

The Transmission of US Shocks to Emerging Markets*

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Abstract

To study the transmission of US shocks to emerging markets, we develop and estimate an asymmetric two-country real business cycle model. The asymmetries in the model arise due to the differences in the size and the riskiness of the economies, as well as the financial frictions in the emerging market. We estimate the model using 17 quarterly time series for Mexico and the US from 1994.I to 2007.IV. We find that US shocks explain 31% of the volatility in Mexico's GDP growth, which is the second largest source of GDP growth fluctuations, only after domestic productivity shocks, which explain 43%. A historical decomposition of the data shows that Mexico's growth substantially benefited from the US growth in the second part of the 1990s, contributing an additional annual growth of one percentage point on average. On the other hand, the 2001 US recession hit Mexico's economy adversely, resulting in growth losses of 3 percentage points in that year. The transmission mechanisms built in the model imply that the spillovers are more sensitive to the financial frictions than to the volume of bilateral trade.

Key Words: Emerging market business cycles; transmission of foreign shocks; estimated two-country model

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1 Introduction

One of the prominent features of the emerging market business cycles is their vulnerability to external shocks. As increasing trade and financial linkages between developed economies and emerging market economies (EMEs) increase the latter's exposure to external economic fluctuations, domestic market imperfections hamper their abilities to smooth-out such spillovers. The aim of this paper is to analyze the transmission of structural shocks in the developed countries to the EMEs through the trade and financial linkages, and to explore the role of domestic market imperfections in exacerbating their vulnerability to such foreign disturbances.

While reduced form studies have empirically documented the transmission of developed country shocks to EMEs—e.g., Mackowiak (2007) and Canova (2005)—, the standard small open economy models have had a difficult time generating the spillovers in the data. Schmitt-Grohe (1998) shows that the traditional channels of transmission through interest rate and terms-of-trade cannot explain the cyclical response of the Canadian economy to US output shocks. More recently, Justiniano and Preston (2010) estimate a small open economy model for Canada and demonstrates that the inability of the model to generate spillovers becomes more acute when the model is estimated. Another strand of the literature shows that the standard two-country model is also not able to generate the spillovers and the comovement in the data. For example, Kose and Yi (2006) include a rich set of trade-related frictions in addition to trade with a third country and show that the model can not generate the cross-country correlations in the data.

We contribute to the literature by developing and estimating an asymmetric two-country real business cycle model to quantify the extent of spillovers of structural US shocks to the EMEs. The key asymmetries arise due to the differences in the country size, riskiness of the economies, and the financial market imperfections that affect production in the emerging market.

To establish the trade channel, we assume that each country completely specializes in producing a traded good, and additionally produces a non-traded good. The traded goods can be domestically consumed, invested or internationally traded. In addition to trading bilaterally, both countries can trade goods with the rest of the world. Financial linkages are established by assuming that the households in the emerging market can borrow from an international financial institution. When lending to the emerging market, the financial intermediary charges a premium over the US interest

rate, which reflects the riskiness of the emerging market economy. The seminal works of Neumeyer and Perri (2005) and Uribe and Yue (2006) show that foreign interest rate shocks constitute an important source of fluctuations in the EMEs when domestic producers face a working capital constraint. Accordingly, we assume that the firms need to borrow to cover a fraction of their total costs before revenues are realized.

As the sources of economic fluctuations in our specification, we include shocks that have been commonly used in previous empirical studies—productivity, preference, investment, government spending and wage mark-up shocks. Motivated by the findings in Corsetti, Dedola, and Leduc (2009), we allow the productivity shocks to be sector-specific. Additionally, we include a terms of trade shock, a country risk shock and shocks to non-bilateral trade.

We estimate the model using Bayesian estimation techniques with seventeen quarterly time series for Mexico and the US from 1994 to 2007. For both Mexico and the US, we include quarter to quarter growth rates of real GDP, consumption, investment, government spending, and manufacturing production. We also include non-bilateral net trade as a fraction of GDP for both economies. For Mexico we include the growth of bilateral exports and imports and the J.P. Morgan EMBI+ Spread. For the US we use the growth rate of hours worked and the real interest rate.

The estimates show that the international linkages and frictions in the model are rich enough to allow the model to closely match some key second moments of the data. In particular, the estimated model predicts correlations of Mexican variables with US and own GDP growth similar to the ones observed in the data.

Using the estimates from the model, we address the following questions: (i) What are the driving forces of the Mexican business cycle?; (ii) What has been the historical impact of US shocks on the Mexican economy?; (iii) What are the roles of trade linkages and working capital frictions in the transmission mechanism of US shocks?

To address the first question, we decompose the volatility of the variables into shares attributed to each of the structural shocks in the model. We find that 31% of fluctuations in the growth of Mexico's GDP can be explained by US disturbances. This is the second largest source of GDP growth fluctuations, only after Mexico's own productivity shocks, which explain 43%. US productivity shocks by themselves explain 23% of those fluctuations. US shocks also explain significant amounts of variation in the growth rates of consumption, manufacturing output, bilateral imports

and exports in Mexico. These results illustrate that the transmission mechanisms embedded in the model work through all key variables in our estimation.

A historical decomposition of the data shows that the spillovers from the US to Mexico were relevant in every quarter of our sample, implying that these are not special events. The results also show that the decline in the growth rate of GDP during Mexico's Tequila crisis of 1995 is mainly explained by the domestic shocks, and that the US shocks have a small effect in the total volatility of that period (around 12%). By contrast, the US shocks explain about 50% of Mexico's GDP volatility during the 2001 US recession. Moreover, using the historical decomposition we find that a counterfactual stabilization of the US economy would have resulted in annual growth losses for Mexico averaging 1.13 percentage points during the first expansionary episode of the US economy in our sample (1994:1–1999:4). On the other hand, during 2001 Mexico's GDP would have grown an additional 3 percentage points had the US recession been stabilized.

In order to analyze the importance of the working capital frictions and bilateral trade in facilitating spillovers, we conduct two counter-factual experiments. In the first one, we analyze how the spillovers would change if Mexico were to diversify trading partners by reducing bilateral trade with the US by 50%, and reallocating those trade shares to the rest of the World. The results of the experiment show that the spillovers from the US would be lower by only 5 percentage points at the mean of the spillover distribution. In the second counter-factual experiment, we examine how the results would change if the borrowing requirements as a fraction of GDP were lowered by 50%. In this case, the spillovers would have been mitigated by 16 percentage points at the mean of the distribution. These two experiments imply that the transmission mechanism in the model is more responsive to changes in the borrowing requirements than changes in bilateral trade.

Our paper fits in the growing literature that investigates the sources of fluctuations in EMEs. Building on Neumeyer and Perri (2005) and Uribe and Yue (2006), Garcia-Cicco, Pancazi, and Uribe (2010) and Chang and Fernandez (2010) estimate small open economy models to compare the roles of financial frictions along with interest rate shocks in explaining empirical regularities of the EME business cycles to the role of trend-shocks proposed in Aguiar and Gopinath (2007). Their findings highlight the importance of the former. Moreover, Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011) show that not only fluctuations in interest rates are relevant in the business cycle of EMEs, but also mean-preserving shocks to the interest rate volatility

can be as important.

Additionally, our paper is related to the studies that address the comovement between Mexico and US such as Burnstein, Kurz, and Tesar (2008) and Comin, Loayza, Pasha, and Serven (2009). Burnstein, Kurz, and Tesar (2008) builds on the standard two-country model by adding intermediate goods as part of vertically integrated international production as their key transmission mechanism between the two countries. Using a calibration exercise in a two-country DSGE model, Comin, Loayza, Pasha, and Serven (2009) focus on international diffusion of technologies through FDI as the key transmission mechanism.

Our study also adds to the growing literature that estimates open economy models to address international aspects of the business cycle. For example, Lubik and Schorfheide (2006), Ireland (2011) and Rabanal and Tuesta (2010) estimate two country models for the Euro Area-US pair. To the best of our knowledge, our paper is the first to estimate a two-country model focusing an emerging-developed country pair.

The rest of the paper is organized as follows. Section 2 presents the set-up of our model. Section 3 describes the estimation methodology, the data we use, the prior distributions we adopt, and the posterior distributions we obtain. Section 4 contains the main results of the paper. Within that section we first present the fit of our model. Then, we use a variance decomposition and a historical decomposition to quantify the role of US shocks in the macroeconomic fluctuations of Mexico. Additionally, we analyze the role of financial frictions and international trade in the transmission mechanism of the estimated model. Finally, Section 5 concludes.

2 The Model

In this section we develop an asymmetric two-country real business cycle model, where one of the countries represents the emerging market, and the other one depicts the US economy. Throughout our discussion, we assume that the emerging market is the home country. The two countries are populated with a continuum of agents, where the US population is normalized to one and the emerging country has a population of mass n . Each country completely specializes in producing a traded good, and additionally produces a non-traded good. The traded goods can be consumed, invested or exported. In addition to trading bilaterally, both countries trade goods with the rest of

the world. In order to partially finance expenditures, households can borrow in the international financial markets. When the emerging market households borrow in the international markets, they pay a premium over the international interest rate. In what follows, we describe the set-up for the households, firms and the government in the home country (the emerging market) in detail, and discuss the dimensions along which the US economy's set-up differs.

2.1 Households

The representative household provides labor to both the traded and the non-traded sectors; accumulates capital and rents it out to the firms; and trades an international bond. The household's preferences take on the form formulated in Jaimovich and Rebelo (2009)

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[\xi_{C,t} C_t - \varphi C_{t-1} - \frac{\vartheta}{1+\eta} L_t^{1+\eta} J_t \right]^{1-\sigma} - 1}{1-\sigma}, \quad (1)$$

where C_t denotes the composite consumption index, L_t is the composite labor supply, J_t is a geometric average of the current and past consumption levels, and $\xi_{C,t}$ is a preference shock. As in Schmitt-Grohe and Uribe (2012), the preferences exhibit habit persistence, where $\varphi \in (0, 1)$ measures the degree of internal habit formation. The process for J_t is given by

$$J_t = \left(C_t - \varphi C_{t-1} \right)^\gamma \left(J_{t-1} \right)^{1-\gamma}, \quad (2)$$

where $\gamma \in (0, 1]$ governs the wealth elasticity of labor supply. In the special case of $\varphi = \gamma = 0$, these preferences reduce to Greenwood, Hercowitz, and Huffman (1988) preferences, where η determines the Frisch elasticity of labor supply, and ϑ is a scale parameter. The composite labor supply is defined as

$$L_t = \left[(L_{N,t})^{1+\chi} + (L_{H,t})^{1+\chi} \right]^{1/(1+\chi)}, \quad (3)$$

where $L_{H,t}$ is the labor supplied to the producers of the home traded good (H good) and $L_{N,t}$ is the labor supplied to the producers of the non-traded good (N good). We assume that the labor efforts in the traded and the non-traded sectors are imperfect substitutes and χ determines the elasticity of substitution between the two.

The consumption basket, C_t , is defined by the usual constant elasticity of substitution (CES) function:

$$C_t = \left[a^{\frac{1}{\theta}} C_{T,t}^{\frac{\theta-1}{\theta}} + (1-a)^{\frac{1}{\theta}} C_{N,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \quad (4)$$

where a is the weight of traded goods in the consumption basket, and θ is the elasticity of substitution between the traded and the non-traded goods. In turn, the traded goods bundle is composed of the domestic traded good, the foreign traded good produced in the US, and a third good produced in the rest of the world (O-good). These goods are bundled with a CES function

$$C_{T,t} = \left[m_H^{\frac{1}{\omega}} C_{H,t}^{\frac{\omega-1}{\omega}} + m_F^{\frac{1}{\omega}} C_{F,t}^{\frac{\omega-1}{\omega}} + m_O^{\frac{1}{\omega}} C_{O,t}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}, \quad (5)$$

where m 's denote the weights of the three goods in the traded goods' basket, and ω is the elasticity of substitution between the traded goods.

Households own the capital stocks in the traded and non-traded sectors, optimally choose their utilization rates, and rent them out to firms. In adjusting the capital stock, households pay a cost, which is quadratic in the change in investment. The capital stock in each sector, $j = \{H, N\}$, evolves over time according to the following law of motion:

$$K_{j,t} = (1 - \delta(u_{j,t})) K_{j,t-1} + I_{j,t} \left[\xi_{I,t} - \frac{\phi}{2} \left(\frac{I_{j,t}}{I_{j,t-1}} - 1 \right)^2 \right] \quad (6)$$

where $I_{j,t}$ is the composite investment good, $\xi_{I,t}$ is an investment shock common to the traded and non-traded sectors, and ϕ determines the cost of adjustment. We adopt the following quadratic function for the depreciation rate

$$\delta(u_{j,t}) = \delta_0 + \delta_1(u_{j,t}) + \frac{\delta_2}{2}(u_{j,t})^2, \quad (7)$$

where $\delta_0 > 0$, $\delta_2 > 0$ and the depreciation technology satisfies $\delta'(u_j) > 0$.

To form a unit of investment in either sector, the household uses the same technology used to aggregate consumption. In particular, the composite investment good in sector $j = \{H, N\}$ is

formed with the CES aggregator:

$$I_{j,t} = \left[a^{\frac{1}{\theta}} X_{jT,t}^{\frac{\theta-1}{\theta}} + (1-a)^{\frac{1}{\theta}} X_{jN,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \quad (8)$$

where a and θ are the same as in the consumption aggregator (4). $X_{jN,t}$ denotes the demand for the non-traded good in forming investment in sector j , and $X_{jT,t}$ is the basket of traded goods that augments investment in that particular sector, which is given by:

$$X_{jT,t} = \left[m_H^{\frac{1}{\omega}} X_{jH,t}^{\frac{\omega-1}{\omega}} + m_F^{\frac{1}{\omega}} X_{jF,t}^{\frac{\omega-1}{\omega}} + m_O^{\frac{1}{\omega}} X_{jO,t}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}, \quad (9)$$

where X_{jk} is the demand for the traded good k , for $k = \{H, F, O\}$.

In order to finance expenditures, the household supplements capital and labor income by borrowing in the international financial markets. The emerging market households borrow by issuing bonds that are denominated in units of the US consumption basket. Given all the expenditures, income and international borrowing, the debt position of the household, denoted by d_t , evolves according to

$$\begin{aligned} e_t d_t = & - \left[w_{H,t}^* L_{H,t} + w_{N,t}^* L_{N,t} + z_{H,t} u_{H,t} K_{H,t-1} + z_{N,t} u_{N,t} K_{N,t-1} + \Pi_t \right] \\ & + \left[C_t + I_{H,t} + I_{N,t} + T_t \right] + e_t R_{t-1} d_{t-1} + e_t \frac{\pi}{2} (d_t - \bar{d})^2, \end{aligned} \quad (10)$$

where e_t is the real exchange rate defined as Mexican consumption baskets per US consumption basket; $z_{H,t}$ and $z_{N,t}$ are the rental rates of capital; $w_{H,t}^*$ and $w_{N,t}^*$ are the wage rates received by the household. The household pays lump-sum taxes, T_t , and receives three types of transfers from firms, financial intermediaries and labor unions. The only role of those lump-sum transfers is to make the standard national income identity to hold in equilibrium, each type of transfer that is included in Π_t is described below. The gross interest rate households face in the international financial markets is denoted with R_t . Following Schmitt-Grohe and Uribe (2003), we assume that the households face quadratic costs when adjusting assets in the international markets, where \bar{d} is the equilibrium debt position of the household.

In modeling the interest rate that the households face in the international markets, we follow Neumeyer and Perri (2005) and Uribe and Yue (2006). We assume that there is a financial in-

termediary, which lends to households both in the US and in the emerging market. Loans to the emerging market are risky since the government can confiscate a fraction of the debt payments. Given the default risk, the financial intermediary charges a premium over the safe (US) interest rate, \tilde{R}_t . Hence, the interest rate for Mexican bonds becomes:

$$R_t = \tilde{R}_t S_t, \quad (11)$$

where the spread, S_t , defines the country risk premium. We assume that the spread follows an autoregressive process that responds to GDP growth and exogenous innovations:

$$S_t = (S)^{1-\rho_s} (S_{t-1})^{\rho_s} \left(\frac{Y_t}{Y_{t-1}} \right)^{\psi_{s,y}} \epsilon_{s,t} \quad (12)$$

where $\rho_s \in (0, 1)$, $\psi_{s,y}$ measures the intensity of the spread response to changes in GDP, S defines the steady-state spread, Y_t (defined below) is GDP, and $\epsilon_{s,t}$ is an i.i.d. shock to the spread.

The household chooses $\{C_t, L_{H,t}, L_{N,t}, I_{H,t}, I_{N,t}, K_{H,t}, K_{N,t}, u_{H,t}, u_{N,t}, d_t\}_{t=0}^{\infty}$ in order to maximize (1) subject to the budget constraint (10), the laws of motion of capital (6) and the depreciation functions (7) for the traded and the non-traded sectors, the labor-supply aggregator (3), and the usual no-Ponzi game condition for d , taking as given rental rates of capital, wage rates, prices for the investment baskets and the interest rate.¹

2.2 Firms

We assume that the firms in the two sectors face similar optimization problems. Output in each sector, $Y_{j,t}$ for $j = \{H, N\}$, is produced with the Cobb-Douglas technology:

$$Y_{j,t} = \xi_{Aj,t} (u_{j,t} K_{j,t-1})^\alpha (L_{j,t})^{1-\alpha}, \quad (13)$$

where $\alpha \in (0, 1)$ and $\xi_{Aj,t}$ denotes sector-specific productivity shocks that are correlated across the traded and non-traded sectors but are orthogonal to the other shocks. The sector-specific technology shocks are motivated by the empirical findings of Corsetti, Dedola, and Leduc (2009),

¹The full set of optimality conditions are available upon request.

who show that the US technology shocks in the traded sector have important international effects.²

We introduce two market frictions to an otherwise standard perfectly competitive firm's problem. First, we introduce mark-up shocks to wages.³ To do so, we follow the set-up in Schmitt-Grohe and Uribe (2012), and assume that the firms in both the traded and the non-traded sectors hire a composite labor input, $L_{j,t}$, which is formed by differentiated labor inputs that are rented out to firms by labor unions. Given the wage posted by the labor union, the firm optimally chooses demand for each type of labor, $L_{\ell j,t}$. The labor union, in turn, maximizes profits by choosing the wage they want to post, taking the wage they pay the households ($w_{j,t}^*$) as given. The optimal condition for the union's problem requires the union to post a wage that is higher than $w_{j,t}^*$ by a mark-up, μ_t , which yields the same wage rate across different labor inputs, i.e., $w_{\ell j,t} = w_{j,t} = \mu_t w_{j,t}^*$.⁴ The mark-up μ_t is exogenous and stochastic. Given that the wage rate is the same across labor inputs, the firm demands identical quantities of each type of labor, and in equilibrium, total amount of labor allocated by the unions equals to the labor supply provided by the households ($L_{j,t}$). The union's profits are transfer in a lump-sum fashion to the consumer (as one component in Π_t).

Second, we assume that the firms in both sectors face a working capital constraint. As in Perri and Quadrini (2012), the financial friction requires the firms to make a fraction of their payments at the beginning of the period, before the revenues are realized. We assume that the liquidity needed at the beginning of the period is equal to a fraction κ_j of the total revenue ($P_{j,t}Y_{j,t}$), and it is obtained through an intra-period loan. Firms repay the loan, along with the interest on the loan, at the end of the same period, once the product is sold.⁵ Hence, the interest payments on the intra-period loan, $\kappa_j(R_t - 1)P_{j,t}Y_{j,t}$, add on to the firm's operating costs. We assume that the profit financial intermediaries make from these interest payments are then distributed back to the consumer in a lump-sum fashion, as one of the transfers in Π_t in the household budget constraint. Additionally, the firms receive subsidies (τ_j), which eliminate the financial-friction distortion to the

²Corsetti, Dedola, and Leduc (2009) estimate an identified VAR with sign restrictions for the US. They find that productivity gains in US manufacturing lead to important cross-country endogenous demand and wealth movements.

³Previous studies (e.g. Smets and Wouters (2007), Schmitt-Grohe and Uribe (2012)) that estimated DSGE models for the US economy have found the wage mark-up shock to be an important source of fluctuations in the US economy. Following those studies, we include this shock in order to identify the different sources of fluctuations that get transmitted to the emerging markets.

⁴Specifically, the union's problem is to choose $w_{\ell j,t}$ in order to maximize $(w_{\ell j,t} - w_{j,t}^*)L_{j,t}[\frac{w_{\ell j,t}}{w_{j,t}^*}]^{-\frac{\mu_t}{\mu_t-1}}$, where $w_{j,t} = [\int_0^n w_{\ell j,t}^{-\frac{1}{1-\mu_t}} d\ell]^{1-\mu_t}$ is the cost of one unit of composite labor used in sector j , and n is the population size.

⁵Unlike Perri and Quadrini (2012), we assume that the debt contracts are perfectly enforceable, and the full amount of the intra-period loan is paid at the end of the period.

prices in the steady-state.

The firms in the traded and non-traded sectors face the problem of choosing labor and capital in order to maximize profits given by

$$\frac{[1 - \kappa_j(R_t - 1)]}{1 - \tau_j} p_{j,t} Y_{j,t} - w_{j,t} L_{j,t} - z_{j,t} u_{j,t} K_{j,t-1}, \quad (14)$$

where τ_j is the rate of subsidy, subject to the production function (13). The sector-specific working capital requirement, κ_j , increases the marginal cost of the firm, and thereby distorts the production decisions. Moreover, it provides a mechanism for the endogenous changes in the interest rate (due to domestic and foreign shocks) to directly affect production.⁶

2.3 Exporters

We assume that there are intermediary firms that buy the Mexican traded good, H , from the domestic producers and export it to the US. The exporting firms are subject to the same working capital requirement as the domestic producers for which they need to cover a fraction of their costs before they receive the payments from the US households. The exporting firms choose the export amount in order to maximize real profits in US consumption basket

$$\frac{[1 - \kappa_E(R_t - 1)]}{1 - \tau_E} \tilde{p}_{H,t} \xi_{tot,t} \tilde{Q}_{H,t} - \frac{p_{H,t}}{e_t} \tilde{Q}_{H,t}, \quad (15)$$

where $\tilde{Q}_{H,t}$ denotes total exports to the US, $\tilde{p}_{H,t}$ is the price of the home traded good in the US, and $\xi_{tot,t}$ is a shock to the terms of trade.⁷ The exporting firm's optimization yields the following pricing equation for the H -good:

$$\tilde{p}_{H,t} = \frac{1 - \tau_E}{[1 - \kappa_E(R_t - 1)]} \frac{p_{H,t}}{e_t \xi_{tot,t}}. \quad (16)$$

⁶Note that the financing requirement set-up we adopt is different than the working capital constraint formulated in Neumeyer and Perri (2005) and Uribe and Yue (2006). In their settings working capital is needed to finance a fraction of the wage bill only. Given their formulation of the financial friction, the constraint in their settings increases the unit cost of labor and distorts the optimal capital-labor mix.

⁷Total exports from the home country to the US consists of exports for consumption and exports for investment in the two US sectors, i.e., $\tilde{Q}_{H,t} = \tilde{C}_{H,t} + \tilde{X}_{NH,t} + \tilde{X}_{FH,t}$.

As the above equation shows, the law of one price holds in the steady state (with $\tau_E = \kappa_E(R-1)$, and $\xi_{tot} = 1$). However, it breaks down outside the steady-state due to the working capital requirement, and the shock to the terms of trade.

2.4 Government

The government purchases goods only from the domestic traded and non-traded sectors, which are combined in a composite good similar to the consumer's consumption basket:

$$G_t = \left[a^{\frac{1}{\theta}} G_{H,t}^{\frac{\theta-1}{\theta}} + (1-a)^{\frac{1}{\theta}} G_{N,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \quad (17)$$

and finances expenditures with lump-sum taxes, T_t . Furthermore, we assume that government spending responds to output growth up to an exogenous shock ($\xi_{G,t}$) according to:

$$G_t = (G) \left(\frac{Y_t}{Y_{t-1}} \right)^{\psi_{G,Y}} \xi_{G,t}, \quad (18)$$

where G defines the steady-state level of government spending and $\psi_{G,Y}$ is the reaction coefficient of government spending to changes in GDP.

2.5 The US Economy and Closing the Model

We assume that the set-up for the US households, firms and government are identical to the ones described above—up to a country-specific parametrization—, except for two aspects. First, we assume that the firms in the US do not face the working capital constraint. Second, we assume that the US households can borrow from the international financial institution at the safe interest rate, \tilde{R}_t , which is endogenously determined.

2.5.1 Market Clearing Conditions

The non-traded goods in both countries can be consumed, invested, and used for government expenditures. Hence, the market condition for the non-traded goods in the emerging market is given by

$$Y_{N,t} = C_{N,t} + X_{NN,t} + X_{NH,t} + G_{N,t}, \quad (19)$$

and an analogous condition holds for the US.

The home traded good, Y_H , can be consumed by domestic and US households, as well as the home government, and it can be used for investment in the traded and non-traded sectors in both countries. The market clearing condition for the H good is

$$Y_{H,t} = (C_{H,t} + G_{H,t} + X_{HH,t} + X_{NH,t}) + \frac{1}{n}(\tilde{C}_{H,t} + \tilde{X}_{NH,t} + \tilde{X}_{FH,t}). \quad (20)$$

Similarly, the US good, Y_F , can be used for consumption and investment in the US, as well as in the emerging market:

$$\tilde{Y}_{F,t} = n(C_{F,t} + X_{HF,t} + X_{NF,t}) + (\tilde{C}_{F,t} + \tilde{G}_{F,t} + \tilde{X}_{FF,t} + \tilde{X}_{NF,t}). \quad (21)$$

2.5.2 Definitions of Observables

For the estimation of the model, we define some additional variables. First, we define each country's GDP in its own consumption basket as

$$Y_t = p_{H,t}Y_{H,t} + p_{N,t}Y_{N,t} \quad \text{and} \quad \tilde{Y}_t = \tilde{p}_{F,t}\tilde{Y}_{F,t} + \tilde{p}_{N,t}\tilde{Y}_{N,t}, \quad (22)$$

for Mexico and the US respectively. We define aggregate investment as the sum of investment in the traded and non-traded sectors:

$$I_t = I_{H,t} + I_{N,t} \quad \text{and} \quad \tilde{I}_t = \tilde{I}_{F,t} + \tilde{I}_{N,t}, \quad (23)$$

for Mexico and the US, respectively. Finally, we define imports from the US to Mexico (in units of US consumption basket) as:

$$imp_t = \frac{p_{F,t}}{e_t}(C_{F,t} + X_{NF,t} + X_{HF,t}) \quad (24)$$

and we define exports from Mexico to the US (in units of US consumption basket) as:

$$exp_t = \frac{1}{n} \frac{p_{H,t}}{e_t}(\tilde{C}_{H,t} + \tilde{X}_{NH,t} + \tilde{X}_{FH,t}). \quad (25)$$

2.5.3 Closing the Economy

We close the model by specifying autoregressive processes for the other net imports as ratios of GDP for the two countries. The “other” traded goods are meant to capture trade between the emerging market and the rest of the world, as well as trade between the US and the rest of the world. The other net imports to GDP ratio is defined as $ONMY_t = \frac{p_{o,t}[C_{o,t} + X_{No,t} + X_{Ho,t}]}{Y_t}$. The process for the home country is given by:

$$ONMY_t = (ONMY)^{1-\rho_{onm}} \left(ONMY_{t-1} \right)^{\rho_{onm}} \left(\frac{Y_t}{Y_{t-1}} \right)^{\psi_{onm,y}} \epsilon_{onm,t}, \quad (26)$$

where $\rho_{onm} \in (0, 1)$, $ONMY$ defines the steady-state value, and $\epsilon_{onm,t}$ is an i.i.d. shock. The process for the US other net imports is formulated the same way, but with its own parameters.

2.6 Shock Processes

Finally, we specify AR(1) processes for twelve of the structural shocks in the model, which in log-linear terms take on the following form

$$\widehat{\xi}_t = \rho_\xi \widehat{\xi}_{t-1} + \widehat{\epsilon}_{\xi,t}, \quad (27)$$

where $\epsilon_{\xi,t}$ is an i.i.d. innovation, and $\xi = \left\{ \xi_C, \tilde{\xi}_C, \xi_I, \tilde{\xi}_I, \xi_{AN}, \tilde{\xi}_{AN}, \xi_{AH}, \tilde{\xi}_{AF}, \xi_G, \tilde{\xi}_G, \xi_{tot}, \tilde{\mu}_t \right\}$.

While we specify the wage mark-up shock in the US as an AR(1) process, we assume that it is non-stochastic and constant for Mexico.⁸ The remaining three shocks, $\left\{ \epsilon_{onm}, \tilde{\epsilon}_{onm}, \epsilon_s \right\}$, are i.i.d. innovations in the corresponding processes.

3 Estimation

We use Bayesian techniques to estimate a subset of parameters of the model and use the standard calibration technique for the remaining parameters. Using quarterly data for Mexico and the US, we estimate 52 parameters of our model that include: i) the parameters that govern the key frictions of the model (habit persistence, wealth elasticity of labor supply, investment adjustment

⁸Due to lack of data, we cannot include hours in the set of observables for Mexico. Since we cannot identify wage mark-up shocks without the observable, we are assuming that the wage mark-up is constant in Mexico.

costs, sensitivity of the depreciation to utilization rate, and working capital requirements); ii) the parameters that govern the structural shock processes; and iii) the parameters that govern the processes for interest rate spread, government spending and other net imports.

We formally test the identification of our estimated parameters with the test of Komunjer and Ng (2011), which does not rely on the sample or the priors adopted in the estimation but only makes use of the model itself and the choice of observables. Assuming that the model has a minimal state representation, Komunjer and Ng obtain rank and order conditions for (local) identification of the set of estimated parameters from the spectral density of the observables. We perform the identification test at 1,000 parameterizations. As suggested by Komunjer and Ng, we apply the identification test using multiple tolerance levels. We find that at all 1,000 points of the parameter space the parameters are identified.⁹

3.1 Calibrated Parameters

The calibrated parameters and their values are listed in Table 1. For both the US and Mexico, we set the coefficient of risk-aversion (σ) to 1, and the elasticity of the labor composite with respect to the utility-based wage-index ($\frac{1}{\eta}$) to 0.5. The US discount factor ($\tilde{\beta}$) is set to 0.98 in order to match the average US real interest rate in our sample; the steady-state value of the spread (S) is set to 255 basis points, the average in our sample, which implies a discount factor for Mexico (β), equal to 0.96.

[Table 1 about here.]

We also set the coefficients regarding the labor supply, capital's share in income and depreciation to be equal for Mexico and the US. The parameter $\chi > 0$ in the labor composite measures the degree of labor substitutability across sectors ($\chi = \infty$ implies perfect substitutability), and it is set to 2 consistent with the low degree of sectorial substitutability estimated by Horvath (2000). We use the usual value of 0.33 for the share of capital in total income (α). In the depreciation technology, while we estimate the depreciation's sensitivity to the utilization rate (δ_2), we calibrate δ_0 to obtain 10%

⁹For this test we picked 1,000 equally spaced parameter vectors from 1.1 million accepted posterior draws that we obtained in our estimation as well as the mean values reported in Table 2. In particular we use the thresholds: 5e-7, 2.5e-8 and 1.25e-9 in the test. It is worth mentioning that to find the minimal state representation of our model we use the SLICOT library at www.slicot.org.

annual depreciation rate in steady-state and δ_1 to obtain full capacity utilization in steady-state. Following Schmitt-Grohe and Uribe (2012), we set the steady-state wage mark-up (μ) to be 15% in the US, and we use the same value for Mexico.

The coefficients for the elasticity of substitution between the traded and non-traded goods in the consumption and investment baskets (θ), are set to 0.75 for both Mexico and the US, which is the estimate obtained by Mendoza (1991). We follow Backus, Kehoe, and Kydland (1995) and set the elasticity of substitution between the domestic and foreign traded consumption goods (ω) to 1.5.

For Mexico and the US, the share of traded goods in the consumption and investment baskets (a) is set to 0.5. The weights for the non-domestic goods in the traded consumption and investment baskets (m_F , m_O , \tilde{m}_H , and \tilde{m}_O) are chosen to match four steady-state ratios: Mexico's bilateral imports and exports to GDP ratio and non-bilateral net imports to GDP ratio for both countries. The relative size of the Mexican population (n) is set to 1/3. Given our calibrated parameters, the steady-state ratio of Mexican GDP to US GDP is 5.8%, the average in our sample.

3.2 Estimated Parameters

To estimate the remaining set of parameters of the model presented in Section 2 we use the Random Walk Metropolis Hasting (RWMH) algorithm, as described in An and Schorfheide (2007). We first log-linearize the first-order conditions that describe the equilibrium of the model and solve the system of linearized rational expectations equations with the methodology of Klein (2000) jointly with the method of Hernandez (2013). The solution of the model and its relation to the data take the state-space form:

$$X_t = \Omega X_{t-1} + \Xi \epsilon_t \tag{28}$$

$$D_t = \Theta X_t + \epsilon_t^{me}, \tag{29}$$

where X_t is the vector of state variables of the model; ϵ_t is a vector that gathers the fifteen i.i.d. structural innovations in the model; the matrices Ω and Ξ represent the solution of the model; D_t is a vector containing the seventeen time series that we include in our estimation; Θ is a matrix that maps the observable variables of the model to its counterpart in the data, and ϵ_t^{me} is a vector

that gathers i.i.d. measurement errors. With the state-space representation (28-29) at hand, it is straight-forward to evaluate the likelihood function and form the posterior to implement the RWMH algorithm—see An and Schorfheide (2007).

The vector of observables for Mexico and the US respectively are

$$\begin{bmatrix} \widehat{Y}_t - \widehat{Y}_{t-1} \\ \widehat{C}_t - \widehat{C}_{t-1} \\ \widehat{I}_t - \widehat{I}_{t-1} \\ (\widehat{G}_t + \widehat{p}_{G,t}) - (\widehat{G}_{t-1} + \widehat{p}_{G,t-1}) \\ (\widehat{Y}_{H,t} + \widehat{p}_{H,t}) - (\widehat{Y}_{H,t-1} + \widehat{p}_{H,t-1}) \\ \widehat{ONMY}_t \\ \widehat{S}_t \\ \widehat{imp}_t - \widehat{imp}_{t-1} \\ \widehat{exp}_t - \widehat{exp}_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{y,t}^{me} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \epsilon_{imp,t}^{me} \\ \epsilon_{exp,t}^{me} \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} \widehat{Y}_t - \widehat{Y}_{t-1} \\ \widehat{C}_t - \widehat{C}_{t-1} \\ \widehat{I}_t - \widehat{I}_{t-1} \\ (\widehat{G}_t + \widehat{p}_{G,t}) - (\widehat{G}_{t-1} + \widehat{p}_{G,t-1}) \\ (\widehat{Y}_{F,t} + \widehat{p}_{F,t}) - (\widehat{Y}_{F,t-1} + \widehat{p}_{F,t-1}) \\ \widehat{ONMY}_t \\ \widehat{R}_t \\ \widehat{L}_t - \widehat{L}_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{\widehat{y},t}^{me} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

where we allow for measurement errors in the GDP growth and bilateral trade variables.¹⁰

We use quarterly data for Mexico and the US from the first quarter of 1994 to the fourth quarter of 2007. For both Mexico and the US, we include quarter to quarter growth rates of real GDP, consumption, investment, government spending, and manufacturing production index—deflated with the corresponding GDP deflator. We also include non-bilateral net trade (other net imports) as a fraction of GDP for both economies. For Mexico, we additionally include the quarter to quarter real growth rates of exports to and imports from the US in terms of the US basket and the J.P. Morgan EMBI+ Spread (expressed in quarterly basis). For the US, we use the growth rate of hours worked and the real interest rate (constructed using the three-month Treasury bill rate and the annual inflation measured with the US GDP deflator and expressed in quarterly basis). All variables are seasonally adjusted and demeaned. More details on the construction and the sources of the data can be found in the Data Appendix.

¹⁰Note that we have 15 structural shocks and 17 observables. We need to include measurement errors in the GDP growth series to avoid stochastic collinearity since in the linearized system GDP is a linear combination of the other observables. Moreover, allowing for measurement errors in the bilateral imports and exports improve the fit of the model for those two variables.

3.2.1 Prior Distributions

The first three columns of Table 2 summarize the prior distributions for the estimated parameters. We keep the prior distributions for the Mexican parameters as symmetric as possible to their US counterparts. In particular, we keep the prior distributions for the parameters that govern the structural shocks symmetric across countries, but we alter the prior distributions for some of the key real rigidities to accommodate the high volatility in the Mexican economy. This prior elicitation presumes that even when structural shocks are similar across economies, the key frictions of the Mexican economy amplify their volatility. Specifically, we choose asymmetric prior distributions for the working capital parameters (κ 's)—which for the US are (deterministically) set to zero—, the investment adjustment cost (ϕ) and the habit persistence parameter (φ) as described below.

[Table 2 about here.]

There is no established value for the severity of the working capital friction in the literature to guide our priors for the κ 's. For example, Neumeyer and Perri (2005) calibrate the working capital constraint parameter for the wage bill to 1, and Uribe and Yue (2006) estimate a value of 1.2.¹¹ These results imply borrowing requirements of around 66% of GDP. In a small open economy for Mexico, Chang and Fernandez (2010) estimate the working capital constraint parameter for the wage bill to be 0.69, that is, borrowing requirements of 45% of GDP. Mendoza and Yue (2012) calibrate borrowing requirements as two thirds of Argentina's M1, which is 6% of GDP. We impose a prior mean for κ 's of 0.25 which imply a prior borrowing requirement of 25% of Mexico's GDP. Formally, we adopt beta distributions with mean 0.25 and standard deviation of 0.17.

For the habit formation parameter (φ) we adopt a beta prior with mean 0.85 and standard deviation 0.1 for the US and mean 0.5 and standard deviation 0.14 for Mexico. Guided by the estimate of the wealth elasticity of labor supply (γ) for the US in Schmitt-Grohe and Uribe (2012), we assume a gamma prior with mean 0.005 and standard deviation 0.003 for both countries.

Regarding the investment technology, we assume a gamma distribution for the investment adjustment cost (ϕ) with mean 5 for the US and mean 1 for Mexico, both with standard deviation

¹¹Neumeyer and Perri (2005) calibrate their model to Argentina, and Uribe and Yue (2006) estimate the coefficient for the working capital constraint using panel data for Argentina, Brazil, Ecuador, Mexico, Peru, Philippines and South Africa.

0.7. For the sensitivity of depreciation to capital utilization (δ_2), we impose a gamma distribution with mean 1 and standard deviation 0.3 for both countries.

In the spread, government spending, and other net imports equations, we choose normal distributions for the response-to-GDP coefficient (ψ 's) to allow for positive or negative responses. For their autoregressive parameters we choose beta distributions, except for Mexican government spending for which we choose a uniform distribution to allow for a negative autocorrelation.

Turning to preference, technology, investment, wage markup and terms of trade shocks, we harmonize the persistence parameters (ρ 's) and choose a beta distribution with mean 0.5 and standard deviation 0.2. For all 15 structural shocks we choose the prior mean of the standard deviations using a calibration-like exercise where we broadly match the standard deviations of our observables while keeping the prior distributions symmetric across countries. Finally we adopt uniform distributions for the standard deviations of our four measurement errors with lower bound of zero and upper bound of 25% of the standard deviation of the corresponding observable.

3.2.2 Posterior Estimates

We use the RWHM algorithm to obtain 4 million draws from the posterior distribution of the 52 estimated parameters of our model. After burning the first 1 million, with a rejection rate of about 60%, we end up with 1.17 million accepted draws.¹²

[Figure 1 about here.]

The mean value and the 5%–95% interval of the posterior distributions we obtain are reported in the last four columns of Table 2. The working capital constraint parameters (κ 's) are among the key parameters for the transmission mechanism in our model. The estimates show that the data update our prior means for κ 's of 0.25 to a posterior mean of 0.77 for κ_N , a posterior mean of 0.87 for κ_H and a posterior mean of 0.24 for κ_E . The estimates for κ_N and κ_H are tightly concentrated around their means with 5%–95% interval of 0.58–0.92 and 0.76–0.95 respectively. The 5th percentile of these posterior distributions lie above the 95th percentile of the prior distribution, showing that the data strongly shape our posterior estimates—see Figure 1.

¹² We verify the convergence properties of the algorithm with diagnostic plots. The trace plots and the running mean plots show that the chain converges relatively quickly.

In general, our posterior estimates show that the data is informative of the parameters of the model as the posterior distributions differ from the prior distributions, with the exceptions of γ and δ_2 (see on-line appendix). In particular, our estimates on the parameters that govern the shocks processes are strongly guided by the data. Interestingly, our estimates of the variances of technology, investment and consumption shocks are comparable across the two countries.

For brevity we do not discuss the remaining parameters individually, instead we further discuss the posterior estimates in terms of their predictions of second moments, variance decompositions and historical decompositions in the next section.

4 The Effects of US Shocks in Mexico

In this section we present the main results on the transmission of US shocks to Mexico. First, we discuss the fit of the model focusing on key second moments predicted by our estimates. Then, we present the variance decomposition of observables, and show that the model predicts a significant degree of transmission of US shocks to Mexico. Third, we provide a historical decomposition of the Mexican variables into the various types of domestic and foreign shocks included in the model and analyze the driving forces of the Mexican business cycle. Finally, we analyze the roles of financial market distortions and bilateral trade in the transmission mechanism of US shocks to Mexico in our estimated model.

4.1 Model Fit

Table 3 presents the model's predictions for the standard deviations, autocorrelations, correlations against US GDP growth and correlations against Mexico's GDP growth for the seventeen observables included in our estimation and the data counterparts. The table shows the means of the posterior distributions of the second moments, calculated with 3 million posterior draws.

Overall, Table 3 shows that the model predicts second moments close to the ones observed in the data. In particular, the model captures well the standard deviations of the variables in our sample. The predicted standard deviations for GDP, consumption and investment for Mexico are 1.60, 2.22 and 5.35, while in the data they are 1.51, 2.77 and 4.23, respectively. Also, the model is able to match well the observed levels of volatility of bilateral exports and imports and output in the

traded sectors. Turning to the US, the standard deviations of GDP, consumption and investment in the US are predicted to be 0.65, 0.92 and 1.73, and in the data they are 0.47, 0.41 and 1.49. Table 3 also shows the observed and predicted serial correlations of the variables. The match between the estimated and observed autocorrelations are close for most variables, except for Mexico’s GDP, spread and imports.

[Table 3 about here.]

More importantly, Table 3 also shows that the estimated model is able to generate a cross-country correlation in GDPs that is similar to the one in the data. The predicted GDP cross-country correlation is 0.47 and it is 0.31 in the data. Justiniano and Preston (2010) discuss the inability of structural small open economy models to generate cross-country correlations, in particular when the model is estimated. By contrast, our two-economy set-up with financial frictions generates the observed cross-country correlations in GDPs as well as key variables of international transmission—i.e., bilateral trade and interest rates. The estimated model implies a correlation between bilateral exports and US GDP (Mexican GDP) equal to 0.29 (0.20), and it is 0.30 (0.31) in the data. The predicted correlation between bilateral imports and US GDP (Mexican GDP) is 0.67 (0.60), and it is 0.49 (0.67) in the data. Moreover, the model generates a correlation between the US interest rate and Mexican GDP (US GDP) equal to 0.08 (0.17) and it is 0.02 (0.19) in the data. However, the model also predicts a negative correlation between the spread and the US GDP, while it is close to zero in the data. In the next subsection we present further analysis which shows that this counter-factual correlation is not a key driver of the other correlation results discussed above, or the spillovers discussed in the next section.

4.2 Variance decomposition

Table 4 documents the mean of the percentage of the unconditional variances of our observables explained by each structural shock, computed from 3 million posterior draws. We also report the fifth and ninety fifth percentiles.

The main result of Table 4 is that US shocks as a group explain 31% of the variation in Mexico’s GDP growth, which is the second largest source of GDP growth fluctuations, only after Mexico’s own productivity shocks that explain 43%. US productivity shocks by themselves explain 23% of

the fluctuations. These results are quantitatively in line with Mackowiak (2007), who employs a VAR analysis to find that external shocks (US factors in addition to commodity prices) explain around 32% of the variation in Mexican GDP.¹³

[Table 4 about here.]

Before discussing other dimensions of the transmission of US shocks to Mexico, let us note that we obtain a sensible decomposition of the US variables. First, the Mexican shocks play no role in explaining the US fluctuations. Second, US productivity shocks account for 58% of the variation in US GDP growth, and the investment, preference and wage mark-up shocks explain 11%, 9% and 18%, respectively. These results are broadly in line with the ones obtained in previous studies (see Justiniano, Primeceri, and Tambalotti (2011), Schmitt-Grohe and Uribe (2012) and Smets and Wouters (2007), among others). Moreover, US consumption growth has a similar decomposition to the GDP growth and investment growth is mainly driven by investment-specific technology shock.

Turning to the Mexican economy, 39% of volatility in consumption growth can be explained by US shocks, 27% by domestic technology shocks and 13% by the terms of trade shock. Investment growth volatility is 75% due to the domestic investment shocks and 14% to the US shocks. The traded output growth volatility is 65% explained by domestic technology shocks and 14% by US shocks. While US shocks explain 68% of the fluctuations in imports, domestic shocks account for 22%, out of which 13% is attributed to the shock to the spread. At almost 80%, the shock to the terms of trade explains the largest fraction of fluctuations in exports, while US shocks have a non-trivial effect explaining 10% of the variation. Taken all together, these results illustrate that the transmission mechanisms embedded in the model work through all key variables in our estimation.

Finally, Table 4 shows that more than half of the fluctuations in the spread can be explained by domestic technology and demand shocks. Out of the total, 36% is attributable to the productivity shocks, and 9% is attributable to the preference shock. Moreover, 28% of the fluctuations in the spread are driven by the US shocks. These results conform with the findings in Uribe and Yue (2006), who show that the movements in the spread can be explained by domestic fundamentals, as well as the changes in the US interest rate.

¹³On the other hand, our results differ from the findings in Canova (2005), who finds that the real US demand and supply shocks do not have big effects on the Mexican economy, but that the US monetary shocks do.

In our setting, structural shocks that affect the US interest rate also affect the interest rate spread in Mexico. However, the counterfactual negative correlation of the spread with US GDP suggests that the model overestimates the US spillovers to the spread. To verify that the transmission mechanisms embedded in our model do not work through the effects of US shocks on the spread, we carry out the following exercise.

We calculate the distribution of US spillovers imposing an exogenous process for spread by setting the spread reaction coefficient to Mexico’s GDP to zero ($\psi_{s,y} = 0$ in equation 12). This experiment shuts down any possible transmission of US shocks to the Mexican economy through the spread. We find that (i) as expected the spread is only explained by the spread shock; (ii) the correlation of the spread with US GDP is zero, whereas the correlation with Mexican GDP becomes counterfactually positive and (iii) the distribution of US spillovers to the Mexican economy remain almost unchanged and the cross-country correlation results discussed above remain also unchanged.

4.3 Historical decomposition

To analyze the impact of US shocks on the Mexican economy over our sample period, we carry out a historical decomposition analysis of the Mexican variables. We use the approach in Koopman and Durbin (2000) to obtain a smoothed estimate of the i.i.d. innovations in the estimated system (28-29) at the mean values of our parameter estimates. The smoothed shocks obtained from the estimation allow for a decomposition of the data into various components due to each of the smoothed innovations such that when we feed the system (28-29) with the smoothed shocks we recover the data. This decomposition allows us to disentangle the historical effects of each structural shock on the variables.

[Figure 2 about here.]

To keep the analysis manageable, we assemble our fifteen shocks into two groups, separating US shocks from the others. In Panel A of Figure 2, we present the fraction of the variation in the growth rate of Mexico’s GDP attributed to each group.¹⁴ The decomposition shows that the

¹⁴The non-US shocks group includes the domestic shocks in Mexico and the terms of trade shock. We constructed a historical decomposition where we separated the terms of trade shock from the domestic shocks. We found that, historically, the terms of trade shock had a very small effect on the growth rate of GDP in Mexico. To simplify the exposition, we present the decomposition with only the two groups of shocks defined above.

US shocks were important throughout the sample years, and that the spillovers from the US were not limited to particular events like recessions. On average, the US shocks account for 30% of the fluctuations in the growth rate of GDP in Mexico over the sample years. It is interesting to note that the decline in the growth rate during Mexico's Tequila crisis of 1995 is mainly explained by the domestic shocks, and that the US shocks have a small effect during that period (around 12%). By contrast, the US shocks explain a larger fraction of the decline in the growth rates of Mexican variables during the 2001 recession. In the first and second quarters of 2001, US shocks account for approximately 40% and 58% of the decline in GDP, respectively.

To further disentangle the expansionary effects from the contractionary effects of US spillovers to Mexico's GDP in our sample, we feed the model with estimates of only the smoothed innovations of US shocks and plot the predicted GDP growth rates against the actual series in Panel B of Figure 2. We find that the US shocks as a group were key drivers of not only the decline in Mexico's GDP during 2001, but also key driving forces in the growth of Mexico's GDP during the late 1990s—expansion years for the US economy. In particular, we find that a counterfactual stabilization of the US economy would have resulted in annual growth losses for Mexico averaging 1.13 percentage points during the expansion years of the US economy (1994:1-1999:4). On the other hand, during 2001 Mexico's GDP would have grown an additional 3 percentage points had the US recession been stabilized.

4.4 The transmission mechanism of spillovers: the roles of trade and financial frictions

The model described in Section 2 contains two key channels for transmission of US shocks to Mexico: the trade channel and the interest rate channel. These two channels are simultaneously in effect throughout the business cycle. To illustrate these channels, suppose there is a positive supply shock in the US that increases US income. The standard trade channel implies that the positive wealth effect will increase US demand for imports from Mexico. To meet the higher demand, Mexican firms increase production and exports, which increases income in Mexico. Higher income, coupled with cheaper US goods, allow Mexican households to consume and invest more. This transmission through the trade channel gets amplified by changes in the interest rate. The positive supply shock in the US lowers the international interest rate, which in turn reduces the cost of borrowing in

Mexico. With lower cost of borrowing, working capital loans become cheaper yielding a lower marginal cost of production and thus acting like a positive supply shock in Mexico.¹⁵

To illustrate the importance of working capital frictions and trade in facilitating spillovers, we conduct two counter-factual experiments. In the first one, we analyze how the spillovers would change if Mexico were to diversify trading partners, and lower trade with the US by 50%. To do so, we reduce the steady-state values of bilateral imports and exports (as fractions of GDP) by 50%, and reallocate those shares to the steady state value of non-bilateral trade, keeping total trade constant. Given the new steady-state configuration, we calculate the counter-factual spillovers the model generates using the full set of posterior draws and compare them with our estimated spillovers. The distribution of spillovers to Mexico's GDP growth in the actual and counter-factual cases are displayed in Panel A of Figure 3. The figure shows that the distribution of spillovers shifts uniformly to the left lowering the mean spillovers from 31% to 26%.

[Figure 3 about here.]

In the second counter-factual experiment we analyze how the results would change if the estimated values of the working capital constraint parameters were lowered by 50%. This would reduce the total borrowing requirements from 87% to 44% of GDP. The distribution of the implied counter-factual and estimated spillovers are shown in the lower panel of Figure 3. The spillovers from the US go down from 31% to 15%. The two counter-factual experiments together imply that the transmission mechanism in the estimated model is more responsive to changes in the borrowing requirements than changes in bilateral trade.

Finally, when we counterfactually set all κ 's to zero we find that the model predicts a zero correlation of the Mexican variables with the US GDP as well as zero spillovers from the US to Mexico in the variance decomposition. This is precisely the result in Justiniano and Preston (2010) in a model with no working capital requirements. Moreover, Justiniano and Preston show that when the estimated model predicts close to zero correlations, then the correlations observed in the data are captured by correlated smoothed innovations—which are assumed orthogonal. Using the threshold value in Justiniano and Preston (2010), our estimated smoothed shocks show no significant cross-country correlations.

¹⁵See impulse responses in the on-line appendix.

5 Conclusion

To analyze the transmission of structural US shocks to emerging markets, we set-up an asymmetric two-country real business cycle model. We assume that the EME differs from the US economy in three aspects: the size of the economy is smaller; it is perceived to be riskier by international lenders; and its domestic producers face credit market imperfections in the form of working capital constraints. The two countries are linked through bilateral trade of consumption and investment goods, as well as an interest parity condition in which the EME pays a risk-premium over the US interest rate.

We estimate the model using seventeen quarterly time-series for Mexico and the US from 1994.I to 2007.IV. The estimated model correctly predicts key cross-country correlations that are observed in the data. The underlying transmission mechanism that allows for the cross-country correlations also imply a significant degree of transmission of shocks from the US to Mexico. The US productivity shocks are the most important source of spillovers, explaining 25% of the GDP growth fluctuations in Mexico. Taken all together, US shocks generate 31% of the volatility of Mexico's GDP. This is the second largest source of GDP growth volatility, only after domestic productivity shocks that explain 43%. A historical decomposition of the data shows that the transmission of shocks occurred both during expansions and contractions in the US. In particular, the expansion in the US during the 1990s contributed to Mexico's growth by one percentage point on average. On the other hand, the 2001 recession in the US led to a reduction of three percentage points in Mexico's growth for that year.

The working capital constraint parameters are the most important feature that allows the model to capture the cross-country correlations (and spillovers) in the data. The identification test of Komunjer and Ng (2011) shows that our estimated parameters are identified. Moreover, our posterior estimates shows that the data is very informative regarding the working capital constraint parameters. Interestingly, when this market imperfection is eliminated by counter-factually setting the working capital constraint parameters to zero, the predicted cross-country correlations and spillovers disappear, generating results similar to the ones in Justiniano and Preston (2010) for a standard small open economy model. Thus, we find the working capital friction to be an important component of the international transmission mechanism.

6 Data Appendix

The following variables we include in our estimation for Mexico are taken from IFS and they are deflated using the GDP deflator:

- Y : Gross domestic product
- C : Household consumption expenditure
- I : Gross capital formation plus change in inventories
- G : Government consumption expenditure

The following variables we include in our estimation for the US are taken from the NIPA tables and they are deflated using the GDP deflator:

- \tilde{Y} : Gross domestic product
- \tilde{C} : Personal consumption expenditures
- \tilde{I} : Gross private domestic investment
- \tilde{G} : Government consumption expenditures and gross investment

The variables corresponding to tradable output in Mexico and US are:

- Y_H : Manufacturing production index (source: INEGI)
- Y_H : Industrial production and capacity utilization index (source: Board of Governors of the Federal Reserve System)

We take the bilateral trade variables from INEGI in US dollars. We add the 3 months in the quarter, annualize and deflate them using the GDP deflator for the US.

- exp : Mexico's exports to the US
- imp : Mexico's imports from the US

The other net imports to GDP ratios for Mexico and the US are calculated as follows:

- $onmy$: $(\text{Total imports}-\text{total exports})/\text{GDP}-(\text{imp}-\text{exp})\cdot\text{Erate}/\text{GDP}$; Erate: nominal exchange rate from IFS; Total imports, exports from IFS
- $on\tilde{m}y$: $(\text{Total imports}-\text{total exports})/\text{GDP}-(\text{exp}-\text{imp})/\text{GDP}$; Total imports and exports from NIPA tables.

We remove a linear trend for both ratios.

The remaining variables are:

- \tilde{L} : average weekly hours of all employees; source: Bureau of Labor Statistics
- S : J.P. Morgan EMBI+ Spread (expresses in quarterly basis).
- \tilde{R} : US real interest rate calculated as the difference between the 3-month Tbill rate (average in the quarter) from FRED (St Louis Fed) and the average of 4-period inflation. Expressed in quarterly basis.

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Table 1: Calibrated Parameters

Parameter	Description	Mexico	US
σ	Coeff. of risk-aversion	1	1
$\frac{1}{\eta}$	Labor elasticity	0.5	0.5
χ	Cross-labor elasticity of substitution	2	2
β	Discount factor	0.96	0.98
α	Capital share	0.33	0.33
$\bar{\delta}$	Steady-state depreciation	0.025	0.025
θ	Elasticity of substitution T and N	0.75	0.75
ω	Elasticity of substitution H , F and O	1.5	1.5
π	Portfolio adjustment cost	0.05	0.05
μ	Steady-state wage mark-up	0.15	0.15
a	Share of T goods in the C and I baskets	0.5	0.5
n	Relative Mexican population	1/3	

Parameters chosen to match the steady-state ratios to average ratios from the data:

Steady-state ratio	Description	Mexico	US
$\tilde{m}_H, m_F, m_O, \tilde{m}_O$			
$\frac{p_F [C_F + X_{TF} + X_{NF}]}{Y}$	Bilateral imports to GDP ratio	0.164	
$\frac{1}{n} \frac{\tilde{p}_H [\tilde{C}_H + \tilde{X}_{TH} + \tilde{X}_{NH}]}{Y}$	Bilateral exports to GDP ratio	0.214	
$\frac{p_O [C_O + X_{TO} + X_{NO}]}{Y}$	Other net imports to GDP ratio	0.058	
$\frac{\tilde{p}_O [\tilde{C}_O + \tilde{X}_{TO} + \tilde{X}_{NO}]}{Y}$	Other net imports to GDP ratio		0.034
$\frac{nY}{eY}$	Mexican GDP to US GDP ratio	0.058	

Table 2: Prior and Posterior Parameter Values

Param.	Dist.	Prior		Mexico Posterior			US Posterior		
		mean	s.d.	mean	5%	95%	mean	5%	95%
Working Capital Constraint									
κ_N	β	0.250	0.173	0.774	0.584	0.918			
κ_H	β	0.250	0.173	0.870	0.756	0.954			
κ_E	β	0.250	0.173	0.236	0.078	0.408			
Preference Parameters									
φ	β	0.500	0.141	0.009	0.004	0.016			
$\tilde{\varphi}$	β	0.850	0.100				0.214	0.185	0.242
γ	Γ	0.005	0.003	0.005	0.001	0.011	0.008	0.002	0.016
Invest. Technology									
ϕ	Γ	1.000	0.707	0.390	0.275	0.566			
$\tilde{\phi}$	Γ	5.000	0.707				4.643	3.599	5.792
δ_2	Γ	1.000	0.316	0.955	0.501	1.519	0.868	0.411	1.438
Government Spending									
$\psi_{G,Y}$	\mathcal{N}	0.150	0.100	0.135	-0.011	0.283			
ρ_{ξ_G}	\mathcal{U}	0.000	0.289	-0.395	-0.487	-0.268			
$\tilde{\psi}_{G,Y}$	\mathcal{N}	0.000	0.100				-0.062	-0.164	0.045
$\tilde{\rho}_{\xi_G}$	β	0.500	0.200				0.199	0.074	0.342
σ_G	Γ	1.000	0.316	3.855	3.405	4.372	0.877	0.698	1.103
Non-bilateral Trade									
ρ_{onm}	β	0.850	0.100	0.893	0.818	0.962	0.943	0.889	0.984
$\psi_{onm,y}$	\mathcal{N}	-0.150	0.100	0.123	-0.021	0.262	0.081	-0.024	0.191
σ_{onm}	Γ	0.300	0.100	0.417	0.353	0.489	0.266	0.225	0.314
EMBI+ Spread									
ρ_s	β	0.850	0.100	0.235	0.203	0.270			
$\psi_{s,y}$	\mathcal{N}	-0.030	0.032	-0.285	-0.314	-0.258			
σ_{ξ_s}	Γ	0.100	0.032	1.019	0.882	1.162			
Preference Shocks									
ρ_{ξ_c}	β	0.500	0.200	0.317	0.095	0.606	0.679	0.482	0.856
σ_{ξ_c}	Γ	2.000	0.447	2.557	1.673	3.550	1.832	1.479	2.268
Wage Markup Shock									
$\tilde{\rho}_{mu}$	β	0.500	0.200				0.279	0.138	0.418
$\tilde{\sigma}_{mu}$	Γ	1.000	0.316				1.448	1.079	1.918
Technology Shocks									
ρ_{ξ_i}	β	0.500	0.200	0.749	0.627	0.897	0.851	0.770	0.917
ρ_{AN}	β	0.500	0.200	0.022	0.006	0.048	0.242	0.200	0.285
ρ_{AH}	β	0.500	0.200	0.026	0.006	0.053	0.177	0.119	0.232
σ_{ξ_i}	Γ	4.000	0.632	3.704	2.958	4.586	4.968	4.057	6.029
σ_{AN}	Γ	0.100	0.032	1.249	1.132	1.373	1.002	0.911	1.098
σ_{AH}	Γ	0.100	0.032	1.083	0.974	1.192	0.679	0.610	0.754
$\sigma_{AN,AH}$	Γ	0.100	0.032	0.061	0.033	0.095	0.043	0.023	0.068
Terms of Trade Shock									
$\rho_{\xi_{tot}}$	β	0.500	0.200	0.193	0.089	0.300			
σ_{tot}	Γ	1.000	0.316	3.318	2.820	3.880			
Measurement Errors									
σ_Y	\mathcal{U}	0.189	0.109	0.376	0.374	0.377			
$\sigma_{\tilde{Y}}$	\mathcal{U}	0.059	0.034				0.118	0.117	0.118
σ_{exp}	\mathcal{U}	0.449	0.259	0.889	0.873	0.896			
σ_{imp}	\mathcal{U}	0.548	0.316	1.092	1.083	1.096			

Note: We show the parameter label for Mexico only when the parameter in both countries share the same priors. Estimates are based on 3 million draws from the posterior distribution.

Table 3: Model Fit

	ΔY	ΔC	ΔI	ΔG	$\Delta \tilde{Y}_H$	$onmy$	S	Δimp	Δexp	$\Delta \tilde{Y}$	$\Delta \tilde{C}$	$\Delta \tilde{I}$	$\Delta \tilde{G}$	$\Delta \tilde{L}$	$\Delta \tilde{Y}_F$	$on\tilde{my}$	\tilde{R}
	Standard Deviations																
DATA	1.51	2.77	4.23	6.63	2.30	0.79	0.26	4.38	3.59	0.47	0.41	1.49	0.68	0.58	0.97	0.69	0.44
MODEL	1.60	2.22	5.35	6.02	1.65	0.92	0.39	3.59	3.69	0.65	0.92	1.73	0.72	0.55	0.69	0.89	0.72
	Correlation with US GDP growth ($\Delta \tilde{Y}$)																
DATA	0.31	0.20	0.33	0.12	0.20	-0.10	0.04	0.49	0.30	1.00	0.45	0.60	0.03	0.42	0.59	-0.17	0.19
MODEL	0.47	0.50	0.21	0.03	0.32	0.03	-0.46	0.67	0.29	1.00	0.85	0.15	-0.05	0.63	0.79	0.00	0.17
	Correlation with Mexico GDP growth (ΔY)																
DATA	1.00	0.62	0.86	0.21	0.84	-0.02	-0.35	0.67	0.31	0.31	0.22	0.25	-0.06	0.30	0.28	-0.09	0.02
MODEL	1.00	0.84	0.30	0.25	0.77	0.04	-0.73	0.60	0.20	0.47	0.48	-0.06	-0.11	0.24	0.40	-0.01	0.08
	Autocorrelation																
DATA	0.27	0.03	0.45	-0.19	0.10	0.86	0.77	0.39	0.20	0.17	0.25	0.60	0.11	0.58	0.69	0.93	0.97
MODEL	0.01	0.01	0.67	-0.40	0.06	0.89	0.23	0.12	0.18	0.39	0.44	0.67	0.18	0.49	0.34	0.94	0.88

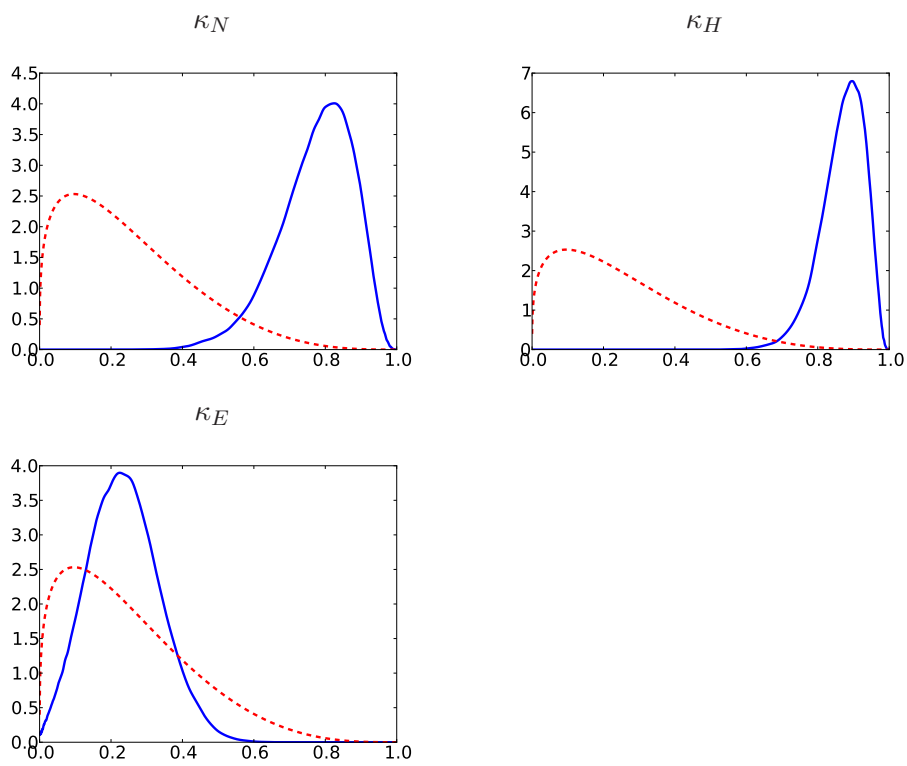
Note: We report the mean of the posterior distributions of the corresponding second moments calculated using 3 million draws.

Table 4: Variance Decomposition (Unconditional Variance)

	Mexico							Bilateral		US							
	ΔY	ΔC	ΔI	ΔG	ΔY_H	$onmy$	S	Δimp	Δexp	$\Delta \tilde{Y}$	$\Delta \tilde{C}$	$\Delta \tilde{I}$	$\Delta \tilde{G}$	$\Delta \tilde{L}$	$\Delta \tilde{Y}_F$	$on\tilde{m}y$	\tilde{R}
ξ_{AN}, ξ_{AH}	42.9	27.0	3.3	0.4	64.7	0.3	35.9	1.8	2.8	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	[36.2 49.4]	[22.9 31.3]	[1.6 5.3]	[0.0 1.1]	[52.6 74.9]	[-0.0 1.0]	[29.7 42.1]	[1.3 2.4]	[1.8 3.9]	[0.0 0.1]	[0.1 0.1]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[-0.0 0.0]	[0.0 0.0]
ξ_I	1.4	4.2	75.0	0.0	2.9	3.1	3.6	6.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	[0.8 2.5]	[2.9 5.8]	[65.7 83.8]	[0.0 0.0]	[1.9 4.6]	[-0.0 10.1]	[2.2 6.0]	[4.6 8.6]	[0.3 0.6]	[0.0 0.0]	[0.0 0.1]	[0.0 0.1]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[-0.0 0.0]	[0.1 0.2]
ξ_C	10.9	6.6	1.2	0.1	14.0	0.2	9.0	0.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	[3.0 21.5]	[1.9 13.1]	[0.4 2.4]	[0.0 0.4]	[3.7 27.8]	[-0.0 0.6]	[2.4 17.7]	[0.1 0.5]	[0.2 1.4]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[-0.0 0.0]	[0.0 0.0]
ξ_S	4.3	8.5	1.0	0.1	1.5	0.0	19.8	12.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	[2.8 6.0]	[5.9 11.4]	[0.5 1.7]	[0.0 0.2]	[0.8 2.3]	[-0.0 0.1]	[14.6 25.5]	[9.3 16.9]	[0.0 0.8]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[-0.0 0.0]	[0.0 0.0]
ξ_G	3.5	0.8	0.4	99.1	0.1	0.1	3.1	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	[2.5 4.7]	[0.5 1.1]	[0.2 0.6]	[97.4 100.0]	[0.1 0.2]	[-0.0 0.2]	[2.2 4.1]	[0.2 0.4]	[0.2 0.5]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[-0.0 0.0]	[0.0 0.1]
ξ_{onm}	0.0	0.0	0.0	0.0	0.0	94.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	[0.0 0.0]	[0.0 0.0]	[0.0 0.1]	[0.0 0.0]	[0.0 0.0]	[82.3 100.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[-0.0 0.0]	[0.0 0.0]
ξ_{tot}	0.5	13.6	5.0	0.0	2.2	0.0	0.4	0.5	79.8	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.1
	[0.3 0.8]	[10.1 17.6]	[2.3 8.3]	[0.0 0.0]	[1.5 3.2]	[-0.0 0.1]	[0.2 0.6]	[0.3 0.7]	[70.5 87.1]	[0.0 0.0]	[0.2 0.4]	[0.0 0.0]	[0.0 0.0]	[0.0 0.1]	[0.0 0.1]	[-0.0 0.0]	[0.1 0.2]
$\tilde{\xi}_{AN}, \tilde{\xi}_{AF}$	23.5	29.6	4.4	0.2	11.2	0.6	21.1	47.5	7.9	58.3	50.8	0.4	2.1	1.1	64.9	0.1	21.2
	[18.3 28.8]	[24.5 34.8]	[2.7 6.4]	[0.0 0.7]	[7.6 15.1]	[-0.0 2.1]	[15.9 26.5]	[42.0 52.8]	[2.9 14.4]	[51.6 64.6]	[44.3 57.1]	[0.2 0.6]	[-0.0 7.2]	[0.6 2.0]	[57.4 71.9]	[-0.0 0.3]	[16.8 26.1]
$\tilde{\xi}_I$	0.5	0.4	7.2	0.0	0.5	1.0	1.0	4.8	0.1	10.7	22.1	97.0	0.0	2.9	9.9	5.7	49.3
	[0.4 0.8]	[0.2 0.6]	[4.9 9.8]	[0.0 0.0]	[0.3 0.6]	[-0.0 3.1]	[0.7 1.4]	[3.5 6.4]	[0.0 0.3]	[7.0 15.4]	[16.2 28.8]	[92.2 99.2]	[0.0 0.0]	[1.7 4.4]	[6.4 14.4]	[-0.0 21.1]	[40.7 57.8]
$\tilde{\xi}_C$	3.6	5.8	2.0	0.0	1.2	0.3	3.1	10.9	0.6	9.4	9.8	2.5	0.7	36.7	8.8	0.5	26.2
	[1.7 6.9]	[3.1 10.3]	[1.0 3.4]	[0.0 0.1]	[0.5 2.5]	[-0.0 0.9]	[1.3 6.1]	[6.0 18.3]	[0.1 1.6]	[4.8 15.1]	[6.0 14.6]	[0.5 7.1]	[-0.0 2.3]	[20.8 53.2]	[4.3 14.4]	[-0.0 1.8]	[19.2 34.2]
$\tilde{\xi}_{mu}$	3.0	3.2	0.4	0.0	1.4	0.1	2.6	4.8	1.2	18.0	16.5	0.0	0.7	59.1	16.3	0.0	2.4
	[2.0 4.2]	[2.1 4.6]	[0.2 0.7]	[0.0 0.1]	[0.9 2.2]	[-0.0 0.2]	[1.7 3.8]	[3.1 7.0]	[0.5 2.2]	[12.4 25.0]	[11.3 23.0]	[0.0 0.1]	[-0.0 2.4]	[42.5 75.6]	[11.0 22.8]	[-0.0 0.1]	[1.5 3.6]
$\tilde{\xi}_G$	0.3	0.3	0.1	0.0	0.1	0.0	0.2	0.5	0.1	0.2	0.4	0.0	96.5	0.2	0.1	0.0	0.3
	[0.2 0.4]	[0.2 0.5]	[0.0 0.1]	[0.0 0.0]	[0.1 0.2]	[-0.0 0.0]	[0.2 0.3]	[0.4 0.7]	[0.0 0.1]	[0.1 0.2]	[0.3 0.5]	[0.0 0.0]	[88.2 100.0]	[0.1 0.3]	[0.0 0.1]	[-0.0 0.0]	[0.2 0.5]
$\tilde{\xi}_{onm}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.7	0.2
	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[0.0 0.0]	[77.8 100.0]	[0.0 0.4]
m.e.	5.6	–	–	–	–	–	–	9.4	5.9	3.4	–	–	–	–	–	–	–
	[4.7 6.5]							[8.0 10.8]	[4.6 7.3]	[2.9 3.9]							

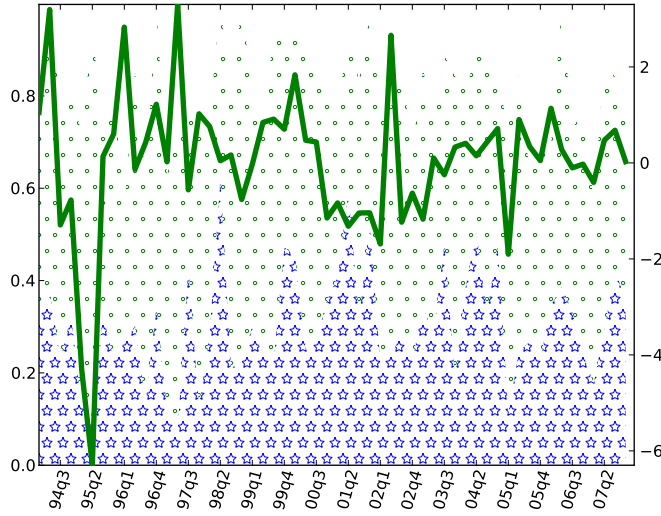
Note: We report the mean of the posterior distributions of the corresponding shares calculated using 3 million draws. The 5%–95% posterior intervals are shown in brackets.

Figure 1: Estimated Posterior Densities for Borrowing Requirements

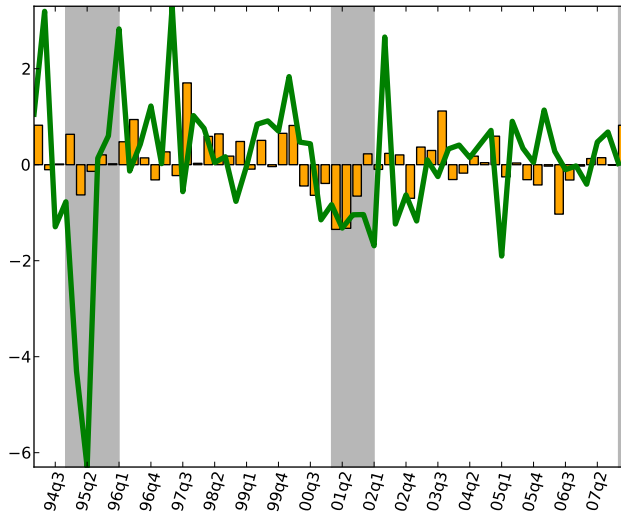


Note: Solid line is the posterior density and dashed line is the prior density. Distributions are calculated using 3 million draws.

Figure 2: Historical Contribution of US Shocks in Mexico's GDP Growth Volatility

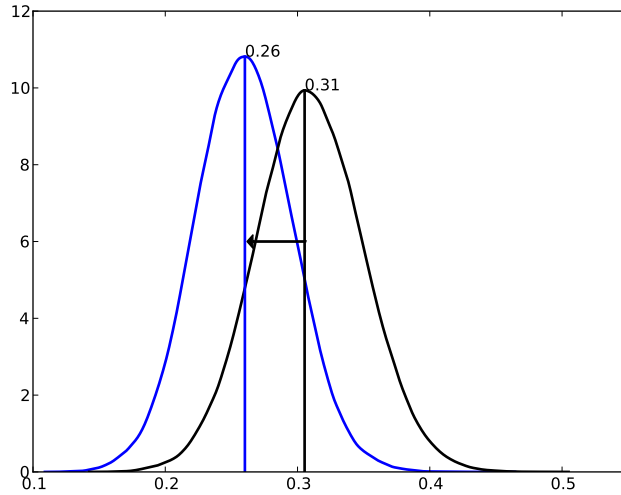


(A) Area marked with \star shows US shocks' total contribution to GDP's quarter-to-quarter growth changes. Area marked with \circ shows the contribution of other shocks. White area is the contribution of m.e. Solid line shows the actual GDP growth.

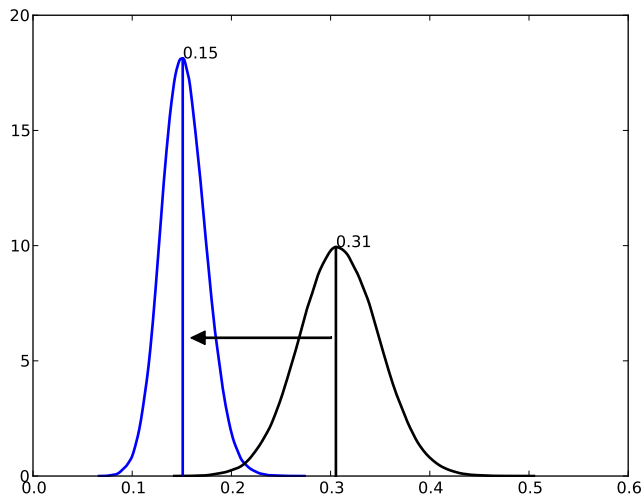


(B) Bars show the predicted Mexico's GDP quarter-to-quarter growth from US shocks only. Solid line shows actual GDP growth. The first shaded area covers the 1995 Tequila crisis, the second covers the 2001 US recession and the last shaded area covers the onset of the US financial crisis.

Figure 3: Counterfactual Experiments



(A) The figure shows the shift in the distribution of the fraction of volatility of GDP growth in Mexico explained by the US shocks when bilateral imports and exports are reduced by 50%.



(B) The figure shows the shift in the distribution of the fraction of volatility of GDP growth in Mexico explained by the US shocks when working capital requirements are reduced by 50%.