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 markets. Using 17 quarterly time series for Mexico and the US from 1994.I to 2007.IV, we estimate a subset of the parameters of the model, including key parameters that define the shocks and frictions. We find that at business cycles frequencies US shocks explain 40% of the volatility in the growth rate of Mexico’s GDP, and 30% of the volatility in consumption’s growth rate. A historical decomposition of the data shows that the transmission of shocks occur throughout the business cycles in the sample. In particular, it shows that Mexico’s growth substantially benefited from the US growth in the second part of the 1990s, but it was adversely hit by the 2001 US recession. By contrast, during the 1994-1995 Tequila crisis, Mexican economy’s poor performance was driven only by domestic shocks. Counter-factual experiments show that spill-overs from the US would be lower if the financial market imperfections were less stringent in Mexico, and/or if part of the bilateral trade were diversified with the rest of the World.

Key Words: Emerging market business cycles; transmission of foreign shocks; Bayesian estimation

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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 spill-overs. 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 small open economies, the standard small open economy models have had a difficult time generating the spill-overs in the data.\(^1\) In the context of international business cycle models, 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 the US output shocks. Other studies concur that the standard trade mechanism fails to generate the spill-overs and the co-movement in the data, and enrich the trade linkages in the model.\(^2\) For example, (Kose and Yi (2006)) include a rich set of frictions and trade with a third country, where as Burnstein, Kurz, and Tesar (2008), and Comin, Loayza, Pasha, and Serven (2009) incorporate product sharing and product cycles, respectively. Moreover, estimating a small open economy model for Canada, Justiniano and Preston (2010) demonstrates that the inability of the model to generate spill-overs becomes more acute when the model is estimated. In short, there is no standard framework in the literature to evaluate the transmission of shocks in developed economies to the EMEs.

We contribute to the literature by developing and estimating a model to quantify the extent of spill-overs of structural US shocks to the EMEs. Furthermore, we analyze the historical importance of US shocks in driving the EME, business cycles and examine the roles of trade linkages and financial imperfections in facilitating the transmission of various structural shocks.

\(^1\)See e.g., Mackowiak (2007) and Canova (2005) for transmission of US shocks to EMEs, documented using VAR analyses.

\(^2\)The conventional trade channel in international business cycle models propagates shocks through changes in international prices, which in turn affect imports and exports (see Backus, Kehoe, and Kydland (1995); Heathcote and Perri (2002)).
To that end, we develop an asymmetric two-country real business cycle model, where one of the economies is characterized as the emerging market and the other one represents the US. The asymmetries arise due to the differences in the size and 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 through borrowing and lending in the international markets. 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. In order to allow for a similar mechanism, we introduce the financial market frictions adopted in those two papers. We assume 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. Changes in the country spread and the US interest rate affect production of the traded and the non-traded goods in the emerging market due to a working capital constraint. We assume that the firms in both sectors, as well as the exporting firms, need to borrow in order to cover a fraction of their payments at the beginning of the period, before the revenues are realized. Consequently, fluctuations in the interest rate affect the cost of borrowing, which in turn affects the production decisions.

We estimate the model using Bayesian estimation techniques with seventeen quarterly time series for Mexico and the US from 1994 to 2007. In our specification we include the shocks that have been commonly used in the previous empirical studies (productivity, preference, investment, government spending and wage mark-up shocks). We augment the standard set of shocks with three other shocks that potentially can be important. Motivated by the findings in Corsetti, Dedola, and Leduc (2009), we include a traded goods sector-specific productivity shock. Additionally, we include a terms of trade and a country risk shock in order to cap-
ture additional sources of uncertainty EMEs face in the international markets. We estimate the parameters of the shock processes in addition to the parameters that determine the real rigidities, such as habit persistence and working capital requirement. Using the estimates from the model, we address the following questions: (i) What are the driving forces of the Mexican business cycle? (ii) What is the historical impact of the US shocks on the Mexican economy? (iii) What are the roles of trade linkages and financial market distortions in exposing the Mexican economy to the US shocks?

We find that 40% of Mexican GDP’s volatility is caused by the US disturbances. Almost all of this foreign impact comes from the productivity shocks in the US, accounting for 37% of the variations in Mexican GDP. US shocks also explain significant amounts of variation in the growth rates of consumption, bilateral imports and exports in Mexico. Moreover, the US disturbances account for 87% of the fluctuations in the Mexican real interest rate, that is, as in the small open economy paradigm, Mexican interest rate is mostly exogenous to the country.

A historical decomposition of the data shows that the spill-overs from the US remain relevant in every quarter of our sample, implying that these are not special events. Moreover, it also illustrates how Mexico’s growth substantially benefited from the US growth in the second part of the 1990s. Specifically, the US shocks contributed to the growth rate of Mexican GDP by 2.26 percentage points over the 1994-2000 period. On the other hand, the growth rate was reduced by 5.17 percentage points during 2001 as a result of the US recession. In contrast to the 2001 recession, during the 1994-1995 Tequila crisis, Mexico economy’s shrank solely due to the domestic disturbances.

In the model, the US shocks get transmitted to the Mexican economy through the usual bilateral trade channel (through changes in the US demand for the Mexican good, and through changes in the prices of the US traded good that Mexican households purchase), as well as through changes in the real interest rate. As the US productivity shocks explain the majority of the variation in the Mexican interest rate, innovations in the US productivity lead to changes in the Mexican interest rate. Due to the market imperfection, which requires the Mexican firms to finance a part of their production with loans, changes in the real interest rate affect production and exporting decisions. This impact of the real interest rate on firms intensifies
the spill-overs from US to Mexico.

In order to analyze the importance of the financial market imperfection and trade in facilitating spill-overs, we conduct two counterfactual experiments. In the first one, we analyze how the spill-overs would change if Mexico were to diversify trading partners by reducing bilateral trade between the US and Mexico by 25%, and reallocating those trade shares to the rest of the World. The results of the experiment shows that if Mexico were to diversify bilateral trade with the US to other countries, spill-overs from the US would be lower. Specifically, the spill-overs would be lower approximately by 8 percentage points at the mean of the distributions. In the second counter-factual experiment, we examine how the results would change if the credit market imperfections were less severe by relaxing the working capital constraints by 25%. Through lower working capital requirements, spill-overs are mitigated by 10 percentage points at the mean of the distribution, as the interest rate fluctuations affect the Mexican economy by less.

The results from the counter-factual exercises show that point to financial market imperfections as factors that exacerbate the EMEs’ exposure to foreign shocks, which arises due to the fact that the real interest rate in Mexico is mostly explained by the economic conditions in the US, and due to trade linkages. This mechanism that is in effect both in the short-term and medium-term, complements the transmission mechanism in Comin, Loayza, Pasha, and Serven (2009), who show that a significant amount of transmission from US to Mexico in the medium-term can be explained by international diffusion of technologies through FDI.

Our results as closely related to and complement the findings in Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011), Garcia-Cicco, Pancrazi, and Uribe (2010), Neumeyer and Perri (2005) and Uribe and Yue (2006) who emphasize the role of EMEs’ financial markets imperfections as a key mechanism in shaping their business cycles. Additionally, the questions we ask in this paper are similar to the ones in Comin, Loayza, Pasha, and Serven (2009), who focus on international diffusion of technologies through FDI as a transmission mechanism of shocks. Where as they obtain spill-overs from US to Mexico in the medium-term through a calibration exercise, we estimate the model and find significant transmission over the full business cycle.
Our study is also related to the growing literature that estimates open economy models with Bayesian techniques. In particular, our set-up is similar to recent examples that estimate two country models, such as Lubik and Schorfheide (2006) and Rabanal and Tuesta (2010) (both for the Euro Area-US pair). Additionally, it is related to recent examples that estimate small open economy models for emerging markets, such as Chang and Fernandez (2010). Combining elements from both set-ups, to the best of our knowledge, our paper is the first to estimate a two country model for an EME coupled with the US economy.

The rest of the paper is organized as follows. In the next section, we present 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. In section 4, we present our main result on spill-overs using a variance decomposition and historical decompositions. We also present counter-factual experiments to illustrate the importance of US shocks for the growth gains/losses, and how the transmission changes when the level of bilateral trade and the severity of market imperfections are reduced. 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 on the interval [0,1]; a fraction \( n \) of the households belongs to the home country, while \( 1 - n \) belongs to the US. 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 can trade goods with the rest of the world. In order to partially finance expenditures, the 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 in the home country 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 are given by

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \xi_{C,t} \left[ (C_t - \varphi \bar{C}_t) - \frac{L_{t+1}}{\theta+1} \right]^{1-\sigma} - 1,$$

where $C_t$ denotes the composite consumption index, $L_t$ is the composite labor supply, and $\xi_{C,t}$ is the preference shock. As in Abel (1990), the preferences exhibit habit persistence, where $\varphi \in (0,1)$ measures the degree of external habit formation, and $\bar{C}_t$ denotes average consumption of all domestic households. The composite labor supply is defined as

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

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 home non-traded good (N good). We assume that the labor efforts in the traded and the non-traded sectors are imperfect substitutes, where $\frac{1}{\chi}$ is the elasticity of substitution between the two.

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

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

where $a$ is the weight of traded goods in the consumption basket, and $\theta_c$ is the elasticity of substitution between the traded and the non-traded goods. The traded goods bundle is composed of the domestic traded good (H-good), $C_H$, and the foreign traded good (F-good) produced in the US, $C_F$, and a third good produced in the rest of the world, $C_O$. The traded consumption basket is given by:

$$C_{T,t} = \left[ m_{H}^{1/\theta_c} C_{H,t}^{\frac{\theta_c-1}{\theta_c}} + m_{F}^{1/\theta_c} C_{F,t}^{\frac{\theta_c-1}{\theta_c}} + m_{O}^{1/\theta_c} C_{O,t}^{\frac{\theta_c-1}{\theta_c}} \right]^{\frac{\theta_c}{\theta_c-1}},$$
where $m$’s denote the weights of the three goods in the traded goods’ basket, and $\omega_c$ is the elasticity of substitution between the traded goods.

Households own the capital stocks in both the traded and the non-traded sectors, determine their rate of utilization, and rent them out to firms. In adjusting the capital stock, the household pays 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:

$$K_{j,t} = (1 - \delta(u_{j,t}))K_{j,t-1} + \xi_{I,t}I_j \left[ 1 - \frac{\phi_j}{2} \frac{I_{j,t}}{I_{j,t-1}} - 1 \right]^2$$ (5)

where $I_{j,t}$ is the composite investment good, $\xi_{I,t}$ is the investment shock common to the traded and non-traded sectors, and $\phi_j$ determines the cost of adjustment. The rate of capital depreciation, $\delta(u_{j,t})$, depends on the intensity with which the capital stock is utilized, which in turn is determined by the households. We adopt the following convex function for the depreciation rate

$$\delta(u_{j,t}) = \delta_{j,0} + \frac{\nu_j + 1}{\nu_j + \frac{\nu_j}{\nu_j + 1}}$$ (6)

where $\delta_{j,1} > 0$ and $\nu_j > 0$.

To form a unit of investment in either sector, the household uses the non-traded good ($N$), as well as a basket of traded goods, formed by all three types of traded goods– the home traded good ($H$), the US traded good ($F$) and the other foreign good ($O$). In particular, the composite investment good in sector $j = \{H, N\}$ is formed with the following CES aggregator:

$$I_{j,t} = \left[ a_{jN}^{\theta_I} X_{jN,t}^{\theta_I - 1} + a_{jT}^{\theta_I} X_{jT,t}^{\theta_I - 1} \right]^{\frac{\theta_I}{\theta_I - 1}},$$ (7)

where $a_{jN}(a_{jT})$ measures the weight of the non-traded (traded) goods in the particular investment basket, and $\theta_I > 0$ measures the degree of substitutability between the traded and non-traded goods in producing the investment basket. $X_{jN,t}$ 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, and it is given by:

$$X_{jT,t} = \left[ m_{jF}^{\frac{1}{\omega_I}} X_{jF,t}^{\frac{\omega_I - 1}{\omega_I}} + m_{jH}^{\frac{1}{\omega_I}} X_{jH,t}^{\frac{\omega_I - 1}{\omega_I}} + m_{jO}^{\frac{1}{\omega_I}} X_{jO,t}^{\frac{\omega_I - 1}{\omega_I}} \right]^{\frac{\omega_I}{\omega_I - 1}},$$ (8)
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

$$
e_t d_t = - \left[ w^*_{H,t} L_{H,t} + w^*_{N,t} L_{N,t} + z_{H,t} u_{H,t} K_{H,t-1} + z_{N,t} u_{N,t} K_{N,t-1} + \Pi_t \right]$$

$$+ \left[ C_t + p_{IH,t} I_{H,t} + p_{IN,t} I_{N,t} + T_t \right] + e_t R_{t-1} d_{t-1} + e_t \left( d_t - \bar{d} \right)^2,$$

where $e_t$ is the real exchange rate\(^4\); $z_{H,t}$ 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; and $p_{IH,t}$ and $p_{IN,t}$ are the prices of the investment baskets in equation (7).\(^5\) The household pays lump-sum taxes, $T_t$, and receives dividend payments from the firms, $\Pi_t$. 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) closely. We assume that there is a financial intermediary, which lends to households both in the US and in the emerging market. The 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, $\tilde{R}_t$.\(^6\) Hence, the effective interest rate becomes:

$$R_t = \tilde{R}_t S_t$$

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\(^4\)The real exchange rate is defined as the price of the Mexican consumption basket in units of the US consumption basket.

\(^5\)Given the CES aggregators in (7) and (8), cost minimization yields $p_{j,I,t} = \left[ a_{j,N} p_{N,t}^{1-\theta_I} + a_{j,F} p_{F,t}^{1-\theta_I} \right]^{\frac{1}{1-\theta_I}}$, with $p_{j,I,t} = \left[ m_{j,H} p_{H,t}^{1-\omega} + m_{j,F} p_{F,t}^{1-\omega} + m_{j,O} p_{O,t}^{1-\omega} \right]^{\frac{1}{1-\omega}}$, as the optimal price of the investment basket, used in sector $j = \{H, N\}$, in units of the final consumption basket.

\(^6\)The financial intermediary’s profits are then distributed to the foreign households as a lump-sum transfer.
where the spread, $S_t$, defines the country risk. As in Neumeyer and Perri (2005), we assume that the spread is exogenous, and it follows an AR(1) process.\footnote{The exogeneity of the spread is supported by the findings in Longstaff, Pan, Pedersen, and Singleton (2011), who show that the country spreads are driven more by global financial market variables than the domestic ones. Similarly, Uribe and Yue (2006) show that more than two thirds of the variation in the country spreads is explained by non-domestic factors.}

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 $\text{(1)}$ subject to the budget constraint (9), the laws of motion of capital (5) and depreciation function (6) for the traded and the non-traded sectors, the labor-supply aggregator (2), and the usual no-Ponzi game condition for $d$, taking as given the rental rates of capital, the wage rates, prices for the investment baskets and the effective interest rate.\footnote{The full set of optimality conditions are provided in the Appendix, which is available upon request.}

\section*{2.2 Firms}

We assume that both traded and non-traded sectors are perfectly competitive, and firms in the two sectors face similar optimization problems. Output in each sector $j = \{H, N\}$ is produced with a Cobb-Douglas technology:

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

(11)

where $\xi_{A,t}$ is the country-wide productivity shock common to both sectors, and $\xi_{Aj,t}$ is a sector-specific productivity shock that affects the traded sector only (i.e., $\xi_{AN,t} = 1, \forall t$).

We introduce two market frictions to an otherwise standard perfectly competitive firm’s problem. First, we introduce mark-up shocks to wages.\footnote{Previous studies (e.g. Smets and Wouters (2007)), Schmitt-Grohe and Uribe (2010) that estimate 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 might get transmitted to the emerging markets.} To do so, we follow the set-up in Schmitt-Grohe and Uribe (2010), and assume that the firms in both the traded and the non-traded sectors hire a composite labor input, $L_{jt}$, which is formed by differentiated labor inputs that are rented out to firms by labor unions. The firm optimally chooses demand for each type of labor, $L_{jt}$, given the wage posted by the labor union. The labor union, in turn, maximizes profits by choosing the wage they want to post, taking the wage they pay the households ($w_{jt}$) as given. The optimal condition for the union’s problem requires the union to post a wage that
is higher than \( w^*_{jt} \) by a mark-up, \( \mu_t \), which yields the same wage rate across different labor inputs, i.e., \( w_{\ell jt} = w_{jt} = \mu_t w^*_{jt} \). The mark-up \( \mu_t \) 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 (\( L_{jt} \)).

Second, we assume that the firms in both sectors face a working capital constraint. As in Perri and Quadrini (2010), 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 \( \kappa_j \) of the total revenue \( (P_{jt}Y_{jt}) \), and 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. Hence, the interest payments on the intra-period loan, \( \kappa_j(R_t - 1)P_{jt}Y_{jt} \), adds 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 firms as subsidies, which allow us to obtain a steady state that is invariant to the external financing friction.

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

\[
\pi_{j,t} = \left[ 1 - \frac{\kappa_j(R_t - 1)}{1 - \tau_j} \right] p_{jt}Y_{jt} - w_{jt}L_{jt} - z_{j,t}u_{j,t}K_{j,t-1},
\]

subject to the production function in (11), and the intra-period external financing requirement, where \( \tau_j \) is the rate of subsidy. The working capital requirement, \( \kappa_j \), which is sector-specific, 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 affect production.\(^{12}\)

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\(^{10}\)Specifically, the union’s problem is to choose \( w_{\ell jt} \) in order to maximize \( (w_{\ell jt} - w^*_{jt})L_{jt}I^{w_{\ell jt}} - \frac{1}{\mu_t} \), where \( w_{jt} = \left[ \int_0^1 w_{jt}^{1-\mu} d\ell \right]^{1-\mu} \) is the cost of one unit of composite labor used in sector \( j \).

\(^{11}\)Unlike Perri and Quadrini (2010), 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.

\(^{12}\)Note 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 increases the unit cost of labor and distorts the optimal capital-labor mix.
2.3 Exporters

We assume that there are intermediary firms that buy the 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, and they need to cover a fraction of their costs before they receive the payments from the US households. Consequently, we can write the problem of a representative exporter as choosing the export amount in order to maximize profits

\[
\pi_{E,t} = \left[ 1 - \kappa_E(\kappa - 1) \right] \tilde{p}_{H,t} \xi_{tot,t} \tilde{Q}_{H,t} - p_{H,t} \tilde{Q}_{H,t}
\]

where \( \tilde{Q}_{H,t} \) is the 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.\(^{13}\) The exporting firm’s optimization yields the following pricing equation for the \( H \)-good:

\[
\tilde{p}_{H,t} = p_{H,t} \frac{1 - \tau_E}{1 - \kappa(\kappa - 1)} \xi_{tot,t}.
\]

As seen in the equation above, the law of one price holds in the steady state with the subsidy given to the exporters. However, it breaks down outside the steady-state due to the working capital requirement, and the terms of trade shock.

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:

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

and finances expenditures with lump-sum taxes: \( T_t = p_{N,t} G_t \). Furthermore, we assume that the government adjusts its spending in response to changes in output, i.e.,

\[
G_t = \left( G_{t-1} \right)^{\rho_G} \left( \Delta Y_t \right)^{\psi_{GY}} \xi_{G,t},
\]

\(^{13}\)Total exports from the home country to the US consists of exports for consumption and investment in the two US sectors, i.e., \( \tilde{Q}_{H,t} = n \left[ \tilde{C}_{H,t} + \tilde{X}_{NH,t} + \tilde{X}_{FH,t} \right] \).
where $\xi_{G,t}$ is the government spending shock.

### 2.5 US Economy and Closing the Model

We assume that the set-up for the US households and firms are identical to the ones described above, except for two aspects. First, we assume that the firms in the US do not face the external financing requirement, and hence do not need to borrow from the households, as they can self-finance their production. Second, we assume that the US households can borrow from the international financial institution at the safe interest rate, $\tilde{R}_t$. Moreover, they receive the profits of the international financial intermediary (arising from the premium charged when lending to the emerging market) through lump-sum transfers.

There are four types of goods produced endogenously in the model, and two goods for which exogenous processes are specified. The exogenously specified "other" goods are meant to capture the trade between the emerging market and the rest of the world, as well as the trade between the US and the rest of the world. The non-traded good in both countries, which can be consumed, invested, and used for government expenditures. Hence, the market conditions for the non-traded goods in the emerging market and the US are respectively given by

$$Y_{N,t} = C_{N,t} + X_{NN,t} + X_{NH,t} + G_t$$

and

$$\tilde{Y}_{N,t} = \tilde{C}_{N,t} + X_{NN,t} + X_{NF,t} + \tilde{G}_t.$$  

The home traded good, $Y_H$, can be consumed by the 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

$$nY_{H,t} = n(C_{H,t} + G_{H,t} + X_{HH,t} + X_{NH,t}) + (1 - n)(\tilde{C}_{H,t} + \tilde{X}_{HN,t} + \tilde{X}_{FH,t}).$$

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

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14 In our estimation, we allow all the parameters for the US to be different than the ones relevant for Mexico.
in the emerging market:

\[(1 - n)\bar{Y}_F, t = n(C_{F,t} + X_{HF,t} + X_{NF,t}) + (1 - n)(\bar{C}_{F,t} + \bar{G}_{F,t} + \bar{X}_{FF,t} + \bar{X}_{NF,t}).\]  

(20)

We close the model by specifying exogenous autoregressive processes for the other net imports of the two countries. This is analogous to defining exogenous debt processes for each country, given the initial levels of debt, and the bilateral net exports determined endogenously.\(^{15}\) We specify the other net imports to GDP ratios as first order processes that depend on the growth rates of GDP, consumption and investment. The process for Mexico is given by:

\[ONMY_t = ONMY_{t-1}^p (\Delta Y_t)^{\psi_{onm,y}} \xi_{onm,t}\]  

(21)

where the other net imports are defined as \(o_{o,t}[C_{o,t} + X_{No,t} + X_{Ho,t}].\) The process for the US other net imports is specified in the same way, with different coefficients.

### 2.6 Shock Processes

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

\[\hat{\xi}_t = \rho \hat{\xi}_{t-1} + \epsilon_{\xi,t},\]  

(22)

where \(\epsilon_{\xi,t}\) is the iid innovation, and \(\xi = \{\xi_C, \xi_G, \xi_I, \xi_A, \xi_AH, \xi_AF, \xi_{tot}, S_t, \bar{\mu}_t\}\). 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 (i.e., \(\mu_t = \mu \forall t\)). The remaining four shocks are the ones that enter the exogenous processes (government spending and other net imports) are themselves iid innovations, i.e., \(\hat{\xi}_t = \epsilon_{\xi,t}\) for \(\xi = \{\xi_G, \xi_G, \xi_{onm}, \xi_{onm}, \xi_S\}\).

\(^{15}\) As we have assumed both countries can issue debt to borrow from the rest of the world, we do not keep track of the bilateral debt.
3 Estimation

As customary in the growing literature that estimate DSGE models, we use Bayesian techniques to estimate a subset of parameters of the model and use the standard calibration technique for the remaining parameters. We estimate: i) the parameters that govern the key frictions of the model—habit persistence, investment adjustment costs, convexity of the depreciation function, and working capital requirements—; ii) the parameters that govern the structural shock processes and measurement errors; and iii) the parameters that govern the processes for government spending and non-bilateral net imports. We confirm the identification of these estimated parameters using the rank and order conditions provided by Komunjer and Ng. We calibrate: i) the parameters that are commonly used in the literature—e.g. coefficient of risk-aversion, share of capital in total income—; ii) the parameters that present an identification challenge for our data-set due to the lack of detailed data—e.g., labor parameters ($\chi$, $\eta$) or elasticities in the consumption and investment baskets ($\theta$, $\omega$)—; and iii) the parameters that help us link steady-state relations with some features of the data (i.e., we match several steady-state ratios to the averages in the data).

3.1 Calibrated Parameters

The calibrated parameters and their values are listed in Table 5. We set the coefficient of risk-aversion, $\sigma = \tilde{\sigma}$, to be equal to 2 for both US and Mexico. The US discount factor $\tilde{\beta}$ is set to 0.998 in order to match the average US real interest rate in our sample; the steady-state of the spread, $S$, is set to 240 basis points, the average in our sample.

We 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). Using sectoral data for the US, Horvath (2000) estimates the equivalent to our parameter $\chi$ to 1, implying a low degree of substitutability. In line with Horvath’s estimate we assign to $\chi$ a value of 2. We set $\eta$ also to 2, which implies that the elasticity of the labor composite with respect to the utility-based wage-index is equal to 0.5. We use the usual value of 0.33 for the share of capital in total income, $\alpha$. While we estimate the degree of convexity of depreciation
as a function of utilization \((\nu)\), we choose the other parameters in the depreciation function 
\((\delta_{j,0}, \delta_{j,1})\) such that we obtain 10\% annual depreciation rate in the steady state.

The coefficients for the elasticity of substitution between the traded and non-traded goods
in the consumption baskets \((\theta_c\text{ for Mexico and the US})\), are set to 0.75, which is the estimate
obtained by Mendoza (1991). In our baseline specification, we follow Backus, Kehoe, and
Kydland (1995) and set the elasticity of substitution between the domestic and foreign traded
consumption goods, \(\omega = \tilde{\omega}\), to 1.5. However, as discussed in Corsetti, Dedola, and Leduc
(2008), those elasticities \((\omega's)\) play an important role in defining the impact of the terms
of trade on the demand for tradables. Given the lack of consensus on the values of those
elasticities, we check the robustness of our results to the choice the those elasticities.\(^\text{16}\) We set
the elasticities in the investment baskets to their consumption-basket counterparts; that is, we
set \(\theta_I = \tilde{\theta}_I = 0.75\), and \(\omega = \tilde{\omega}_I = 1.5\). Similarly, we set the elasticity of substitution between
the traded and non-traded goods in the government’s consumption basket \((\theta_G = \tilde{\theta}_G)\) to 0.75.

The share parameters in the consumption and investment baskets are set as follows. The
share of traded goods in the consumption basket \(a = \tilde{a}\) is set to 0.5. Similarly, the share on
non-traded goods in the investment of both traded and non-traded sectors is set to 0.5, that
is \(m_{NN} = \tilde{m}_{NN} = 0.5\) and \(m_{TT} = \tilde{m}_{TT} = 0.5\). The weights for the non-domestic goods in the
traded consumption basket \((m_F, m_O, \tilde{m}_H, \text{ and } \tilde{m}_O)\), jointly with the weights in the tradable
investment basket \((m_{TF}, m_{TO}, \tilde{m}_{TH}\text{ and } \tilde{m}_{TO})\) match the following six steady-state ratios to
the corresponding averages in the data: Mexican imports from the US as a fraction of Mexican
GDP (16.4\%), Mexican exports to the US as a fraction of Mexican GDP (21.4\%), investment
goods imported from the US to Mexico as a fraction of total imports from the US (13.3\%),
investment goods exported from Mexico to the US as a fraction of total exports to the US
(20.8\%), the ratio of Mexican net trade to GDP excluding trade with the US—non-bilateral
net imports—(5.8\%), the ratio of US net trade to GDP excluding trade with Mexico—non-
bilateral net imports—(3.42\%). The sources of the data we use to construct these ratios, and
other details on their construction can be found in the Data Appendix. Moreover, we impose
\(m_{NF} = m_{TF}, m_{NO} = m_{TO}, \tilde{m}_{NH} = \tilde{m}_{TH}\), along with four restrictions, where for each traded

\(^\text{16}\)The elasticity parameter is usually estimated to be small in macro models, e.g., it is 0.9 in Heathcote and
Perri (2002), and it is estimated to be large using micro data, e.g., the aggregate elasticity is found to be between
6 and 7 in Imbs and Mejean (2009) using industry level data for the US.
basket, $m$’s add up to one, in order to obtain the shares in consumption and investment baskets.

Finally, the relative size of the Mexican economy, $n$, is chosen such that the steady-state ratio of Mexican GDP to US GDP is equal to 5.8%, the average value of the ratio of the GDP’s in our sample. We choose a very small value (0.00005) for the parameter that determines the cost of debt adjustment, $\varsigma$, which ensures the stationarity of the solution.

### 3.2 Estimated Parameters

We use the standard Bayesian estimation methods with the Random Walk Metropolis Hasting (RWMH) algorithm, as described in An and Schorfheide (2007), to estimate the remaining set of parameters of the model presented in Section 2. To briefly describe the methodology, let $\lambda$ be the vector of estimated parameters of the model. Given the vector $\lambda$, we solve the log-linearized model with the method of Sims (2002). The solution of the model and its relation to the data take the state-space form:

$$X_t = \Gamma X_{t-1} + \Xi \epsilon_t$$

$$D_t = \Theta X_{t-1} + \epsilon_{me}^t,$$

where $X_t$ is the vector of state variables of the model; $\epsilon_t$ is a vector that gathers the fifteen i.i.d. structural innovations in the model; the matrices $\Gamma$ and $\Xi$ represent the solution of the model; $D_t$ is a vector containing the seventeen time series that we include in our estimation (at time $t$); $\Theta$ is a matrix that maps the corresponding variable of the model to its counterpart in the data, and $\epsilon_{me}^t$ is a vector that gathers the i.i.d. measurement errors. Given the state-space representation above, we use the Kalman Filter—as detailed in Hamilton (1994) or Ireland (2004) in the context of DSGE models—to evaluate the likelihood function $L(\lambda|D)$. With the likelihood and the postulated prior distributions of $\lambda$, $\varphi(\lambda)$, described below, we obtain the posterior distribution (up to a constant): $\varphi(\lambda|D) \propto L(\lambda|D)\varphi(\lambda)$.

The RWMH algorithm can be summarized as follows. First, we initialize the RWMH by maximizing the log of the posterior—$\ln L(\lambda|D) + \ln \varphi(\lambda)$—and obtain the posterior mode, $\hat{\lambda}$, and the inverse of the Hessian at the posterior mode, $\hat{\Sigma}$. Second, for $s = 1, 2, \ldots, 3e^6$ (that is, 3 million draws), we obtain draws for $\lambda$ from the proposed distribution $N(\lambda^{(s-1)}, c\hat{\Sigma})$, with
\( \lambda^0 = \tilde{\lambda} \). The parameter vector \( \lambda \) is accepted (\( \lambda^s = \lambda \)) with probability \( \min \{1, r(\lambda^{(s-1)}, \lambda|D)\} \) and rejected (\( \lambda^s = \lambda^{(s-1)} \)) otherwise, where the acceptance ratio is defined as 
\[
    r(\lambda^{(s-1)}, \lambda|D) = \frac{\mathcal{L}(\lambda|D)p(\lambda)}{\mathcal{L}(\lambda^{(s-1)}|D)p(\lambda^{(s-1)})}.
\]
Finally, we burn the first 250 thousand draws and use the remaining 2.75 million draws to obtain our results discussed below.

### 3.2.1 Data

We use quarterly data for Mexico and the US from the first quarter of 1994 to the fourth quarter of 2007, and include seventeen variables in our empirical analysis. For both Mexico and the US, we include quarter to quarter growth rates of real GDP, real consumption, real investment, and manufacturing production index. We also include real government spending and non-bilateral net trade (other net imports) as a fraction of GDP for both economies. In addition, we include the growth rates of Mexican exports to and imports from the US, the growth rate of per capita hours worked in the US, the US real interest rate (constructed using the three-month Treasury bill rate and the annual inflation measured with the US GDP deflator), and the real interest rate for Mexico (constructed as the sum of the US real interest rate and the J.P. Morgan EMBI+ Spread). 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.

### 3.2.2 Prior Distributions

The first three columns in Table 2 summarize the prior distributions for the estimated parameters. We specify the same prior distributions for all of the parameters that are common to Mexico and the US, except for the measurement errors. Following Smets and Wouters (2007), the priors of the structural shock processes are as harmonized as possible. Except for the innovation in the consumption and investment shock processes, the prior distribution of the standard errors of the structural innovations listed in subsection 2.6 (\( \sigma_{\xi} \)) is a normal with mean 0.5 and standard deviation 0.5, truncated to take on non-negative values.\(^{17}\) To accommodate the high volatility of consumption and investment in Mexico, we choose normal distributions with higher means (2 and 4), and higher standard deviations (1 and 1) for the innovations in

\(^{17}\) In specifying the truncated normal distributions for positive values, we choose the mean and the standard deviation for the non-truncated Normal distribution, and report the implied mean and standard deviation of the truncated distribution in the tables.
the consumption and investment processes, both of which correspond to loose priors. The autorecorrelation coefficients of the structural shocks ($\rho_\xi$) have beta prior distributions with mean 0.5 and standard deviation of 0.17.

The choice for prior distribution of the habit persistence parameter is the commonly used ones in the literature. The prior distribution of habit persistence parameter ($\varphi$) is a beta distribution with mean 0.5 and standard deviation of 0.22. The prior distributions for the investment adjustment cost parameters ($\phi_N$ and $\phi_T$) and the capacity utilization elasticity ($\nu_N$ and $\nu_T$) are chosen to accommodate the high volatility of investment in Mexico and have gamma and inverse-gamma distributions, respectively, with means equal to 7 and 0.5, and standard deviations of 1 and 0.5.

There is no established value for the working capital constraint parameter in the literature to guide our choice of the prior distributions for the $\kappa$’s. For example, where as 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, Mendoza (2006) uses a value of 0.25 in a business cycle model with collateral for the Mexican economy.\textsuperscript{18} Since in our set-up the firms are required to pay a fraction of their total costs at the beginning of the period, for the working capital constraint parameters in all three sectors ($\kappa_N$, $\kappa_T$ and $\kappa_E$), we choose a beta distribution (with mean 0.5 and standard deviation of 0.14), that allows us to constrain the parameter between 0 and 1.

Since we do not a priori know the magnitudes or signs of the reaction coefficients on GDP growth in the government spending and other net import processes ($\psi_{G,Y}$ and $\psi_{om, y}$), we adopt a normal prior distribution with mean zero and standard deviation of 0.1 for all of them. Finally, in the spirit of Schmitt-Grohe and Uribe (2010), we choose uniform prior distributions for the standard deviations of the i.i.d. measurement errors, and allow the standard deviation of measurement errors to be at most 25% of the standard deviation of the corresponding variable in our data-set.

\textsuperscript{18}Neumeyer 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.
3.2.3 Posterior Distributions

The mean value and the 90\% posterior interval of the posterior distributions we obtain are reported in the last four columns of Table 2. We find that the posterior distributions of parameters that define the structural shocks are strongly shaped by the data (and less so by our priors). The mean value for the persistence of the general productivity shock in the US is 0.17, and the persistence of the productivity shocks in the traded goods sector is 0.12.\textsuperscript{19}

For Mexico, we find the same persistence parameter of the general productivity shock at 0.17, and a much larger persistence of the sector-specific shock, at 0.25. Both of those coefficients have a larger 90\% posterior interval for Mexico than the US. The standard deviation of the productivity shocks are very similar across countries: 1.05 and 1.57 for the US ($\tilde{\sigma}_A$, $\tilde{\sigma}_{AT}$), and 1.17 and 1.60 for Mexico ($\sigma_A$, $\sigma_{AT}$). The implications of these estimates are further discussed in the following section in terms of a variance decomposition.

At the mean values, the investment shock in Mexico is more persistent than in the US (0.91 vs 0.76) with a larger standard deviation (7.61 vs 5.78). While the preference shock in Mexico is slightly less persistent than in the US (0.13 vs 0.15 for the US), it also is more volatile, with a larger standard deviation (5.51 vs 4.42). The higher standard deviation of investment and preference shocks in Mexico is consistent with the well documented higher volatility of consumption and investment in emerging markets (see e.g. Neumeyer and Perri (2005)). The other two potentially shocks for Mexico are the shocks to the spread and the terms of trade shock. The spread shock is estimated to be fairly persistent, with a mean of 0.79, but has a very low standard deviation (0.21). The terms of trade shock displays the opposite characteristics: it is barely persistent with a mean of 0.05, but is quite volatile with a mean standard deviation of 4.29.

Turning to the behavioral and friction parameters, our findings can be summarized as follows. First, the mean value for the habit persistence parameter is ten times larger for the US (0.30) than the one for the US (0.03). This finding also reflects the high consumption volatility in the EMEs compared to the developed economics. Similarly, the mean value of the

\textsuperscript{19}It is difficult to compare our estimates for the productivity shocks to the previously estimated values (e.g. 0.92 in Schmitt-Grohe and Uribe (2010) and 0.95 in Smets and Wouters (2007)), since we have a two-sector model with a general and a sector-specific shock. Moreover, the sample we are able to use is much shorter than the sample used in the previous studies.
posterior distributions of the investment-adjustment cost parameters \( (\phi)'s \) is smaller for Mexico (4.97 vs 5.39); whereas the elasticity of capacity utilization \( (\nu) \) is higher for Mexico (0.48 vs 0.19). As investment is more volatile in Mexico than in the US, both of these parameters for Mexico yield less investment-smoothing in the model than for the US.

The parameters that are important for financing production in Mexico are the working capital constraint parameters \( (\kappa)'s \). We find that the estimates of \( \kappa \) are quite different across the sectors. It is lowest for the non-traded sector at 0.22; twice as big for the traded sector at 0.44; and it is high at 0.65 for the exporting firms. It is difficult to compare these estimates to the previously found parameters in Uribe and Yue (2006) and Chang and Fernandez (2010), as they consider working capital requirement for the wage bill only. Nevertheless, our estimates resemble the findings in Chang and Fernandez (2010), who set-up a small open economy model for Mexico, and find the working capital parameter to be 0.69 in a sample that covers 1980-2003.

## 4 The Effects of US Shocks in Mexico

In this section we present the results on the transmission of the US shocks to Mexico. First, we present the variance decomposition of the variables based on the mean of the estimated parameters, and show that the model predicts a significant impact of US shocks on the Mexican variables. Second, we provide the historical decomposition of the Mexican variables into the various types of domestic and foreign shocks included in the model to analyze the different driving forces of the Mexican business cycle. Within that subsection, we also show the growth gains and losses from counter-factually stabilizing the US shocks in our sample. Third, we briefly describe the transmission mechanism of US shocks to Mexico, and analyze the roles of financial market distortions and international trade in the exposure of Mexican economy to US shocks.

### 4.1 Variance decomposition

Table 3 documents the unconditional forecast error variance decomposition of the variables included in our estimation based on the posterior means presented in the previous section. The
main result of Table 3 is that, at business cycles frequencies, the US shocks in total explain 40% of the variation in Mexico’s GDP growth, and 30% of Mexico’s consumption growth. Among the various shocks, the US productivity shocks have the largest impact on Mexico’s GDP and consumption, at 20% and 15% for the general productivity shock, and 17% and 14% for the traded sector-specific technology shock, respectively. We obtain similar results—not shown to save space—from the variance decompositions at different horizons (e.g., four, twelve or twenty quarters). 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.\textsuperscript{20} Moreover, the result on the importance of the technology shock in the US traded sector is in line with the empirical findings of Corsetti, Dedola, and Leduc (2009), who show that the US technology shocks in the traded sector have important international effects.\textsuperscript{21}

Before discussing the 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 technology shocks (productivity and investment shocks) jointly account for 60% of the variation in US GDP growth, and the preference and wage mark-up shocks explain 22% and 16%, respectively. These results are very similar to the ones obtained in previous studies (see Smets and Wouters (2007), Schmitt-Grohe and Uribe (2010) and Justiniano, Primeceri, and Tambalotti (2011), among others). While US consumption growth is explained equally by the technology and preference shocks, investment growth is mainly driven by investment-specific technology shocks.

Turning to the Mexican economy, there are some additional interesting results that emerge from the variance decomposition in Table 3. First, in terms of the domestic shocks, the technology shocks in Mexico explain 43% of the volatility of GDP, and the preference shocks account for another 11%. Second, the Mexican preference shock explains 47% of volatility in consumption, whereas the domestic technology shocks explain only about 1%. Third, investment growth volatility in Mexico is mainly due to the investment shocks (89%), and at business

\textsuperscript{20}On the other hand, our results are at odds with the findings in Canova (2005), who finds that the real US demand and supply shocks do not have big effects, but that the US monetary shocks do.

\textsuperscript{21}Corsetti, 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.
cycles frequencies the US shocks have negligible impact on investment growth. The variance decomposition of the growth rates of bilateral imports and exports shows that while both domestic and foreign shocks are equally important for the imports (from Mexico to the US), domestic shocks and the terms of trade shock explain more of the fluctuations in the exports. Domestic shocks account for 46% of the fluctuations in the growth rate of imports, out of which 32% is attributed to the consumption shock. The rest of the fluctuations in the growth rate of imports is mainly due to the US technology shocks at 42%. As for the fluctuations in the growth rate of exports, domestic shocks account for 35%, and the US shocks account for 20%. The terms of trade shock matters more for exports (24%), then for imports (9%).

The final result of the variance decomposition worth highlighting is the decomposition of the Mexican interest rate into domestic and foreign shocks. Table 3 shows that the the fluctuations in the Mexican interest rate are mainly explained by the US shocks, and the decomposition is very similar to the decomposition of the US interest rate. The US technology shocks jointly explain 70% of the fluctuations in the Mexican interest rate (79% of the US interest rate), and the consumption shock explains 16% (18% of the US interest rate). Only 13% of the fluctuations are attributed to the spread shock, which captures the differences in the Mexican and US interest rates not explained by the fundamentals. The fact that the Mexican interest rate is mainly explained by US shocks implies that any innovation that affects the US interest rate will have significant repercussions on the Mexican economy since it also be moving the real interest rate in Mexico. Moreover, this result confirms the assumption of exogenous real interest rates commonly used in the small open economy models.

4.2 Historical decomposition and counterfactual growth gains

To analyze the impact of US shocks for the Mexican economy over our sample period, we carry out two related exercises using the estimates discussed in the previous section: (i) a historical decomposition of the Mexican variables; (ii) a counter-factual experiment where US shocks are stabilized to assess the potential (counter-factual) growth gains and losses from such a stabilization. The smoothed shocks obtained from the estimation allow for a decomposition of the data, where feeding the model with those shocks and the measurement errors, we re-
cover the (demeaned, year-over-year) data in our sample (see equations (23) and (24)). This decomposition allows us to disentangle the historical effects of each structural shock on the data.

To keep the analysis manageable, we assemble our fifteen shocks into four groups. Domestic shocks are grouped as technology and demand shocks. The technology shocks include the general technology shock, the sector-specific technology shock in the tradable sector and the investment shock. Demand shocks include the preference shock, the exogenous (government) spending shock, and the shock to non-bilateral imports (other net imports). The remaining shocks are grouped as US shocks (all US technology and demand shocks) and international shocks (terms of trade and country risk shock). The results of the historical decomposition of Mexican variables into the four categories of shocks are shown in Figure 1. The figures show that the US shocks have been important for all of the major Mexican variables throughout the sample years. Hence, the spill-overs from the US are not limited to particular events (like recessions), but rather constitute a steady component of the Mexican business cycle.

The US shocks account for sizeable fractions of the fluctuations in the growth rates of Mexican GDP, consumption and investment throughout the sample, averaging 0.41, 0.38 and 0.35, respectively. They also explain the variations in the growth rates of imports (from the US) and exports (to the US) in every period of the sample, averaging 0.46 and 0.27. It is interesting to note that the decline in the growth rates during the recession of 1995 in Mexico is mainly explained by the domestic shocks, and the US shocks have a negligible effect (less than 10%) during that period. The fraction of the drop explained by domestic shocks in the first quarter of 1995 is approximately 0.8 for GDP, consumption and investment. By contrast, the US shocks explain a larger fraction of the decline in the growth rates of Mexican variables during the 2001 recession. For the growth rate of GDP, the US shocks account for approximately 60% of the decline, where as the domestic shocks account for only 20%.

To further illustrate the qualitative effects of the US shocks on Mexico’s economy, we perform a counter-factual experiment using the estimated parameters of the model as follows. First we feed the model with estimates of all the smoothed shocks and recover the data; then, we counter-factually feed the model with all shocks but the smoothed innovations of US
shocks. That is, US innovations ($\tilde{\epsilon}_A$, $\tilde{\epsilon}_{AT}$, $\tilde{\epsilon}_C$, $\tilde{\epsilon}_{ann}$, $\tilde{\epsilon}_\mu$ and $\tilde{\epsilon}_G$) are set to zero for all quarters of the sample except for the first quarter. The difference between the growth rates in the data and the counter-factual growth rates show the growth gains (if positive) and losses (if negative) for Mexico from a hypothetical stabilization of the US economy.

Panel A of Figure 2 shows the gains for Mexico’s growth from the counter-factual stabilization of the US economy. The experiment shows that a counter-factual stabilization of the US shocks would have resulted in an average loss of 2% in annual growth of Mexican GDP in the 1994:2-2000:4 period. Since the Tequila crisis during 1994:4-1995:4 lead to a recession due to domestic shocks, hypothetically stabilizing the US economy would not have had much of an impact on the GDP growth. On the other hand, the counter-factual US stabilization would have resulted in growth gains for Mexico during the 2001 US recession. The counter-factual stabilization yields an additional growth of 5% in Mexico’s GDP for the year 2001.

In short, both the historical decomposition and the counter-factual experiment show that the US shocks affect Mexico’s economy almost in all of the time periods. They also show that while Mexico benefited from the US growth in the second half of the 1990s, the 2001 US recession hit the Mexican growth adversely.

4.3 The roles of trade and financial frictions in the transmission of shocks

The model described in section 2 contains two channels for the 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. Since the general productivity shock in the US has the largest impact on the Mexican variables, we can illustrate the transmission mechanism of US shocks by focusing on the impulse responses of the main Mexican variables to this particular shock. The impulse responses calculated at the mean values of the posterior distribution can be found in the Appendix.

Following a positive productivity shock, US consumption, GDP and investment increase. Additionally, it leads to a decline in the real interest rate. Given the interest parity condition in (10), this decline in the US real interest rate translates into a decline in the Mexican interest

22 Note that the measurement errors are irrelevant for the counter-factual since they remain the same and thus vanish when we take the difference between the data and the counter-factual.
rate.\textsuperscript{23} A lower real interest rate reduces the cost of production, as it makes the working capital loans cheaper, and thereby increases the output in both the traded and non-traded sectors in Mexico. Additionally, this drop in the real interest rate triggers an inter-temporal reallocation of goods, making it cheaper to consume in the current period, thereby increasing consumption and lowering investment. The expansion in consumption applies to all components of the consumption basket: non-traded consumption as well as the domestic and US traded goods.

In addition to boosting Mexican production due to lower interest rates, the US productivity shock also leads to an increase in Mexican output due to higher US demand for Mexican imports. To meet the higher demand, the Mexican traded good firms increase production, and higher exports to the US lead to an increase in income in Mexico. With higher income, the Mexican households are able to consume more, which in turn implies an increased demand for US goods, i.e., higher imports.

To further illustrate the importance of credit market failures and trade in facilitating spill-overs, we conduct two counter-factual experiments. In the first one, we analyze how the spill-overs would change if Mexico were to diversify trading partners, and lower trade with the US. To do so, we reduce the steady-state values of bilateral imports and exports (as fractions of GDP) by 25%, and reallocate those shares to the steady state value of other net imports. Given the new steady-state configuration, we calculate the counter-factual spill-overs the model generates using 100 thousand draws from the posterior distributions of the parameters, and compare them with the actual spill-overs the 100 thousand draws yield.\textsuperscript{24} The distribution of spill-overs in the actual and counter-factual cases are displayed in Panel A of Figure 3. As shown in the figure, the predicted spill-overs for each draw are lower in the counter-factual case. Hence, the experiment implies that if Mexico were to diversify exports to and imports from US to other countries, spill-overs would be lower. Specifically, the spill-overs differ approximately by 8 percentage points at the mean of the distributions.

In the second counter-factual experiment we analyze how the results would change if the

\textsuperscript{23}When we decompose the impulse responses into adjustments due to foreign and domestic components, we find that the changes in the Mexican interest rate obey solely the foreign state of the economy (i.e., the US state variables). This result complies with the exogenous interest rate assumption in the small open economy models. Details available upon request.

\textsuperscript{24}The 100 thousand draws are chosen to represent the whole set of 2.75 estimates we obtain, and therefore, are in equal distance from each other.
credit market imperfections were less severe. For that purpose, we lower the estimated values
of the working capital constraint parameters (the $\kappa$’s for the traded, non-traded and the export
sectors) by 25% for each of the 100 thousand parameter draws. The distribution of the implied
counter-factual and actual spill-overs are shown in Panel B of Figure 3. As in the previous
experiment, the spill-overs are mitigated for lower values of the $\kappa$’s. The mean value of the
spill-overs is lower by 10 percentage points, when the working capital constraints are relaxed
by 25%. Relaxing the working capital constraints reduces the firms’ exposure to interest rate
fluctuations, which are mainly driven by US shocks. With lower exposure, the firms’ production
decisions are affected less by fluctuations in the US economy.

5 Conclusion

In order to analyze the transmission of structural US shocks to emerging markets, we set-up an
asymmetric two-country real business model, and estimate it using fifteen time series for Mexico
and US. The estimated model endogenously generates a significant degree of transmission of
shocks, where 40% of the volatility of Mexican GDP and around 30% of the volatility of Mexican
consumption can be explained by US shocks. Among the structural shocks, the productivity
shocks affect Mexico the most.

There are three key elements in the model that are crucial for generating spill-overs: the
standard trade linkages, where the countries trade consumption and investment goods; the
country-risk adjusted interest parity condition, which links the domestic interest rate to the
US interest rate, and thereby to the fluctuations in the US economy; and the working capital
constraints that require the Mexican firms to finance a part of their production with loans.
Due to the financial market imperfection, the changes in the real interest rate affect production
and exporting decisions. The real interest rate’s impact on firms intensifies the effects of US
shocks in Mexico, and increases the extent of transmission of the shocks. The mechanisms
identified in this paper point toward trade diversification and improvements in the domestic
financial system as policy tools that can reduce the EMEs’ exposure to foreign shocks.
References


### Table 1: Calibrated Parameters

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

$m_H, m_F, m_O, m_{TH} = m_N H, m_{TF} = m_N F, m_{TF} = m_N F, n$

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Note: T stands for traded, and NT stands for non-traded goods.

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Note:
### Table 3: Unconditional Variance Decomposition

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**Note:** All the shocks are orthogonal. The [10,90] posterior intervals are shown in brackets.
Figure 1: Historical Decomposition: Contribution of Shocks (left scale) to Fluctuations in Macroeconomic Variables (right scale)

$\Delta$ GDP  $\Delta$ Consumption  $\Delta$ Investment

$\Delta$ Imports  $\Delta$ Exports  $\Delta$ Tradable Sector

Note: Technology Shocks include the general technology shock, the sector-specific technology shock in the tradable sector and the investment shock. Demand Shocks include the preference shock, government or exogenous spending shock and the shock to non-bilateral imports (other net imports). US shocks include all US technology and demand shocks. International
Figure 2: The Historical Role of US Shocks in the Mexican GDP
(A) Mexico’s GDP Growth (solid line) and GDP’s Growth History with Only US Shocks (bars)

(B) Gains for Mexico’s Growth From the Counter-factual Stabilization of the US Economy
Panel (A) shows the shift in the distribution of US spill-overs to Mexican GDP growth when bilateral imports and exports are reduced by 25% but total trade is kept constant by adjusting trade with the rest of the World.

Panel (B) shows the shift in the distribution of US spill-overs to Mexican GDP growth when the working capital constraints are relaxed by 25%.

Distributions are constructed with 100 thousand posterior draws.