohé-Uribe effect in the model: policies that encourage spending will also produce more foreign debt and thus trigger the real depreciation of the local currency. We specifically showed that fiscal policy is an alternative to monetary policy because the local currency tends to depreciate in a similar way as when monetary policy is used, especially when the economy faces serious shocks. For instance, this result indicates that in the context of a zero lower bound, fiscal policy can replace monetary policy, producing the necessary adjustment needed by open economies.

To illustrate the previous result, we simulated a composite shock comprising several external factors that together better describe a moment of crisis than a single shock acting separately and quickly disappearing, as would occur in normal times with standard and recurrent cyclical fluctuations. In this article, we argue that this type of composite shock more realistically characterizes critical situations in which countries decide to implement expansionary fiscal policy, such as the financial crisis of 2008 or the COVID-19 crisis. This is because the compound nature of the shock highlights the likely interaction of several external financial and real factors, which are difficult (and unnatural) to separate in a crisis.

The implications of this last conclusion are limited by a country's level of foreign debt, especially in emerging economies. Excessive use of foreign debt to finance public spending increases the risk of default. That is why it is key to build a strong fiscal stance in noncrisis periods, so as to have the option of increasing external indebtedness in times of severe crisis. Otherwise, the remedy will be worse than the disease, and the interest rate will have to be raised to generate the necessary resources to pay the foreign debt, with the consequent negative impact on the economy.

This result is far from the Mundell-Fleming model, including the fact that the adjustment that takes place in an open economy in a crisis consists, in part, of a decrease in spending (imports, consumption, and investment), rather than a substantial increase in exports, although in small economies the value of exports grows. Thus, the real depreciation of the local currency works differently than in the Mundell-Fleming model: to boost the economy, one must produce inflation and speed up the adjustment of the economy.

However, all the positive effects of fiscal policy with a flexible exchange rate depend crucially on the possibility of a depreciation of the local currency. Otherwise, the economy falls into a deep recession, regardless of the policy implemented. This is because in the absence of a local currency depreciation, deflation delays the adjustment in relative prices. In other words, the effectiveness of an expansionary fiscal policy depends crucially on the depreciation of the currency. If for some reason the dominant currency falls in international markets, the impact of fiscal policy is reduced.

Appendix A.1. Data, Observed Variables, and Shocks

The model was estimated for the following countries: Australia, Canada, Colombia, Chile, Mexico, and New Zealand. The large open economy (LOE) model corresponds to Canada and Mexico, which are top trading partners of the United States, along with China. For the rest of the countries, we use the small open economy (SOE) model. The breakdown into emerging and developed countries follows the World Economic Outlook (WEO) classification (IMF, 2020): the group of emerging countries includes Chile, Colombia, and Mexico; developed countries, Australia, Canada, and New Zealand.

The length of the sample in each country—which depends on data availability—is as follows: Australia: 1994Q2–2017Q4; Canada: 1997Q2–2017Q4; Colombia: 2005Q2–2017Q4; Chile: 1997Q2–2017Q4; Mexico: 2007Q2–2017Q4; and New Zealand: 1994Q2–2017Q4. The data are from the Organization for Economic Cooperation and Development, the Bank for International Settlements, the Federal Reserve Economic Database (FRED), and the respective central banks of each country.

The following observed variables are considered in the estimation of the model: real gross domestic product (GDP), private consumption expenditure (C), general government consumption expenditure (G), gross fixed capital formation (I), exports of goods and services (X), imports of goods and services (M), CPI inflation rate (Π), nominal interest rate (R), real exchange rate (E), employment (N), wage rate (W), commodity prices (P^{CM}), U.S. CPI inflation rate (Π^*), effective federal funds rate (R^*), and U.S. real gross domestic product (GDP^*)[5].

There are 19 shocks and 15 observed variables. Since an excess of shocks can cause the shocks to be correlated (Pagan and Robinson (2020)), we reduced the number to 16 and calibrate three of them to achieve the estimates. The selection criterion was to leave the structural shocks that are traditionally used in this type of model (productivity, preferences, international liquidity premium, cost-push, fiscal policy, monetary policy, investment, domestic exports, commodity prices, foreign GDP, foreign inflation, and external interest rate) and measurement shocks in variables that the model has trouble explaining (employment and wages) or are fundamental for explaining the article's hypothesis (exports and imports). The calibrated shocks correspond to variables that are assumed to have high measurement certainty (GDP, consumption, and investment). Table A.1.1 indicates the calibration of the standard deviations of the group of this variables, which is based on the statistical information available by country.

[5]The programs and the database are available on request from the authors by e-mail.

The measurement equations were expressed as follows:

$$V\_OBS_{j,t} = \alpha_j + \widehat{v}_{j,t} - \widehat{v}_{j,t-1} + \epsilon_{j,t},\ \epsilon_{j,t} \sim N\left(0, \sigma_j^2\right) \tag{A1.1}$$

$$V\_OBS_{i,t} = \alpha_i + \widehat{v}_{i,t} - \widehat{v}_{i,t-1}, \tag{A1.2}$$

where $\hat{v}_t = ln(V) - ln(\overline{V})$ when the variables are measured in levels ($\overline{V}$ is the steady-state value; $\hat{v}_t$ is simply the rate if the variable is originally measured in this way).

The observed variables that were estimated with an equation of type (A1.1) are GDP, C, I, X, M, N, and W. Therefore, the set of parameters α_i are: $\{\alpha_{GDP}, \alpha_N, \alpha_W\}$.

where we restrict the model so that the variables GDP, C, I, X, and M have the same long-term growth rate, α_{GDP}, ie, balance growth path. The standard deviations are grouped in the following set: $\left\{\sigma^2_{GDP}, \sigma^2_C, \sigma^2_I, \sigma^2_X, \sigma^2_M, \sigma^2_N, \sigma^2_W\right\}$.

The observed variables that were estimated with an equation of type (A1.2) are G, Π, R, E, P^{CM}, Π^*, R^*, and GDP^*. Therefore, the set of parameters α_j are: $\{\alpha_G, \alpha_\Pi, \alpha_R, \alpha_E, \alpha_{PCM}, \alpha_{\Pi^*}, \alpha_{R^*}, \alpha_{GDP^*}\}$.

Table A.1.1—Calibrated Standard Deviations for GDP, Consumption, and Investment.

	Australia	Canada	Chile	Colombia	Mexico	Nueva Zelanda
σ_{GDP}	0.53	0.63	1.03	0.93	1.19	0.87
σ_C	0.53	0.44	0.11	0.65	1.30	0.81
σ_I	2.91	1.97	3.95	3.16	2.58	4.01

Note: GDP: gross domestic output; C: private consumption expenditure; and I: gross fixed capital formation.

Appendix A.2. Steady State and Calibrated Parameters

The steady state is the solution of the model without uncertainty and assuming flexible prices. Throughout the section, an overbar indicates steady-state values.

National account variables.

The methodology consists of obtaining information from the sample so that the stationary state depends on three structural parameters: β, δ, and α_1 (see Table A.2.2).

The solution to the steady state starts with calculating the conditions of optimality in the factor markets:

$$\alpha_1 \frac{Y_t}{K_t} = \frac{Z_t}{P_t},\ \phi_2 \alpha_3 \frac{Y_t}{M_t} = E_t. \tag{A2.1}$$

Unlike the short-term model, in steady state we assume constant returns to scale:

$$\frac{\overline{K}}{\overline{Y}} = \frac{\alpha_1 \beta}{1-\beta\left(1-\delta\right)},\ \alpha_3 = \frac{\overline{M}}{\overline{Y}}. \tag{A2.2}$$

Next, we deal with the aggregate restriction of the economy and GDP definition:

$$\overline{Y} = \overline{C} + \overline{I} + \overline{G} + \overline{X}^D + \overline{E}\frac{\overline{P}^{CM}}{\overline{P}^*}\overline{X}^{CM}; \tag{A2.3}$$

$$\overline{GDP} = \overline{Y} - \overline{EM}.$$

Assuming that $\overline{E} = \overline{P}^{CM} = \overline{P}^* = 1$,

$$1 = \frac{\overline{C}}{\overline{Y}} + \frac{\overline{I}}{\overline{Y}} + \frac{\overline{G}}{\overline{Y}} + \frac{\overline{X}^D}{\overline{Y}} + \frac{\overline{X}^{CM}}{\overline{Y}}, \tag{A2.4}$$

$$1 = \frac{\overline{Y}}{\overline{GDP}} - \frac{\overline{M}}{\overline{GDP}}.$$

we can obtain the ratio $\frac{\overline{Y}}{\overline{GDP}}$ by assuming, a given value for imports over GDP:

$$\frac{\overline{Y}}{\overline{GDP}} = 1 + \frac{\overline{M}}{\overline{GDP}} \Rightarrow \frac{\overline{GDP}}{\overline{Y}} = \frac{1}{1 + \frac{\overline{M}}{\overline{GDP}}}. \tag{A2.5}$$

Combining equations (A1.1) and (A1.2), we get the investment-GDP ratio in function of the parameters: β, δ, and α_1 (see Table A.2.2).

$$\frac{\overline{I}}{\overline{Y}} = \delta\frac{\overline{K}}{\overline{Y}} = \frac{\delta\alpha_1\beta}{1-\beta\left(1-\delta\right)}, \tag{A2.6}$$

The above condition is achieved if the parameter ξ has a specific value that ensures that δ_t is equal to δ. Indeed, from the first-order condition of capital utilization, we have:

$$\overline{\mu} = \left(\frac{\overline{Z}}{\delta\xi\overline{Q}^T}\right)^{\frac{1}{\eta_{MU}}}. \tag{A2.7}$$

Considering that $\overline{Q}^T = 1$ and $\overline{Z} = \frac{1-\beta(1-\delta)}{\beta}$, then

$$\overline{\mu} = 1 \Leftrightarrow \xi = \frac{1-\beta\left(1-\delta\right)}{\delta\beta}. \tag{A2.8}$$

Next,

$$\frac{\overline{I}}{\overline{GDP}} = \frac{\overline{I}}{\overline{Y}}\frac{\overline{Y}}{\overline{GDP}}. \tag{A2.9}$$

On the other side,

$$\frac{\overline{G}}{\overline{Y}} = \frac{\overline{G}}{\overline{GDP}}\frac{\overline{GDP}}{\overline{Y}}, \quad \frac{\overline{X}^{CM}}{\overline{Y}} = \frac{\overline{X}^{CM}}{\overline{GDP}}\frac{\overline{GDP}}{\overline{Y}}. \tag{A2.10}$$

We can then define exports as follows:

$$\overline{X} = \overline{X}^D + \overline{X}^{CM} \Rightarrow \frac{\overline{X}}{\overline{Y}} = \frac{\overline{X}^D}{\overline{Y}} + \frac{\overline{X}^{CM}}{\overline{Y}} \Rightarrow \frac{\overline{X}^D}{\overline{Y}} = \frac{\overline{X}}{\overline{Y}} - \frac{\overline{X}^{CM}}{\overline{Y}}, \tag{A2.11}$$

where:

$$\frac{\overline{X}}{\overline{Y}} = \frac{\overline{X}}{\overline{GDP}} \frac{\overline{GDP}}{\overline{Y}}. \tag{A2.12}$$

Then we can calculate the Consumption-output ratio in function of the parameters: β, δ, and α_1 (see table A.2.2):

$$\overline{C} + \overline{I} + \overline{G} = \overline{GDP} - (1 - \beta)\, \overline{B}^*, \tag{A2.13}$$

$$\frac{\overline{C}}{\overline{Y}} + \frac{\overline{I}}{\overline{Y}} + \frac{\overline{G}}{\overline{Y}} = \frac{\overline{GDP}}{\overline{Y}} - (1 - \beta)\, \frac{\overline{B}^*}{\overline{Y}}. \tag{A2.14}$$

Then,

$$\frac{\overline{C}}{\overline{Y}} = \frac{\overline{GDP}}{\overline{Y}} - \frac{\overline{I}}{\overline{Y}} - \frac{\overline{G}}{\overline{Y}} - (1 - \beta)\, \frac{\overline{B}^*}{\overline{Y}}, \tag{A2.15}$$

and

$$\frac{\overline{C}}{\overline{GDP}} = \frac{\overline{C}}{\overline{Y}} \frac{\overline{Y}}{\overline{GDP}}, \; \frac{\overline{B}^*}{\overline{Y}} = \frac{\overline{B}^*}{\overline{GDP}} \frac{\overline{GDP}}{\overline{Y}}. \tag{A2.16}$$

On the one hand, investment- GDP and consumption-GDP ratios can be calculated using the information from the country sample presented in table A.2.1.

On the other hand, the parameters β, δ, and α_1 can be set as follows. We assume that the total capital of the economy, PK, is composed of domestic and imported capital. Then the following expression holds:

$$PK = \alpha_1 + \alpha_3 \Rightarrow \alpha_1 = PK - \alpha_3, \tag{A2.17}$$

and

$$\alpha_3 = \frac{\overline{M}}{\overline{Y}} = \frac{\overline{M}}{\overline{GDP}} \frac{\overline{GDP}}{\overline{Y}}. \tag{A2.18}$$

Table A.2.1—GDP Ratios in Steady State obtained from country samples

	Australia	Canada	Chile	Colombia	Mexico	Nueva Zelanda
$\frac{\overline{B}^*}{\overline{GDP}}$	0.99	1.19	0.42	0.44	0.36	0.98
$\frac{\overline{X}^{CM}}{\overline{GDP}}$	0.18	0.23	0.15	0.09	0.01	0.10
$\frac{\overline{M}}{\overline{GDP}}$	0.20	0.33	0.30	0.19	0.29	0.28
$\frac{\overline{G}}{\overline{GDP}}$	0.17	0.20	0.11	0.17	0.11	0.18
$\frac{\overline{X}}{\overline{GDP}}$	0.19	0.35	0.34	0.16	0.28	0.29

Source: Authors' calculations.

Note: B^*: external debt; GDP: gross domestic output; X^{CM}: commodity exports; G: general government consumption expenditure; M: imports of goods and services; and X: exports of goods and services.

We use various values for the parameters $PK \in [0.4, 0.65]$, with intervals of 0.05, and $\delta \in [0.01, 0.03]$ (the depreciation rate), with intervals of 0.005, to get the steady-state ratios for investment and consumption. A summary of the parameters needed for this calculation is presented in table A.2.2. The accuracy in terms of errors between actual and estimated ratios is presented in table A.2.3, which indicates that the parameters in table A.2.2 are reasonable for making our estimates.

Indexation in the Phillips curve.

In relation to the calibration of the Phillips curve of the prices of products exported from small open economies, there is a wide dispersion of estimated values for price indexing in studies between and within countries. In the cases of

Table A.2.2—Calibrated Parameters to Calculate Investment-GDP and Consumption-GDP Ratios in Steady State

	Australia	Canada	Chile	Colombia	Mexico	Nueva Zelanda
$\mathcal{PK}$	0.60	0.50	0.50	0.40	0.55	0.45
α_1	0.42	0.29	0.26	0.23	0.32	0.22
α_2	0.40	0.45	0.50	0.60	0.45	0.55
α_3	0.17	0.25	0.23	0.16	0.22	0.22
δ	0.01	0.01	0.02	0.02	0.01	0.03

Source: Authors' calculations.

Note: PK: domestic and imported capital; α_1: capital share; α_2: labor share; α_3: import share; and δ: depreciation rate. In all countries, we assume a value for parameter β of 0.99.

Table A.2.3—Calibrated Investment-GDP and Consumption-GDP Ratios in Steady State

		Australia	Canada	Chile	Colombia	Mexico	Nueva Zelanda
$\frac{\overline{C}}{\overline{GDP}}$	Model	0.55	0.54	0.63	0.63	0.67	0.59
	Data	0.56	0.55	0.61	0.64	0.67	0.58
	Error	0.012	0.011	0.018	0.013	0.001	0.010
$\frac{\overline{I}}{\overline{GDP}}$	Model	0.25	0.23	0.24	0.18	0.20	0.21
	Data	0.26	0.22	0.23	0.20	0.20	0.22
	Error	0.007	0.018	0.016	0.021	0.001	0.002

Source: Authors' calculations.

Note: GDP: gross domestic output; C: private consumption expenditure; and I: gross fixed capital formation.

Europe and the United States, Smets and Wouters (2003,2007) estimate a δ_X of 0.65 for Europe and 0.2 for the United States; Galí, Gertler, and Lopez-Salido (2001) obtain estimates of 0.6 for both European and U.S. data; and Christiano, Eichenbaum, and Evans (2005) find that full dynamic indexation delivers the best-fitting value for U.S. data.

In the case of Japan, Fujiwara, Hirose and Shintani (2011) find a value of 0.3 for the parameter δ_X, but Iiboshi et al (2015) obtain much higher estimated values of 0.5–0.8. For China, Dai, Minford, and Zhou (2015) find values of 0.17–0.6 depending on the econometric technique used, while Li and Liu (2017) find values around 0.6.

The labor markup.

Finally, for the calculation of the parameter ϵ_w, there is no direct information, as in the case of ϵ_D with De Loecker and Eeckhout (2018), so we need to use an approximation. This was based on two facts. First, in the steady state, wage flexibility allows demand to be equalized with labor supply:

$$\left(\frac{\epsilon_w}{\epsilon_w - 1}\right) \overline{N}^{\varphi-1}\overline{C}^{\sigma} = (1-t)\,\alpha_2 \frac{\overline{Y}}{\overline{N}}, \tag{A2.19}$$

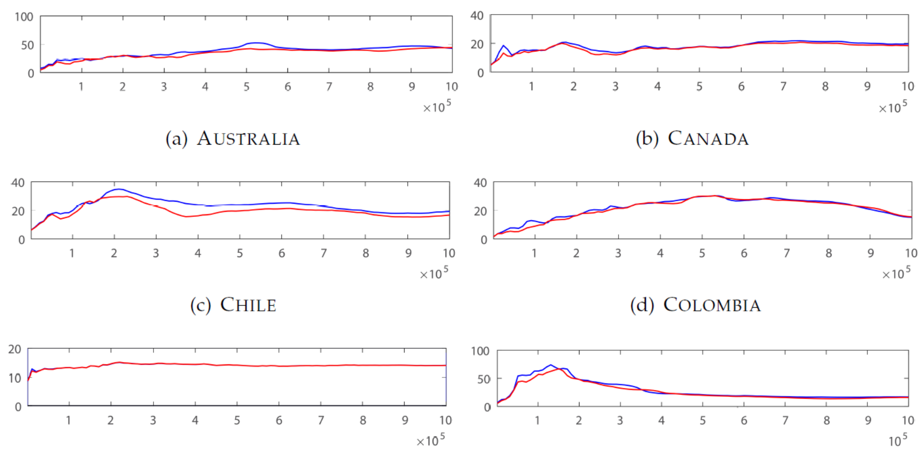
where t is the tax wedge and $\left(\frac{\epsilon_w}{\epsilon_w-1}\right)$ is the markup that families get, after firms deduct their markup, since we assume that firms also have market power. Second, in the literature, the estimated values of parameters σ and φ are remarkably close to 2, which is also our priority for both cases. Therefore, assuming that both parameters will be close to two is a reasonable approximation, as we found in our estimates (see Appendix A.4, Table A.4.1). The above equation can then be ordered as follows, assuming that the level of technology has been set arbitrarily such that $\overline{Y} = 1.0$ in steady state:

$$\left(\frac{\epsilon_w}{\epsilon_w - 1}\right) = (1-t)\,\alpha_2 \frac{1}{\overline{N}^2\overline{C}^2}. \tag{A2.20}$$

We obtain the value of ϵ_w using the steady state value for $\overline{C}$ from above and the tax information t for 2018 from the OECD.Stat database and imposing the effective values of total hours worked over the total time for work in year $\overline{N}$ for 2018, also from the OECD.Stat database.

Appendix A.3. Stability of the Estimates

FIGURE A.3. BROOKS-GELMAN CRITERIA FOR CHECKING STABILITY OF ESTIMATES



(a) AUSTRALIA (b) CANADA (c) CHILE (d) COLOMBIA (e) MEXICO (f) NEW ZEALAND

Source: Authors' calculations, based on the model presented in section II.

Note: The figure shows the differences of the value of the marginal likelihood with respect to the within and between mean, according to the standard methodology of Brooks and Gelman (1998). The blue line corresponds to the convergence between the chains; the red line is the convergence within the chains.

Appendix A.4. Estimated Parameters

This appendix presents the estimates for all the model parameters and the shocks mentioned in the article. The estimates of the measurement equations were omitted but are available from the authors on request by e-mail.

Table A.4.1—Estimated Parameters

	Prior Distribution					Posterior Distribution											
		Prior Mean				Small Open Economies[a] (SOE)			Large Open Economies[b] (LOE)			Emerging Economies[c] (EE)			Developed Economies[d] (DE)		
	Type[e]	Mean (SOE)	Mean (LOE)	Mean (EE)	Mean (DE)	Mean	90% HPDI		Mean	90% HPDI		Mean	90% HPDI		Mean	90% HPDI	
Structural Parameters																	
γ	B	0.30	0.32	0.32	0.30	0.40	0.35	0.46	0.36	0.30	0.42	0.38	0.32	0.44	0.40	0.34	0.46
σ	G	2.00	2.00	2.00	2.00	2.02	2.00	2.04	2.00	1.99	2.01	2.00	1.99	2.01	2.02	2.00	2.05
λ_C	B	0.26	0.33	0.37	0.20	0.30	0.27	0.34	0.37	0.34	0.40	0.38	0.35	0.43	0.27	0.25	0.29
Ω_E	U	0.30	0.30	0.30	0.30	0.40	0.35	0.46	0.17	0.04	0.28	0.32	0.23	0.41	0.33	0.26	0.39
ϕ_{RP01}	B	0.13	0.13	0.15	0.10	0.04	0.02	0.05	0.06	0.03	0.08	0.04	0.01	0.06	0.05	0.04	0.06
ϕ_{RP02}	B	0.13	0.13	0.15	0.10	0.03	0.02	0.04	0.05	0.03	0.07	0.03	0.01	0.05	0.04	0.03	0.06
θ_W	B	0.75	0.75	0.75	0.75	0.81	0.79	0.83	0.75	0.74	0.76	0.80	0.79	0.82	0.78	0.76	0.79
δ_W	B	0.45	0.55	0.51	0.45	0.52	0.46	0.59	0.56	0.51	0.62	0.62	0.55	0.69	0.46	0.41	0.50
φ	G	2.00	2.00	2.00	2.00	2.01	2.00	2.02	2.00	1.99	2.02	2.00	1.99	2.02	2.01	2.00	2.02
ϕ_{01}	U	0.90	0.90	0.90	0.90	0.90	0.88	0.92	0.94	0.89	0.99	0.89	0.85	0.93	0.94	0.92	0.95
ϕ_{02}	U	0.90	0.90	0.90	0.90	0.94	0.90	0.97	0.87	0.82	0.94	0.93	0.88	0.98	0.90	0.86	0.94
ξ_{01}	U	0.50	0.50	0.50	0.50	0.81	0.73	0.90	0.54	0.44	0.63	0.49	0.37	0.63	0.95	0.90	1.00
ξ_{02}	U	0.50	0.50	0.50	0.50	0.06	0.03	0.10	0.16	0.08	0.25	0.10	0.04	0.17	0.09	0.05	0.13
η^{MU}	U	0.26	1.38	0.26	1.01	0.32	0.25	0.38	0.31	0.08	0.55	0.23	0.12	0.34	0.40	0.27	0.53
Ω_M	B	0.56	0.50	0.50	0.58	0.52	0.47	0.57	0.48	0.43	0.53	0.48	0.43	0.54	0.53	0.48	0.58
Ω_N	B	0.49	0.54	0.53	0.48	0.62	0.58	0.67	0.63	0.58	0.68	0.62	0.58	0.68	0.63	0.58	0.67
θ_D	B	0.69	0.75	0.75	0.67	0.75	0.73	0.77	0.74	0.73	0.75	0.76	0.75	0.77	0.73	0.71	0.75
δ_D	B	0.46	0.45	0.45	0.47	0.45	0.40	0.50	0.51	0.46	0.56	0.44	0.39	0.49	0.50	0.45	0.55
$\mathcal{AC}$	G	0.25	0.28	0.27	0.25	0.21	0.17	0.25	0.30	0.24	0.37	0.26	0.21	0.32	0.22	0.18	0.27
Ω_R	B	0.70	0.70	0.70	0.70	0.83	0.81	0.85	0.75	0.71	0.78	0.81	0.78	0.84	0.79	0.77	0.81
ψ_π	G	2.00	2.02	2.01	2.00	2.00	1.95	2.05	2.06	2.01	2.11	2.01	1.95	2.07	2.03	1.98	2.07
ψ_Y	G	0.50	0.50	0.50	0.50	0.84	0.71	0.95	0.44	0.32	0.56	0.69	0.55	0.82	0.73	0.62	0.82
ψ_{01}	G	0.10	0.10	0.10	0.10	0.10	0.09	0.11	0.10	0.08	0.11	0.10	0.09	0.11	0.10	0.09	0.11
ψ_{02}	G	0.10	0.09	0.09	0.10	0.10	0.09	0.11	0.10	0.08	0.11	0.09	0.08	0.10	0.10	0.09	0.12
ϕ_{XCM}	U	0.50	0.50	0.50	0.50	0.45	0.28	0.60	0.13	0.00	0.31	0.32	0.13	0.54	0.36	0.25	0.47
Ω_{XCM}	U	0.50	0.50	0.50	0.50	0.86	0.75	0.94	0.70	0.39	1.00	0.84	0.63	1.00	0.77	0.64	0.91
Ω_X	B	0.50	0.50	0.50	0.50	0.62	0.58	0.66	0.59	0.54	0.63	0.58	0.53	0.63	0.63	0.59	0.67
η	G	NaN	2.00	2.54	2.54	NaN	NaN	NaN	1.99	1.98	2.00	2.54	2.53	2.55	2.53	2.53	2.53
Persistence of the Exogenous Processes																	
ρ_A	B	0.50	0.50	0.50	0.50	0.86	0.82	0.90	0.88	0.82	0.93	0.89	0.85	0.93	0.85	0.80	0.89
ρ_{PCM}	B	0.50	0.50	0.50	0.50	0.74	0.70	0.78	0.85	0.79	0.91	0.77	0.71	0.83	0.78	0.74	0.82
ρ_L	B	0.50	0.60	0.57	0.50	0.69	0.65	0.77	0.90	0.83	1.00	0.71	0.62	0.85	0.82	0.79	0.84
ρ_G	B	0.50	0.50	0.50	0.50	0.78	0.73	0.83	0.78	0.70	0.85	0.78	0.70	0.85	0.78	0.73	0.83
ρ_{GDP^*}	B	0.50	0.50	0.50	0.50	0.90	0.87	0.93	0.86	0.81	0.91	0.84	0.79	0.90	0.93	0.92	0.95
ρ_{Π^*}	B	0.50	0.65	0.60	0.50	0.71	0.66	0.76	0.67	0.58	0.76	0.64	0.57	0.72	0.74	0.69	0.80
ρ_{R*}	B	0.50	0.50	0.50	0.50	0.90	0.89	0.91	0.90	0.87	0.93	0.88	0.86	0.90	0.92	0.90	0.93

Source: Authors' calculations.

Note: a Average of the estimated parameters for Australia, Chile, Colombia and New Zealand; *b* Average of the estimated parameters for Mexico and Canada; *c* Average of the estimated parameters for Chile, Colombia and Mexico; *d* Average of the estimated parameters for Australia, Canada and New Zealand; *e* U: Uniform, G: Gamma, B: Beta, N: Normal, IG: Inverse-Gamma. SOE: small open economy; LOE: large open economy; EE: emerging economy; and DE: developed open economy. Parameters are averages of the estimated parameters in each country; for definitions, see section II. Model. The estimates were made with Bayesian econometrics, with simulations to achieve appropriate convergence.

Table A.4.2—Estimates Standard Deviations and Measurement Equation Parameter

	Prior Distribution					Posterior Distribution											
		Prior Mean				Small Open Economies[a] (SOE)			Large Open Economies[b] (LOE)			Emerging Economies[c] (EE)			Developed Economies[d] (DE)		
	Type[e]	(SOE)	(LOE)	(EE)	(DE)	Mean	90% HPDI		Mean	90% HPDI		Mean	90% HPDI		Mean	90% HPDI	
St. Dev. of the Innovations																	
σ_A	IG	1.00	1.00	1.00	1.00	1.38	1.14	1.60	1.16	0.88	1.43	1.49	1.21	1.77	1.12	0.90	1.32
σ_D	IG	1.00	1.00	1.00	1.00	0.99	0.76	1.22	0.76	0.53	0.96	0.78	0.60	0.95	1.04	0.77	1.31
σ_L	IG	1.00	1.00	1.00	1.00	2.37	1.90	2.78	1.43	1.02	1.82	2.16	1.54	2.73	1.95	1.67	2.19
σ_G	IG	1.00	1.00	1.00	1.00	1.55	1.39	1.70	0.74	0.62	0.85	1.50	1.34	1.65	1.06	0.93	1.18
σ_{MP}	IG	0.25	0.25	0.25	0.25	0.56	0.46	0.67	0.70	0.57	0.81	0.39	0.31	0.48	0.82	0.68	0.95
σ_{PCM}	IG	6.00	6.00	6.00	6.00	11.89	10.74	13.06	14.78	12.96	16.52	17.20	15.07	19.29	8.51	7.89	9.13
σ_S	IG	1.00	1.00	1.00	1.00	0.49	0.42	0.57	0.53	0.42	0.63	0.63	0.52	0.74	0.38	0.31	0.44
σ_I	IG	3.00	3.00	3.00	3.00	2.09	1.79	2.36	2.35	1.99	2.70	2.06	1.76	2.34	2.28	1.95	2.61
σ_{X^D}	IG	4.00	4.00	4.00	4.00	3.90	3.31	4.51	3.92	3.40	4.41	4.15	3.51	4.77	3.67	3.18	4.19
σ_{GDP^*}	IG	1.00	1.00	1.00	1.00	0.69	0.59	0.79	0.79	0.66	0.92	0.73	0.61	0.87	0.71	0.62	0.81
σ_{Π^*}	IG	1.00	1.00	1.00	1.00	0.88	0.76	0.98	0.81	0.69	0.93	0.95	0.81	1.07	0.77	0.67	0.86
σ_{R^*}	IG	1.00	1.00	1.00	1.00	0.81	0.71	0.92	0.76	0.61	0.90	0.66	0.57	0.75	0.93	0.79	1.07
Measurement Equation Parameters																	
ρ_X	U	1.00	1.00	1.00	1.00	0.08	0.01	0.15	0.21	0.11	0.31	0.19	0.08	0.29	0.06	0.00	0.12
α_{GDP}	N	0.67	0.67	0.67	0.67	0.84	0.80	0.87	0.57	0.54	0.61	0.81	0.77	0.86	0.68	0.65	0.71
α_{Π}	G	0.51	0.51	0.51	0.51	0.71	0.68	0.74	0.74	0.70	0.78	0.92	0.88	0.97	0.52	0.49	0.54
α_R	G	1.00	1.00	1.00	1.00	1.22	1.18	1.25	0.92	0.87	0.97	1.25	1.20	1.30	0.98	0.95	1.02
α_E	N	0.20	0.20	0.20	0.20	0.37	0.29	0.46	0.09	-0.02	0.20	0.24	0.14	0.34	0.32	0.23	0.40
α_{PCM}	N	0.12	0.29	0.23	0.12	0.23	0.14	0.33	0.33	0.23	0.43	0.29	0.18	0.39	0.25	0.16	0.34
α_{GDP^*}	N	0.60	0.60	0.60	0.60	0.51	0.47	0.55	0.47	0.42	0.51	0.43	0.39	0.47	0.56	0.52	0.60
α_{Π^*}	G	0.55	0.55	0.55	0.55	0.56	0.54	0.58	0.48	0.46	0.51	0.50	0.47	0.53	0.57	0.55	0.59
α_{R^*}	G	0.65	0.65	0.65	0.65	0.53	0.49	0.57	0.41	0.36	0.45	0.41	0.36	0.45	0.58	0.54	0.62
α_N	N	0.67	0.67	0.67	0.67	0.60	0.50	0.70	0.36	0.23	0.50	0.64	0.53	0.74	0.40	0.30	0.52
α_W	N	0.25	0.30	0.28	0.25	0.32	0.23	0.42	0.43	0.32	0.56	0.30	0.19	0.42	0.42	0.33	0.51
St. Dev. Of the Measurement Equations																	
σ_X	IG	4.50	3.25	3.67	4.50	3.59	3.23	3.93	2.98	2.65	3.33	3.56	3.12	3.98	3.22	2.95	3.48
σ_M	IG	4.50	3.75	4.00	4.50	4.24	3.82	4.65	3.32	2.96	3.67	3.70	3.26	4.13	4.16	3.81	4.52
σ_N	IG	2.50	2.50	2.50	2.50	1.84	1.54	2.08	2.18	1.92	2.41	2.10	1.73	2.39	1.80	1.60	1.99
σ_W	IG	1.75	3.00	2.33	2.00	2.24	2.05	2.43	3.06	2.69	3.42	3.95	3.57	4.33	1.07	0.95	1.19

Source: Authors' calculations.

Note: a Average of the estimated parameters for Australia, Chile, Colombia and New Zealand; *b* Average of the estimated parameters for Mexico and Canada; *c* Average of the estimated parameters for Chile, Colombia and Mexico; *d* Average of the estimated parameters for Australia, Canada and New Zealand; *e* U: Uniform, G: Gamma, B: Beta, N: Normal, IG: Inverse-Gamma. SOE: small open economy; LOE: large open economy; EE: emerging economy; and DE: developed open economy. Parameters are averages of the estimated parameters in each country; for definitions, see section II. Model. The estimates were made with Bayesian econometrics, with simulations to achieve appropriate convergence.

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