Durable Goods, Financial Frictions, and Business Cycles in Emerging Economies

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Abstract

Business cycles in emerging economies display very volatile consumption and strongly countercyclical trade balance. We show that aggregate consumption in these economies is not more volatile than output once durables are accounted for. Then, we present and estimate a real business cycles model for a small open economy that accounts for this empirical observation. Our results show that the role of permanent shocks to aggregate productivity in explaining cyclical fluctuations in emerging economies is considerably lower than previously documented. Moreover, we find that financial frictions are crucial to explain some key business cycle properties of these economies.

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1 Introduction

Business cycles in emerging economies are characterized by strongly countercyclical current accounts and sovereign interest rates and by highly volatile consumption. In addition, total consumption expenditure volatility exceeds that of income (Aguiar and Gopinath, 2007). This fact is known as the “excess volatility of consumption puzzle”. There are two strands of literature which explain these facts. The first strand, represented chiefly by Aguiar and Gopinath (2007), claims that business cycle fluctuations in these economies are driven by permanent shocks to productivity. The second strand argues that financial frictions are not only needed but essential to explain the empirical regularities of emerging economies (Neumeyer and Perri, 2005, and García-Cicco, Pancrazi, and Uribe 2010).\(^1\)

In this paper, we investigate the role of consumption of nondurable and durable goods in explaining the business cycle regularities observed in emerging economies. To the best of our knowledge, none of the existing literature highlights the importance of consumer durable goods in shaping the cyclical dynamics of these economies.\(^2\) The main contribution of our paper is to fill this gap.

To this end, we first study the observed cyclical behavior of disaggregated consumption in emerging and developed economies. We collect data on output, investment, exports, imports, and consumption of both durable and nondurable goods for a set of 32 countries, of which 14 are emerging economies. Our main empirical finding is that, contrary to total consumption expenditure, nondurable consumption is less volatile than output. We also observe that durable expenditure is much more volatile than output. In addition, we find that spending in both nondurable and durable goods is more volatile in emerging economies than in developed ones.

To explain these empirical facts, we build a two-sector real business cycles (RBC) model for a small open economy with both transitory and trend shocks to productivity. The model considers nondurable goods which can be used for consumption, and durable goods which are used for consumption or investment. We assume, for simplicity, that durable goods are traded across borders while nondurables are non-tradable.\(^3\) Our framework also features a one-period bond as the only internationally traded financial asset. We estimate the model with the generalized method of moments (GMM), using data from Mexico, and show that the observed cyclical behavior of nondurable and durable consumption expenditure provides important information to estimate the model and the parameters of the productivity processes.

Our first finding is that accounting for consumer durables greatly reduces the role of permanent shocks to productivity in driving business cycle fluctuations. In a similar setting to ours, but without durable goods, Aguiar and Gopinath (2007) estimate that shocks to trend

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\(^1\)There are alternative explanations which rely on one or the other framework. For instance, Boz et al. (2011) extend Aguiar and Gopinath’s (2007) model to include imperfect information, and Fernandez-Villaverde et al. (2011) use shocks to the volatility of the borrowing premium to explain the volatility of consumption in emerging economies.

\(^2\)Several other papers in the business cycles literature study the importance of durable goods. See, Baxter (1996), De Gregorio et al. (1998), and Engel and Wang (2011), among others. However, they do not focus on emerging economies.

\(^3\)This assumption also mimics observed trade patterns which show that the trade intensity is much higher for durable goods than for nondurables (Engel and Wang, 2011).
must be very volatile to be able to match the volatility of aggregate consumption in emerging economies. In our framework, however, a high variance of permanent shocks makes durable spending and the trade balance too volatile. Hence, by targeting the volatilities of durable consumption expenditure and of net exports, we are imposing a strong constraint on the variance of permanent shocks.

Furthermore, exogenous productivity shocks (permanent or transitory) are not enough to replicate some key properties of business cycles in emerging economies, including the excess volatility of consumption spending and the countercyclicality of the trade balance. This happens because the real interest rate barely responds to such shocks and, as a result, a key mechanism for the propagation of fluctuations is shut down. The presence of durable goods, in our model, adds a new important channel for intertemporal consumption smoothing which is, for the most part, absent from the existing literature on business cycles in emerging economies. This new channel adds new relevance to the role played by real interest rates in generating the volatile consumption and countercyclical trade balance we observe in most emerging economies. Hence, there is the need for an economic friction causing the borrowing premium to be volatile and countercyclical. Any type of financial friction inducing this type of interest rate behavior should suffice.

Therefore, our second main finding is that the model must be augmented to include financial frictions. We do this by considering a reduced form for this type of frictions whereby the borrowing premium responds to the output gap. In this, we follow others in the literature who consider a convenient reduced-form representation of an underlying financial friction and do not provide an explicit microfoundation (García-Cicco et al., 2010). When interest rates are countercyclical, households borrow more from abroad during economic expansions in order to take advantage of better credit conditions and thus finance the purchase of durables. Since these goods are tradable, the run-up in durable goods spending, during the economic expansions, translates into a decrease in the trade balance. Thus, our results offer evidence against the prominent role of shocks to trend growth found by Aguiar and Gopinath (2007), and lend support to the view of García-Cicco et al. (2010) that financial frictions are crucial to understand business cycles in emerging economies. Our contribution is to provide a quantitatively important channel – durable consumption spending – through which financial frictions shape business cycles in emerging economies.

Our results are robust to a host of possible misspecifications. In particular, we try several different model specifications, namely including intermediate goods, using different assumptions on the correlation structure of the transient shocks or on preferences, or considering

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4 In early RBC models for small open economies, interest rates disturbances play a minor role in driving the business cycle (Mendoza, 1991). In many of those studies, the real interest rate channel acts mostly through its impact on capital accumulation and this would cause investment to be excessively volatile. When one adds endogenous borrowing limits to these models, consumption volatility increases substantially as savings cannot be used to smooth consumption when the borrowing limit binds (De Resende, 2006). Alternatively, the excessive volatility of consumption can be explained with a friction in the form of a working capital borrowing requirement (Neumeyer and Perri, 2005). In this case, a countercyclical borrowing premium amplifies the variability of consumption because it makes the demand for labor more sensitive to the interest rate.

5 An example of an underlying friction is a commitment problem causing endogenous default or resulting in endogenous borrowing limits (Eaton and Gersovitz, 1981).
alternative reduced forms for financial frictions. In all cases, our results remain and, in some cases, are even reinforced.

The rest of the paper is organized as follows. In the next section, we document new stylized facts regarding cyclical fluctuations in consumption in emerging economies. In Section 3, we present our model. Section 4 describes the estimation procedure, presents the results, and checks their robustness. Section 5 concludes.

2 Data and Stylized Facts

In this section we document the major stylized facts of business cycles in large and small open economies. In doing this, we follow standard detrending techniques used elsewhere in the literature (Aguiar and Gopinath, 2007) and report sample standard deviations and correlations of various components of aggregate spending relative to gross domestic product. Our main innovation is that we collect data on consumption spending in both nondurable and durable goods for a significant cross section of emerging and developed countries.

2.1 Data

Our sample comprises 32 countries for which we are able to find data on durable goods’ spending and, whenever possible, up to the beginning of the recent financial crisis (last quarter of 2008). We split the sample into developed and emerging economies depending on their Morgan Stanley Capital International (MSCI) classification developed by MSCI Inc.6 We then divide the sub-sample of developed economies into two groups according to size and follow the rule that an economy is large if its gross domestic product (GDP) represented at least two percent of the world’s GDP in the year 2000. This leaves three groups: small developed economies (Austria, Canada, Denmark, Finland, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, and Sweden), large developed economies (France, Germany, Italy, Japan, United Kingdom, and United States), and emerging economies (Chile, Colombia, Czech Republic, Estonia, Hong Kong SAR, Hungary, Republic of Korea, Israel, Mexico, Poland, Slovenia, Slovak Republic, South Africa, and Turkey).7 For each country we collect data (in real terms) on GDP, total private consumption expenditure, consumption of nondurable goods (including services)8, expenditure in durable goods, investment, and the trade balance.

All data is from the OECD’s Quarterly National Accounts, except for the U.S. (Bureau of Economic Analysis), Chile (Central Bank of Chile), Colombia (EMED - Emerging Americas database), Hong Kong and Korea (CEIC - Asia database), Mexico (INEGI - Instituto Nacional

6 We classify a country as developed if it was included in the MSCI Developed Markets index for most of the sample period and as having an emerging market otherwise. This criterion means that we include Israel as an emerging market economy since, for the entire sample period it was defined as such by MSCI Inc. and only recently upgraded to advanced economy status (May 2010).

7 Hong Kong and Israel have been recently upgraded to advanced market status by MSCI.

8 The inclusion of services under nondurable consumption is standard in the durable goods literature (see Baxter, 1996, for example) and can be justified on the grounds that durables are different than nondurable goods and services because they can be inventoried (Gomes et al., 2009).
de Estadística y Geografía), South Africa (Emerging EMEA database), and Turkey (Turkish Statistical Institute). All variables are sampled at a quarterly frequency, seasonally adjusted when needed, converted to logs (except net exports) and detrended using the Hodrick-Prescott (HP) filter with smoothing parameter $\lambda = 1600$.

In Tables 1 through 3, in addition to the sample period used for each country, we report standard deviations for the above mentioned variables and their correlations with GDP. We also show the weighted average of each statistic for the three country groupings using current U.S. dollar GDP in the year 2000 as weights (data from the World Bank’s World Development Indicators).

2.2 Facts

When it comes to business cycles in emerging economies and small developed economies, there are four stylized facts often cited in the literature (see Neumeyer and Perri, 2005, Uribe and Yue, 2006, Aguiar and Gopinath, 2007, and García-Cicco et al., 2010). First, emerging market economies have higher volatilities of output and consumption when compared to developed economies. Second, consumption expenditure is more volatile than output in emerging markets while it is not (quite) as volatile as output in developed economies. Third, net exports are more volatile and more countercyclical in emerging markets when compared to developed economies. Finally, real interest rates are countercyclical and leading in emerging markets and acyclical and lagging in developed economies (Neumeyer and Perri, 2005).

To these facts we add three new facts concerning spending in nondurables and durable goods in small economies, based on our sample summarized in Tables 1 and 2.

Fact 1 Consumption of nondurables is less volatile than output in both developed and emerging economies.

The sample average of volatility of nondurable consumption relative to that of output is 0.93 in emerging countries and 0.8 in small developed economies. In both cases, they are significantly below 1: $t$-statistics for the null that nondurable consumption is as volatile as output are -4.48 and -5.85 for emerging countries and small developed economies, respectively.

Fact 2 Spending in durable goods is much more volatile than output in both sets of economies.

The average relative volatility of durable goods expenditure is 3.78 for small developed economies and 4.22 for emerging economies. $T$-statistics for the null that durable spending is as volatile as output are 14.08 and 10.79 for emerging countries and small developed economies, respectively. These ratios are, therefore, significantly different from 1, for both sets of economies.

Fact 3 Consumption spending in both durables and nondurables is relatively more volatile in emerging economies than in developed economies.

Deseasonalization uses the Census Bureaus X-12 ARIMA program. Detrending is needed so that the unconditional moments of these non-stationary series are defined. Finally, the choice of filtering method does not seem to matter much since the symmetric Band-Pass filter delivers similar sample statistics but with higher standard errors (available from the authors).
Tables 1 and 2 show that the point estimates for the average relative volatilities of nondurable consumption and durable spending are different between the two sets of economies. Using a Welch’s $t$-test (Welch, 1947) for the equality of two sample means, we conclude that the average relative volatility of nondurable consumption is higher in emerging countries than in small developed ones at the 1 percent significance level.\textsuperscript{10} However, using the same test, we cannot reject the null that the average relative volatility of durable spending is the same for the two groups of countries ($t = 1.27$). This does not invalidate Fact 3 since our sample statistics for the developed economies are biased upwards due to the inclusion of Portugal and Spain. In fact, most or all of the sample period for which we have data coincides with these countries’ adoption of the euro, which triggered a sharp reduction in real interest rates and a run-up in durable spending. If we exclude Portugal and Spain, the average relative volatility of durable spending for small developed economies declines to 3.22 (slightly lower than in large developed economies; see Table 3) and the null of equal means can now be rejected at the 1 percent confidence level ($t = 2.73$).

Finally, our sample shows significant variability on a country-by-country basis within the emerging countries’ group in terms of both the relative volatility of total consumption spending and the correlation of the trade balance with output. For the volatility of consumption, emerging countries range between 17 percent below that of output for Poland and 50 above that of output for Turkey. The dispersion of results is even more striking for the countercyclical of the net exports-output ratio. While developed economies show uniformly mildly countercyclical trade balances (the average correlation of net exports with GDP in our sample of small advanced economies is only -0.10 and in line with the averages of -0.17 and -0.25 for OECD countries reported by Aguiar and Gopinath, 2007, and Engel and Wang, 2011, respectively), emerging economies as a group show an average correlation of the net exports-output ratio with GDP of -0.48 but with some countries having strongly procyclical trade balances (Hong Kong at 0.55) while others have strongly countercyclical net exports (Mexico at -0.86).

\section{The Model}

We model a two-sector neoclassical small open economy populated by a continuum of homogeneous households of unit mass. Our stochastic environment combines transitory and trend shocks to productivity in line with recent RBC frameworks focusing on emerging economies (see Aguiar and Gopinath, 2007, and García-Cicco et al., 2010). In addition, the model incorporates consumer durable goods and reduced-form financial frictions.

In our model economy, firms are competitive and allocate the two factors of production, capital and labor, between two sectors. One sector produces nondurable goods, $Y_{n,t}$, which can only be used for consumption. The other sector produces durable goods, $Y_{d,t}$, which can be used for consumption or as capital. Production technology in each sector $i \in \{n,d\}$ is Cobb-Douglas:

$$Y_{i,t} = F_i(K_{i,t}, L_{i,t}, z_{i,t}, \Gamma_t) = e^{z_{i,t}} K_{i,t}^{\alpha_i} (\Gamma_t L_{i,t})^{1-\alpha_i},$$

\textsuperscript{10}The Welch’s test statistic is given by $t = (\bar{X}_1 - \bar{X}_2)/\sqrt{s_1^2/T_1 + s_2^2/T_2}$ and follows, under the null, a $T$ distribution with approximately $(s_1^2/T_1 + s_2^2/T_2)^2/((s_1^2/(T_1 - 1))^2 + (s_2^2/(T_2 - 1))^2)$ degrees of freedom. For the case of nondurable goods, the $t$-stat is 3.41.
where $\alpha_i \in (0, 1)$, $K_{i,t}$ and $L_{i,t}$ denote capital and labor used in sector $i$, and $\Gamma_t$ and $z_{i,t}$ represent stochastic productivity processes.

The random variable $\Gamma_t$ is the cumulative product of shocks to trend, which are governed by an AR(1) process $g_t$. Moreover, sector-$i$’s productivity process $z_{i,t}$ is stationary and also follows an AR(1) process. Thus, we can write

$$
\Gamma_t = \prod_{j=0}^{t} e^{g_j},
$$

(2)

$$
g_t = (1 - \rho_g) \ln \mu_g + \rho_g g_{t-1} + \epsilon_{g,t},
$$

(3)

$$
z_{i,t} = \rho_i z_{i,t-1} + \epsilon_{i,t}, \text{ with } i \in \{n, d\}.
$$

(4)

The innovation $\epsilon_{g,t}$ is an i.i.d. random variable drawn from a normal distribution with zero mean and standard deviation $\sigma_g$. The random vector $(\epsilon_{n,t}, \epsilon_{d,t})$ is also i.i.d. and is drawn from a bivariate normal distribution with zero mean and covariance matrix $\Sigma_Z$ given by

$$
\Sigma_Z = \begin{bmatrix}
\sigma_n^2 & \rho_{nd}\sigma_n\sigma_d \\
\rho_{nd}\sigma_n\sigma_d & \sigma_d^2
\end{bmatrix}.
$$

(5)

Our environment incorporates two direct sources of sectoral comovement: the common shock to trend, and the contemporaneous correlation between transitory shocks, $\rho_{nd}$. The assumption that the durable and the nondurable goods sectors share a common shock to trend is justified and is not overly restrictive. Galí (1993) uses a similar assumption when modeling the changes in consumption of nondurables and durables as ARMA processes. Moreover, shocks to trend are often associated with changes in government policies (Aguiar and Gopinath, 2007) and are, therefore, expected to affect simultaneously all sectors in the economy.

Regarding the correlation between sectoral shocks, there is no reason to arbitrarily assume it is zero. Moreover, allowing these shocks to be correlated may improve the ability of the model to replicate the joint dynamics of sectoral output as suggested in Hornstein and Praschnik (1997) and Baxter (1996). In the robustness section we examine the role of this correlation.

There exists an infinitely-lived representative household with preferences over leisure $(1 - L_t)$ and a composite consumption bundle $C_t$, and discount factor $\beta \in (0, 1)$. Period utility $U(C_t, 1 - L_t)$ is Cobb-Douglas, and the consumption bundle is a CES aggregation of nondurable goods $N_t$ and the stock of durables $D_t$. In particular, let

$$
U(C_t, 1 - L_t) = \frac{(C_t^\theta (1 - L_t)^{1-\theta})^{1-\sigma}}{1-\sigma}, \quad \text{and}
$$

(6)

$$
C_t = (\mu N_t^{-\gamma} + (1 - \mu) D_t^{-\gamma})^{-\frac{1}{\gamma}},
$$

(7)

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11 In an earlier version of this paper (Álvarez Parra et al., 2011), we incorporate intermediate goods in the model as another source of comovement. In the robustness section 4.3, we show that the presence of intermediate goods is immaterial for our quantitative results. In the Appendix, we detail the solution of this more general model.

12 As a preview of our results, when we impose uncorrelated shocks our quantitative results do change somewhat. In particular, the model can only account for about 55 percent of the observed correlation between sectoral outputs. It also generates less output volatility and shocks to trend account for a larger share of this volatility.
where $\theta \in (0, 1)$ is the utility share of consumption, $\sigma > 0$ is the coefficient of relative risk aversion, $\frac{1}{1+\gamma} > 0$ is the elasticity of substitution between durable and nondurable goods, and $\mu \in (0, 1)$ represents the utility share of nondurable consumption.\(^{13}\)

The household owns the stocks of consumer durables and capital which is sector-specific. The accumulation of durables as well as capital in each sector is subject to quadratic adjustment costs, as it is standard in the literature. Thus, the law of motions of these three stocks are

$$K_{n,t+1} = X^n_{k,t} + (1 - \delta_k)K_{n,t} - \frac{\phi}{2} \left( \frac{K_{n,t+1}}{K_{n,t}} - \mu_g \right)^2 K_{n,t}, \quad (8)$$

$$K_{d,t+1} = X^d_{k,t} + (1 - \delta_k)K_{d,t} - \frac{\phi}{2} \left( \frac{K_{d,t+1}}{K_{d,t}} - \mu_g \right)^2 K_{d,t}, \quad \text{and} \quad (9)$$

$$D_{t+1} = X^d_{d,t} + (1 - \delta_d)D_{t} - \frac{\psi}{2} \left( \frac{D_{t+1}}{D_{t}} - \mu_g \right)^2 D_{t}, \quad (10)$$

where $\delta_d$ and $\delta_k$ are depreciation rates of durable goods and capital; $X^n_{k,t}$ and $X^d_{k,t}$ are investment in sectoral capital; and $X^d_{d,t}$ stands for household purchases of durable goods.\(^{14}\)

Adjustment costs of capital are often used to prevent the model from delivering excessive volatility of investment. Likewise, adjustment costs of the stock of durables help the model reproduce the inertia of durable expenditure observed at the aggregate level.\(^{15}\)

We also assume that there exists perfect labor mobility across sectors which implies that, in equilibrium, wages are equal in both sectors. Hence, the household is indifferent regarding the sectoral allocation of labor, which is then determined by firms’ labor demand.

An important assumption we need to make is that one of the goods must be non-tradable. This assumption is essential to be able to solve for the equilibrium of this economy. If both goods were tradable, the relative price between the two goods would be exogenously given. As a result, the equilibrium system of equations would be overdetermined due to conditions on factor prices across sectors which must be satisfied.\(^{16}\)

We therefore assume that only the durable good can be traded across borders. Our choice is supported by empirical evidence which shows that durables account for most of trade in goods. For instance, Engel and Wang (2011) find that, for OECD countries, the average share

\(^{13}\)Alternatively, we could use separable preferences in leisure and consumption such as GHH preferences (Greenwood et al., 1988). However, since Kydland and Prescott (1982), the RBC literature has a long tradition using non-separable preferences. In fact, Guerron-Quintana (2008) presents compelling evidence that data favors non-separable preferences. Moreover, in the international finance field, Jermann (2002) finds that non-separability in preferences helps explain home bias in portfolio choice. In the robustness section we consider separable GHH preferences, and show that our main conclusions hold.

\(^{14}\)We do not restrict $X^n_{k,t}$, $X^d_{k,t}$ and $X^d_{d,t}$ to be positive. This implies that agents can move capital from one sector to the other, or transform consumer durables into capital (and the other way around). In any case, the sector specific adjustment cost must be paid. Including consumer durables and capital as state variables in each sector is required given these adjustment costs.

\(^{15}\)To generate the observed lumpiness and discontinuous nature of this expenditure at the micro level, however, some degree of consumer heterogeneity and non-convexities in the adjustment technology is needed (see Caballero, 1993). Additionally, see Cooper and Haltiwanger (2006) for an explanation of the role of capital adjustment costs using firm-level data.

\(^{16}\)See Appendix A.5 for a more detailed argument.
of durables in imports and exports of goods (excluding raw materials and energy) is 69 and 65 percent, respectively. For Mexico, these shares increase to 74 and 78 percent. Mexican data also reveals that domestic nondurable goods represent nearly 96 percent of total nondurable consumption.

Finally, asset markets are incomplete. The only financial asset is an internationally traded one-period bond whose non-contingent payments are defined in units of the durable good. We denote $q_t$ as the price of the bond, and $B_{t+1}$ as the amount of bonds bought by the household at period $t$. In other words, the latter represents borrowing from abroad. As in Schmitt-Grohé and Uribe (2003), households take the bond price as given, which is endogenously affected by country fundamentals. Specifically, the bond price depends on the aggregate bond position $\tilde{B}_{t+1}$ as well as on (expected) next-period output $Y_{t+1}$, and is given by the following equation:

$$q_{t}^{-1} = 1 + r^* + \chi \left( \exp \left( \frac{\tilde{B}_{t+1}}{\Gamma_t} - \tilde{B} \right) - 1 \right) + \eta \left( E_t \frac{Y_{t+1}}{\Gamma_t} - \tilde{Y} \right),$$

(11)

where $r^*$ is the exogenous international interest rate, and $-\tilde{B}$ and $\tilde{Y}$ are the steady-state levels of (detrended) aggregate debt and output.\textsuperscript{17}

The borrowing premium implicit in (11) can be seen as a reduced form of several underlying mechanisms associated with financial frictions, along the lines of García-Cicco et al. (2010). The term $\eta \left( E_t \frac{Y_{t+1}}{\Gamma_t} - \tilde{Y} \right)$, with $\eta < 0$, could potentially generate a countercyclical real interest rate typically observed in emerging economies (see Neumeyer and Perri, 2005, for instance), possibly as a consequence of deeper market frictions. For example, government commitment problems in international financial markets may lead to sovereign default and endogenous borrowing limits as in Eaton and Gersovitz (1981). The other term, $\chi \left( \exp \left( \frac{\tilde{B}_{t+1}}{\Gamma_t} - \tilde{B} \right) - 1 \right)$, is standard in this literature and seeks to prevent a non-stationary behavior of net foreign assets (Schmitt-Grohé and Uribe, 2003).

The competitive equilibrium allocation of this economy is equivalent to the allocation chosen by a social planner who takes the bond price $q_t$ as given.\textsuperscript{18} Therefore, we focus on the planner’s problem and solve for the (constrained) Pareto optimal allocation. Since the economy features a stochastic trend, finding a stationary solution requires making the following variable transformation. Define $\tilde{W}_t \equiv W_t / T_{t-1}$ as the detrended counterpart of $W_t$.

In order to define the stationary planner’s problem, let $S = (\tilde{D}, \tilde{K}_d, \tilde{K}_n, \tilde{B}, z_d, z_n, g)$ be the state vector and $x = (\tilde{N}, \tilde{D}', \tilde{K}'_d, \tilde{K}'_n, \tilde{B}', L, L_d, L_n)$ be the choice vector. It is also useful to denote $\tilde{\beta} \equiv \beta e^{\theta (1-\sigma)}$ and drop time subscripts. The following Bellman equation describes the planner’s dynamic programming problem:

$$V(S) = \max_x \left\{ \frac{\left( \tilde{C}^\theta (1-L)^{1-\theta} \right)^{1-\sigma}}{1-\sigma} + \tilde{\beta} E \left[ V(S') \right] | S \right\}$$

(12)

\textsuperscript{17}Clearly, in equilibrium, $B_{t+1} = \tilde{B}_{t+1}$.

\textsuperscript{18}In the Appendix A.3 we show this equivalence.
subject to

\[ \hat{N} = F_n(\hat{K}_n, L_n, z_n, e^g), \]

\[ e^g(\hat{D}' + \hat{K}_n' + \hat{K}_d' + q\hat{B}') = F_d(\hat{K}_d, L_d, z_d, e^g) + (1 - \delta_k)(\hat{K}_n + \hat{K}_d) + (1 - \delta_d)\hat{D} - \]

\[ \frac{\phi}{2} \left( e^g \frac{\hat{K}_d'}{\hat{K}_d} - \mu_g \right)^2 \hat{K}_d - \frac{\phi}{2} \left( e^g \frac{\hat{K}_n'}{\hat{K}_n} - \mu_g \right)^2 \hat{K}_n - \]

\[ \frac{\psi}{2} \left( e^g \frac{\hat{D}'}{\hat{D}} - \mu_g \right)^2 \hat{D} + \hat{B}, \]

\[ L = L_n + L_d \leq 1, \]

\[ \hat{C} = (\mu \hat{N}^{-\gamma} + (1 - \mu)\hat{D}^{-\gamma})^{-\frac{1}{\gamma}}, \]

Equation (13) is the feasibility condition for nondurable goods and reflects the assumption that these goods are non-tradable. Equation (14) is the resource constraint for durable goods. It incorporates the fact that these goods are tradable and that the foreign bond is specified in units of durable goods.

In the Appendix A.1 we derive the optimality conditions associated with the planner’s problem. With these equations and resources constraints, we solve for the optimal allocation using Dynare which linearizes the model around its deterministic steady state.

4 Quantitative Results

In this section, we calibrate the parameters associated with the deterministic steady-state version of the model and estimate the remaining parameters by GMM. We parameterize the model to the Mexican economy at a quarterly frequency.

4.1 Calibration

Starting with the technology parameters, we set \( \alpha_n = 0.52 \) and \( \alpha_d = 0.32 \) to match the income shares of labor in the nondurable and durable sectors (0.48 and 0.68, respectively) as in Baxter (1996). Using the same source, we set the annual depreciation rates for capital and durables to 7.1 and 15.6 percent. Finally, we set \( \mu_g = 1.0074 \) to match the average quarterly GDP gross growth rate in our sample.

The exogenous interest rate \( r^* \) is set to satisfy the steady-state condition \( \beta(1 + r^*) = \mu_g^{1-\theta(1-\sigma)} \). The steady-state debt level \(-\hat{B}\) is set such that its ratio to GDP is 10 percent. The parameter \( \chi \), which determines the sensitivity of the bond price to the debt level, is set to

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19 In the Appendix A.6, we describe the sources of the Mexican data we use.

20 This ratio only matters to determine the steady-state level of net exports and is immaterial for results.
-0.001, as is standard in the literature (see Schmitt-Grohé and Uribe, 2003, and Neumeyer and Perri, 2005, and Aguiar and Gopinath, 2007).\textsuperscript{21}

As for the preference parameters, we work with a discount factor $\beta$ of 0.98 and a coefficient of relative risk aversion $\sigma$ of 2, which are standard values in the RBC literature. We set $\gamma = 0.163$ so that the elasticity of substitution between goods $\left(\frac{1}{1+\gamma}\right)$ is 0.86, as in Gomes, Kogan, and Yogo (2009).\textsuperscript{22} Finally, given the previous parameter values, we calibrate the utility share of nondurables $\mu$ and the Cobb-Douglas exponent for consumption in the utility function $\theta$ to jointly match the average share of nondurable consumption in total consumption expenditure of 91.8 percent and a steady-state fraction of time devoted to work of 1/3. This yields $\mu = 0.881$ and $\theta = 0.423$. We summarize the calibrated parameter values in Table 4.

### 4.2 GMM Estimation Results

We estimate the remaining 10 parameters using GMM.\textsuperscript{23} The parameters are: the standard deviation of the technology shocks, $\sigma_g$, $\sigma_n$, and $\sigma_d$; the autocorrelation coefficients of the shock processes, $\rho_g$, $\rho_n$, and $\rho_d$; the correlation between sectoral shocks $\rho_{nd}$; the coefficients of the adjustment cost of durable goods and capital, $\psi$ and $\phi$; and the financial friction parameter $\eta$.\textsuperscript{24}

We include the following 17 moment conditions: the standard deviations of output $\sigma(y)$, output growth $\sigma(\Delta y)$, the net exports-output ratio $\sigma(nx)$, and the borrowing premium $\sigma(bp)$; the standard deviations relative to that of output of total consumption expenditure $\sigma(c)/\sigma(y)$, nondurable consumption $\sigma(cn)/\sigma(y)$, durable expenditure $\sigma(cd)/\sigma(y)$, and investment $\sigma(i)/\sigma(y)$; the correlation of output with total consumption $\rho(ym,c)$, investment $\rho(ym,i)$, the net exports-output ratio $\rho(nx)$, and the borrowing premium $\rho(bp)$; the correlation between sectoral outputs $\rho(n,d)$, and the first-order autocorrelation of output $\rho(ym)$, output growth $\rho(\Delta y, \Delta y_{-1})$, and both sectoral outputs $\rho(y_n,j, y_{n-1}, j = \{n, d\})$. All variables are in logs, except the net exports-output ratio. We also HP filter all variables, except output growth $\Delta y_t$ which is the first difference of (unfiltered) log output. Furthermore, moment conditions are based on theoretical moments.

The estimated parameter values with standard errors in parentheses are shown in Table 5. We also report the random walk component of sectoral Solow residuals (as calculated by

\textsuperscript{21} Strictly speaking, $\chi$ does not affect the steady state because its corresponding term in the bond price equation is zero in the steady state. In our model with financial frictions, we focus on the parameter $\eta$ which we associate with the induced country-risk hypothesis of Neumeyer and Perri (2005) and is more in line with the well-known empirical fact that the borrowing premium in emerging economies is countercyclical.

\textsuperscript{22} This value means that the two goods are gross substitutes (the condition being $\sigma > 1 + \gamma/\theta$). It is also consistent with Ogaki and Reinhart’s (1998) finding that the intratemporal elasticity of substitution between durables and nondurables is significantly higher than the intertemporal elasticity of substitution. In addition, it is close to the value assumed by Hornstein and Praschnik (1997) of unit elasticity.

\textsuperscript{23} We use a two-step estimation procedure. In the first step we estimate the parameter vector $\xi$ using as weighting matrix either the identity matrix or the inverse of the matrix $S_T$ evaluated at the initial parameter vector. $S_T$ is the heteroskedasticity and autocorrelation robust estimator of the covariance matrix $S_0 = E[\sum_{j=-\infty}^{\infty} g(x_t, \xi_0) g(x_{t+j}, \xi_0)]$, where $g(x_t, \xi)$ is a vector-valued function which defines the moment conditions $E[g(x_t, \xi)] = 0$, $\xi_0$ is the true parameter vector, and $x$ is a vector of time series. We compute $S_T$ using the method proposed by Newey and West (1987) with the Barlett kernel. In the second step, we re-estimate $\xi$ using as weighting matrix the inverse of $S_T$ evaluated at the parameter vector found in the first step.

\textsuperscript{24} Notice that none of these parameters affect the steady state around which the linearization is performed.
Aguiar and Gopinath, 2007), the share of output volatility attributed to shocks to trend, and the $p$-value for the $J$-test of over-identifying restrictions. Table 6 displays the corresponding theoretical and empirical moments.

We begin by estimating a constrained version of the model with $\eta = 0$. We call this specification the no financial frictions case. Column 1 in Tables 5 and 6 reports the results for this specification. Column 2 shows the results of the full estimation of the model with financial frictions, where we estimate the whole vector of 10 parameters, including $\eta$. We associate this parameter with financial frictions, which is consistent with Neumeyer and Perri’s (2005) induced country risk hypothesis.

In Table 5 we observe that estimates of the parameters in columns 1 and 2 are significant at the 1 percent level except for $\rho_g$, which in both cases is not statistically different from zero, using standard asymptotic theory of GMM estimation. We take this as only suggestive evidence of the significance of the estimates because of the well-known finite sample bias of GMM estimation of DSGE models. It is also worth noting that the moment conditions for both specifications are valid given the low values of the $J$-statistics and their $p$-values (with the caveat that asymptotic approximations may be poor in our small sample).

Specification 1 yields highly persistent transitory shocks with both $\rho_n$ and $\rho_d$ over 0.89, in line with Aguiar and Gopinath (2007). In contrast, our estimate of $\sigma_g$ (1.63) is significantly smaller than theirs, whereas our estimates for $\sigma_n$ (1.26) and $\sigma_d$ (1.50) are much larger than their estimates of the standard deviation of the transitory shock. We also obtain a correlation of sectoral shocks $\rho_{nd}$ of 0.57 which is consistent with Hornstein and Praschnik’s (1997) estimated correlation of sectoral productivity innovations for the United States (0.6).

These estimation results suggest that shocks to trend play a less important role in driving business cycle fluctuations in emerging economies than what Aguiar and Gopinath (2007) find. Our estimates imply that the random walk components $\omega_n$ and $\omega_d$ are well below the range between 0.88 and 1.13 that Aguiar and Gopinath report for Mexico. As a result, trend shocks account for 34 percent of GDP volatility.

The model with no financial frictions, however, does not deliver the so-called excess volatility of consumption, a central feature of business cycles in emerging economies. As shown in column 1 of Table 6, it underestimates the volatilities of both durable and nondurable consumption expenditure, especially the former. In principle, the model could match the volatility of total consumption relative to output observed in the data by increasing $\sigma_g$. The solid line in Figure 1 illustrates this point. There, we plot the volatilities of total consumption, durable expenditure and the net exports-output ratio, and the correlation of the net exports-output ratio with output against $\sigma_g$. This figure also shows that increasing $\sigma_g$ generates a more counter-cyclical net exports-output ratio, which the model underestimates as well.

The main reason why $\sigma_g$ is not sufficiently large is because we are also targeting the volatilities of durable expenditure and the net exports-output ratio. Doing this imposes discipline on the GMM estimation which tends to reduce the importance of shocks to trend. This happens

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25 GMM estimation tends to require at least 300 observations for asymptotic approximations, and convergence is slow (Canova, 2007, pp. 195-197).

26 Given Aguiar and Gopinath’s (2007) full estimation results for Mexico (see column 4 of their table 4), we calculate that trend shocks account for 77 percent of output fluctuations in their model.

27 The remaining parameters are fixed at the same values estimated in specification 1.
because increasing $\sigma_g$ in order to match $\frac{\sigma(c)}{\sigma(y)}$ comes at the expense of overestimating $\frac{\sigma(c_d)}{\sigma(y)}$ and $\sigma(nx)$. Our assumption on tradability is crucial to get these two moments to behave in this fashion. It establishes a tight link between the dynamics of durable expenditure and net exports that implies a joint response to shocks which, in turn, makes their volatilities move together.

The moment conditions concerning $\frac{\sigma(c)}{\sigma(y)}$, $\sigma(nx)$, and $\rho(y,nx)$ also put a bound on the persistence of the shock to trend and, consequently, the size of the random walk component of total factor productivity. An alternative way of increasing the volatility of consumption relative to output is to have a very persistent trend shock (i.e., $\rho_g$ over 0.9). However, this makes not only durable expenditure and the net exports-output ratio too volatile but also the latter strongly procyclical. The increase in $\frac{\sigma(c_d)}{\sigma(y)}$ and $\sigma(nx)$ is due to the fact that, with higher $\rho_g$, any given shock to trend affects the average productivity growth rates for a longer period. Agents respond to this larger change in future income by adjusting their stock of durables and capital more, which in turn makes net exports more responsive as well. The procyclicality of net exports comes from the fact that, with highly persistent shocks to trend, a positive shock causes output to initially fall because labor supply also decreases due to the strong positive income effect.

Figure 1 also shows the response of the selected moments when the rate of depreciation of durables $\delta_d$ takes two larger values: 0.5 and 1. We observe that, for any given $\sigma_g$, a higher $\delta_d$ implies lower $\frac{\sigma(c)}{\sigma(y)}$ and $\sigma(nx)$. Moreover, these two moments respond less to a change in $\sigma_g$ when $\delta_d$ is higher. As a result, when durability is low (the two higher $\delta_d$), it takes a large $\sigma_g$ to deliver a sufficiently volatile total consumption. In contrast, when durability is high ($\delta_d = 0.039$), a small $\sigma_g$ generates a high volatility of consumption. This shows that adding consumer durable goods into the model provides an amplification mechanism of shocks to trend. Therefore, these shocks do not need to be as large, which lowers their importance relative to transitory shocks as driving force of output fluctuations.

Another important reason why consumption volatility in our model without financial frictions is not as high as in the data is the strongly procyclical borrowing premium, which makes consumption spending smoother. In addition, it causes net exports to be much less countercyclical than in the data. Figure 2 shows the effect on consumption and net exports of introducing financial frictions in the model by decreasing the borrowing premium parameter $\eta$. As this parameter falls, the borrowing premium becomes less procyclical and eventually turns countercyclical. Moreover, consumption volatility increases and the net exports to output ratio becomes more countercyclical.

The estimation of the model with financial frictions (specification 2) yields a negative $\eta$ which generates a more volatile and countercyclical borrowing premium in line with the em-

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28In order to explore to what extent these two moments conditions prevent $\sigma_g$ from being sufficiently large, we do the following estimation exercise. We estimate $(\sigma_g,\sigma_n,\sigma_d)$ by targeting the following four moments: $\frac{\sigma(c)}{\sigma(y)}$, $\frac{\sigma(c_d)}{\sigma(y)}$, $\frac{\sigma(n)}{\sigma(y)}$, and $\frac{\sigma(i)}{\sigma(y)}$. We set the remaining parameters to their estimated value in specification 1. We obtain much larger shocks to trend relative to transitory ones. In particular, we obtain $\sigma_g = 1.78$, $\sigma_n = 1.04$ and $\sigma_d = 0.92$. As a result, shocks to trend account for about 54 percent of output volatility, well above what we obtain in specification 1. Moreover, the model overestimates the volatilities of consumer durable expenditure and of the net exports-output ratio, yielding 4.58 and 1.98, respectively.

29In these cases, we recalibrate the parameters $\mu$ and $\theta$ in order to keep unchanged the share of consumption of both goods and the time devoted to work in the steady state.
pirical evidence.\textsuperscript{30} As a result, consumption expenditure is indeed more volatile than output, net exports are much more countercyclical (see column 2 of Table 6), and the quality of fit of the model improves along several dimensions.

To evaluate this improvement we implement the method proposed by Schorfheide (2000). The procedure consists in ranking two competing models according to a loss measure, conditional on an empirical model which is supposed to accurately represent the underlying economic data, such as a vector autoregression (VAR). Intuitively, this method measures the degree of overlap between the distribution of moments generated by a number of simulations of each model and that of the moments generated by the VAR.\textsuperscript{31} For this effect, we choose only four moments: $\frac{\sigma(c)}{\sigma(y)}$, $\frac{\sigma(c_n)}{\sigma(y)}$, $\frac{\sigma(c_d)}{\sigma(y)}$, and $\rho(y, nx)$. Schorfheide’s (2000) $L_{\chi^2}$ loss is 62.62 for specification 1 and only 9.40 for specification 2 (the associated risk is 1 and 0.93, respectively). The improvement brought by the inclusion of financial frictions is also made clear by inspecting Figure 3, where we plot $\frac{\sigma(c)}{\sigma(y)}$ against $\rho(y, nx)$. The degree of overlap between the distribution of moments generated by the reduced form empirical model and the model with financial frictions is higher than for the model without financial frictions.\textsuperscript{32}

The intuition behind the cyclical behavior observed in the model with financial frictions can be found in the interaction between the accumulation of durables and the countercyclical borrowing premium. During economic expansions, for instance, consumers take advantage of the lower interest rate by borrowing more in order to increase the stock of durables as well as capital. Since durable goods are tradable, part of the accumulation of durables and capital resorts to imports. As a result, net exports fall more and consumption expenditure and investment increase more during expansions making the net exports-output ratio more countercyclical and consumption more volatile relative to output. In fact, when we shut down the financial friction by setting $\eta = 0$, while holding all other parameters at their estimated values under specification 2, we observe that $\frac{\sigma(c)}{\sigma(y)}$ falls to 0.99 and $\rho(y, nx)$ increases to -0.22.

To further illustrate the role of financial frictions, we plot, in Figure 4, the impulse-response (IR) functions of consumption, investment and the net exports-output ratio for two cases: $\eta = -0.031$ (solid line), as estimated, and $\eta = 0$. The top three graphs show the impact of a transitory shock to the nondurable goods sector whereas the bottom three display the effect of a shock to the durable goods sector. Financial frictions help transitory shocks generate not only more volatile consumption but also countercyclical net exports. Without financial frictions, we observe that the net exports-output ratio tends to behaves procyclically since investment and consumption do not respond enough when a shock occurs.\textsuperscript{33} In contrast, with financial frictions, consumption and investment increase sufficiently to generate a drop in the net exports-output ratio.

\textsuperscript{30}This is also consistent with Neumeyer and Perri’s (2005) findings.
\textsuperscript{31}The details on how the procedure is implemented are included in Appendix A.7.
\textsuperscript{32}The overlap of the distribution of moments generated by specification 1 with the 95 percent probability contour for the distribution of moments generated by the VAR is zero, while it is roughly 67 percent for specification 2. See Appendix A.7.
\textsuperscript{33}In fact, total consumption barely increases after a positive shock hits the durable goods sector because nondurable consumption falls almost as much as durable expenditure increases. This drop in nondurable consumption is caused by the drop in output in this sector, as labor is directed to the durable goods sector which is experiencing a boost in productivity.
The very different response of consumption to a transitory shock with and without financial frictions is mostly explained by the behavior of durable expenditure. Similarly to investment, it responds much more to shocks in the presence of financial frictions because of the intertemporal substitution effect associated with changes in the interest rate.

The addition of financial frictions also yields less persistent transitory shocks with \( \rho_n = 0.79 \) and \( \rho_d = 0.69 \). Moreover, sectoral shocks are less positively correlated, with an estimate of \( \rho_{nd} = 0.43 \). This happens because financial frictions introduce a propagation mechanism through which sectoral shocks affect the economy both across sectors and over time.

We obtain \( \sigma_d = 1.19 \) which is lower than our estimate in specification 1 because financial frictions amplify the effect of transitory shocks on durable expenditure and investment. Hence, these shocks do not need to be as large to generate as much volatility in these variables. In contrast, our estimates of \( \sigma_n = 1.35 \) and \( \sigma_g = 1.81 \) are somewhat larger than their values in specification 1. These estimates imply that the random walk component of the sectoral Solow residuals are 0.35 and 0.61 in the nondurable and durable sectors, respectively, which are also well below of the range found by Aguiar and Gopinath (2007) for Mexico. The variance decomposition of GDP shows that trend shocks account for 48 percent of output fluctuations.

One interesting question is whether the model with durable goods needs a smaller degree of financial frictions, measured by \( \eta \), to deliver the required dynamics. We have argued that the presence of durable goods provides a channel that amplifies shocks and helps explain the cyclical behavior of key variables (see Figure 1). Therefore, it is likely that the omission of the durability channel has implications for the estimate of \( \eta \). Impulse-response functions for different degrees of durability suggest this.\(^\text{34}\) Differences in the responses of durable expenditure and the net exports-output ratio are remarkable.

To explore this further, we carry out a calibration exercise in which we solve for \( \eta \), together with \((\sigma_y, \sigma_n, \sigma_d)\), targeting the following four moments: \( \sigma(y), \sigma(c)/\sigma(y), \sigma(nx) \) and \( \rho(y, bp) \). We do that for \( \delta_d = \{0.039, 1\} \).\(^\text{35}\) In the case of no durability \( (\delta_d = 1) \), the resulting \( \eta \) is, in absolute value, about 20 percent larger than in the case with \( \delta_d = 0.039 \). Therefore, when we consider durable goods, the model does indeed require a smaller degree of financial frictions.

In conclusion, we have two main findings. First, including durable goods in an RBC model for emerging economies reduces the role of trend shocks relative to what has been found in the literature. Second, to replicate the observed high volatility of consumption and countercyclicality of net exports and the borrowing premium, we need to incorporate financial frictions.

### 4.3 Robustness

In this subsection we perform a number of exercises to check the robustness of the main results presented above. In each case, we reestimate the model with financial frictions, which makes our specification 2 our point of reference for comparison purposes. The parameter estimates and resulting moments for each exercise are shown in columns 3 through 7 of Tables 5 and 6.

The first exercise investigates whether our results are robust to the introduction of intermediate inputs. We consider an extension of the model where nondurable goods are also used...
as intermediate inputs in the production of durable goods. For simplicity, we assume that the technology in this sector is Leontief which combines two components: value added, which is produced using the Cobb-Douglas function \( F_d \) in equation (1), and the intermediate input \( M_n \).

In particular, output in the durable sector is given by

\[
Y_{d,t} = \min \left\{ \frac{F_d(K_{d,t}, L_{d,t}, z_{d,t}, \Gamma_t)}{\Omega}; \frac{M_{n,t}}{\Omega} \right\},
\]

(17)

where \( \Omega \) is the quantity of the intermediate input needed to produce one unit of the durable good. We set \( \Omega = 0.3 \), which is close to what Kouparitsas (1998) documents for Mexico (0.28) and, for instance, within the range (between 0.26 and 0.38, depending on the measure) observed for the U.S. by Hornstein and Praschnik (1997).

Under this alternative model, the contribution of shocks to trend to output volatility stays unchanged at 48 percent. Furthermore, the model generates basically the same moments as the benchmark model. Therefore, the presence of intermediate inputs is not crucial for our results to hold.

Our second robustness check studies the role of correlated sectoral shocks. In this case, we impose \( \rho_{nd} = 0 \). Columns 4 shows the results. When we have uncorrelated sectoral shocks, the estimation yields basically the same values for the other parameters. This implies that the model significantly underestimates the correlation of sectoral outputs which is now 0.37 versus 0.67 in the data. Moreover, we observe an increase in the importance of shocks to trend, measured by their contribution to output volatility, from 48 to 55 percent. The intuition for this result is that with uncorrelated sectoral shocks, their joint impact on business cycle fluctuations diminishes. As a consequence, the model overestimates the volatility of nondurable consumption relative to output. Total consumption is also more volatile than in the data despite the model underestimating the volatility of durable expenditure. The latter does not fluctuate as much because the model generates little negative correlation between the borrowing premium and output of -0.10 even though \( \eta \) remains essentially the same at -0.032. The reason for this weakly countercyclical behavior of the borrowing premium is that trend shocks play a more important role. The main mechanism behind this relationship is as follows. A positive trend shock implies an increase in long-run output and, in consequence, an increase in debt as households borrow more. Since the interest rate tends to increase as debt goes up (due to \( \chi < 0 \)), a larger \( \sigma_g \) tends to make the interest rate procyclical.

In conclusion, imposing \( \rho_{nd} = 0 \) biases the importance of permanent shocks upward. Even in these cases, however, we find a much less prominent role of shocks to trend than what Aguiar and Gopinath (2007) find.

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36In terms of parameter estimates, the only significant change concerns the estimate of \( \rho_{nd} \) which falls from 0.43 to 0.30. This happens because there exists one additional source of sectoral comovement and, consequently, \( \rho_{nd} \) does not need to be as high in order to reproduce the correlation of sectoral outputs.

37A related question is whether our assumption of no substitutability between value added and intermediate inputs in the production of durable goods is too restrictive (i.e., Leontief technology). We also explore this by using a Cobb-Douglas technology which assumes an elasticity of substitution equal to 1. The results, which are not shown in the tables, are essentially the same as in specification 3. We conclude that our results with intermediate goods are not driven by the assumption of Leontief technology.
We also investigate whether our results hold with GHH preferences, which are often used in the RBC literature. Column 5 shows the results. The main finding of this exercise is that shocks to trend play a much less important role than in our benchmark case with Cobb-Douglas preferences. These shocks now account for 22 percent of output volatility. This happens because hours worked are much more responsive to shocks to trend since, with GHH preferences, there is no wealth effect on labor supply. As a result, output, durable expenditure, investment and net exports become more volatile than what is found in the data and in specification 2. Financial frictions do not have to be as large and the parameter $\eta$ falls, in absolute value, from -0.031 to -0.015. We conclude that the assumption of GHH preferences strengthens our findings.

Next we consider two distinct configurations of the borrowing premium. First, we introduce an orthogonal shock since it could help explain the behavior of country interest rate premia (Uribe and Yue, 2006). Then, we allow for transitory and permanent income shocks to impact the borrowing premium differently.

With the first modified version of the borrowing premium we want the model to generate a more volatile borrowing premium than what we get with our benchmark specification. Now equation (11) becomes

$$q_t^{-1} = 1 + r^* + \chi \left[ \exp \left( \frac{\bar{B}_{t+1} - \bar{B}}{\Gamma_t} - 1 \right) \right] + \eta \left( E_t Y_{t+1} \frac{\Gamma_t}{\bar{Y}} - \bar{Y} \right) + \epsilon_{b,t},$$

where $\epsilon_{b,t}$ is an i.i.d. shock with variance $\sigma_b^2$, which we also estimate. Results are shown in column 6. The estimate of $\sigma_b = 0.26$ causes the volatility of the borrowing premium to more than double with respect to specification 2. The augmented model also delivers a smaller shock to trend, as $\sigma_g$ goes from 1.81 to 1.36. This happens precisely because the volatility of the borrowing premium increases, which in turn makes durable expenditure and net exports more volatile. Thus, the introduction of orthogonal shocks to the borrowing premium reduces the contribution of trend shocks in terms of output volatility to 33 percent and financial frictions are still needed. Therefore, our main results remain.

The second robustness test on the specification of the borrowing premium requires incorporating an extra term in the borrowing premium that depends directly on the shock to trend $\epsilon_g$. In particular, we consider the following version of equation (11):

$$q_t^{-1} = 1 + r^* + \chi \left[ \exp \left( \frac{\bar{B}_{t+1} - \bar{B}}{\Gamma_t} - 1 \right) \right] + \eta \left( E_t Y_{t+1} \frac{\Gamma_t}{\bar{Y}} - \bar{Y} \right) + \nu \epsilon_{g,t}.$$

The reason why we add the term $\nu \epsilon_{g,t}$ is because trend shocks have a different effect on the borrowing premium than transitory shocks do. A positive shock to trend causes output to be initially below its new trend. Given $\eta < 0$, this positive shock makes the borrowing premium increase and, therefore, tends to make it procyclical. Transitory shocks have the opposite effect. The new term allows the borrowing premium to respond differently to permanent and transitory shocks. Our estimation results (column 7) show the borrowing premium responding positively to trend shocks ($\nu = 0.09$). This, however, generates a higher volatility of the borrowing premium compared to specification 2, which tends to make durable expenditure and net exports more volatile. The estimate of $\sigma_g$ falls and trend shocks contribute less to
output volatility. We can conclude from this exercise that our main findings are robust to this alternative specification of the borrowing premium.

5 Conclusions

Business cycles in emerging economies are characterized by very volatile aggregate consumption and countercyclical trade balances. This paper documents three new stylized facts about business cycles in these economies as well as in small developed economies. The first fact is that consumption of nondurable goods is less volatile than output in both developed and emerging economies. The second fact is that expenditure in durable goods is much more volatile than output in both sets of economies. Thirdly, we find that consumption spending in both durables and nondurables is more volatile in emerging economies than in developed economies.

To explain these key properties of business cycles in emerging economies, we present a small open economy neoclassical growth model with consumer durables, nondurable goods, shocks to trend, and transitory sector-specific shocks. We estimate the underlying parameters of the model using data for Mexico, which we take as representative of an emerging economy.

We first find a greatly diminished role for permanent shocks as a driver of economic fluctuations at a business cycle frequency for emerging countries. Furthermore, exogenous productivity shocks, permanent or temporary, are not enough to explain key business cycle facts in emerging economies, such as a highly volatile consumption and a strongly countercyclical trade balance. We provide two explanations for this finding. First, durable spending is very sensitive to permanent shocks which imposes a cap on the variance of those shocks. Second, if real interest rates are not responsive to economic conditions, the ability of durable goods expenditure to act as a major channel for the propagation of business cycle fluctuations is greatly diminished. Hence, we conclude that some type of friction is needed. We also find that financial frictions in the form of a countercyclical country risk premium greatly improve the model’s ability to replicate the above mentioned facts and therefore play an essential role. For this reason, while still finding shocks to trend relevant in explaining output and consumption fluctuations in developing countries, our results reinforce those of García-Cicco et al. (2010).

A natural extension to this paper is to add microfoundations to our financial friction. The added structure to this key ingredient of our model could suggest improvements to the way we model the borrowing premium. For instance, we find that orthogonal shocks to the interest rate help generate more volatile consumption and net exports and, in consequence, reduce the role of permanent shocks to productivity. Consider, for example, an increase in the variance of the terms of trade. As external income becomes more volatile, default incentives become smaller and, as a consequence, foreign debt conditions endogenously improve. On the one hand, this allows for smoother consumption of nondurables, but on the other hand, the purchase of durables may react as households want to take advantage of better borrowing conditions. As a result, this type of shocks may imply a high volatility in the purchase of durable goods and a relatively small volatility of consumption of nondurables with respect to income volatility. We believe that other types of shocks to the borrowing premium may also play a role and that more work is needed (see Fernandez-Villaverde et al., 2011, and Gruss and Mertens, 2009, for instance).
References


Figure 1: Effect of shocks to trend on consumption and net exports.
A-B: The standard deviations of total consumption expenditure and durable expenditure relative to the standard deviation of output as a function of $\sigma_g$. C-D: The standard deviation and the correlation with output of the net exports-output ratio as a function of $\sigma_g$. All variables are HP filtered. We draw each figure for three values of $\delta_d$: 0.039 (our benchmark), 0.5 and 1. For $\delta_d = 0.039$, we use benchmark parameters in Table 4. For $\delta_d = \{0.5, 1\}$, we recalibrate $\mu$ and $\theta$. The remaining parameters correspond to specification 1 in Table 5 except $\sigma_g$ that takes values from 0 to 5.
Figure 2: Effect of financial frictions on consumption and net exports.
A-B: The standard deviations of total consumption expenditure, nondurable consumption and durable expenditure relative to the standard deviation of output as a function of $\eta$. C-D: The correlation with output of the net exports-output ratio and the borrowing premium as a function of $\eta$. All variables are HP filtered. We use benchmark parameters in Table 4 and estimates for specification 1 in Table 5 except $\eta$ that takes values from -0.01 to 0.
Figure 3: Quality of fit of models with and without financial frictions.
The relative volatility of total consumption (Y-axis) against the correlation with output of the net exports-output ratio (X-axis) generated by: (i) a VAR(1) of filtered output, consumption, nondurable consumption, durable spending, investment, and the net exports-output ratio; (ii) our model without financial frictions; and (iii) our model with financial frictions. The plot is based on 5,000 simulations of each model.
Figure 4: Impulse-response functions for transitory shocks.
A: IR functions for a transitory shock to productivity in the nondurable goods sector of total consumption, investment and the net exports-output ratio. B: IR functions for a transitory shock to productivity in the durable goods sector of total consumption, investment and the net exports-output ratio. All variables are in levels. We use benchmark parameters in Table 4 and estimates for specification 2 in Table 5 except \( \eta \) that also takes value 0.
Table 1: Business Cycle Moments in Emerging Market Economies

Macroeconomic volatility measured by standard deviation ($\sigma$) of quarterly GDP ($y$), total consumption expenditure ($c$), consumption of nondurable goods ($c_n$), expenditure in durable goods ($c_d$), investment ($i$), and net exports-GDP ratio ($nx$). Cyclical properties of macroeconomic variables measured by contemporaneous correlations ($\rho$) with quarterly GDP of total consumption expenditure, consumption of nondurable goods, expenditure in durable goods, investment, and the net exports-GDP ratio. All variables are in logs (except $nx$) and detrended using the HP filter. Country weights for sample average calculated using current U.S. dollar GDP in the year 2000. Group average is weighted by country GDP and sample size. GMM Standard errors in parenthesis (Matlab routines by Constantino Hevia).

<table>
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<th>$\sigma(c)$</th>
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<th>$\sigma(c_d)$</th>
<th>$\sigma(i)$</th>
<th>$\sigma(nx)$</th>
<th>$\rho(y,c)$</th>
<th>$\rho(y,c_n)$</th>
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Table 2: Business Cycle Moments in Small Developed Economies

Macroeconomic volatility measured by standard deviation ($\sigma$) of quarterly GDP ($y$), total consumption expenditure ($c$), consumption of nondurable goods ($c_n$), expenditure in durable goods ($c_d$), investment ($i$), and net exports-GDP ratio ($nx$). Cyclical properties of macroeconomic variables measured by contemporaneous correlations ($\rho$) with quarterly GDP of total consumption expenditure, consumption of nondurable goods, expenditure in durable goods, investment, and net exports-GDP ratio. All variables are in logs (except $nx$) and detrended using the HP filter. Country weights for sample average calculated using current U.S. dollar GDP in the year 2000. Group average is weighted by country GDP and sample size. GMM Standard errors in parenthesis (Matlab routines by Constantino Hevia).

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Table 3: Business Cycle Moments in Large Developed Economies

Macroeconomic volatility measured by standard deviation ($\sigma$) of quarterly GDP ($y$), total consumption expenditure ($c$), consumption of nondurable goods ($c_n$), expenditure in durable goods ($c_d$), investment ($i$), and net exports-GDP ratio ($nx$). Cyclical properties of macroeconomic variables measured by contemporaneous correlations ($\rho$) with quarterly GDP of total consumption expenditure, consumption of nondurable goods, expenditure in durable goods, investment, and net exports-GDP ratio. All variables are in logs (except $nx$) and detrended using the HP filter. Country weights for sample average calculated using current U.S. dollar GDP in the year 2000. Group average is weighted by country GDP and sample size. GMM Standard errors in parenthesis (Matlab routines by Constantino Hevia).

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27
Table 4: Calibrated parameters

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Table 5: Estimated parameters
Specifications 1 through 7 are as follows: (1) benchmark model without financial frictions; (2) benchmark model with financial frictions; (3) model with intermediate goods; (4) model with uncorrelated sectoral shocks; (5) model with GHH preferences; (6) model with i.i.d. shocks to borrowing premium; and (7) model with financial frictions dependent on the type of shock to output. Statistic "ε_g share" is the share of shocks to trends in GDP's variance decomposition.

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Statistics

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† The parameter in this row is σ_{b} for column 6 and ν for column 7.
Table 6: Empirical and theoretical moments
Specifications 1 through 7 are as follows: (1) benchmark model without financial frictions; (2) benchmark model with financial frictions; (3) model with intermediate goods; (4) model with uncorrelated sectoral shocks; (5) model with GHH preferences; (6) model with i.i.d. shocks to borrowing premium; and (7) model with financial frictions dependent on the type of shock to output.

| Moment | Data   | GMM specification | | | |
|--------|--------|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|        |        | benchmark         | robustness | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| $\sigma(y)$ | 2.35 | 2.37 | 2.22 | 2.23 | 2.06 | 2.71 | 2.28 | 2.23 |
| $\sigma(\Delta y)$ | 1.50 | 1.72 | 1.76 | 1.76 | 1.60 | 2.19 | 1.66 | 1.72 |
| $\sigma(c)/\sigma(y)$ | 1.09 | 0.96 | 1.09 | 1.09 | 1.15 | 1.09 | 1.10 | 1.08 |
| $\sigma(c_n)/\sigma(y)$ | 0.89 | 0.82 | 0.88 | 0.88 | 0.97 | 0.88 | 0.88 | 0.88 |
| $\sigma(c_d)/\sigma(y)$ | 4.19 | 3.87 | 4.13 | 4.14 | 4.02 | 4.46 | 4.89 | 4.15 |
| $\sigma(i)/\sigma(y)$ | 3.67 | 3.27 | 3.65 | 3.66 | 3.52 | 3.92 | 3.77 | 3.66 |
| $\sigma(n_x)$ | 1.64 | 1.82 | 1.73 | 1.74 | 1.69 | 2.26 | 2.00 | 1.73 |
| $\sigma(bp)$ | 2.12 | 0.04 | 0.46 | 0.50 | 0.43 | 0.33 | 1.10 | 0.66 |
| $\rho(y, c)$ | 0.94 | 0.90 | 0.93 | 0.93 | 0.89 | 0.96 | 0.91 | 0.94 |
| $\rho(y, i)$ | 0.95 | 0.74 | 0.94 | 0.95 | 0.94 | 0.86 | 0.88 | 0.95 |
| $\rho(y, n_x)$ | -0.86 | -0.30 | -0.75 | -0.76 | -0.69 | -0.66 | -0.63 | -0.77 |
| $\rho(y, bp)$ | -0.20 | 0.56 | -0.21 | -0.22 | -0.10 | -0.46 | -0.14 | -0.23 |
| $\rho(n_x, y_d)$ | 0.67 | 0.62 | 0.63 | 0.63 | 0.37 | 0.81 | 0.59 | 0.64 |
| $\rho(y_t, y_{t-1})$ | 0.81 | 0.76 | 0.71 | 0.71 | 0.72 | 0.70 | 0.76 | 0.73 |
| $\rho(\Delta y_t, \Delta y_{t-1})$ | 0.24 | 0.08 | 0.01 | 0.02 | 0.04 | -0.04 | 0.08 | 0.04 |
| $\rho(y_{n,t}, y_{n,t-1})$ | 0.52 | 0.75 | 0.69 | 0.69 | 0.67 | 0.73 | 0.75 | 0.70 |
| $\rho(y_{d,t}, y_{d,t-1})$ | 0.70 | 0.75 | 0.68 | 0.68 | 0.68 | 0.63 | 0.73 | 0.71 |
Supplementary Material for
“Durable Goods, Financial Frictions, and Business Cycles in Emerging Economies”

A Appendix

In this appendix, we first show the equations characterizing the solution of the planner’s problem presented in section 3, with the addition of intermediate goods as the general case (for the case of no intermediate goods, set $\Omega = 0$). Then, we define the competitive equilibrium associated with our environment, and show the equivalence between these two allocations. We also present the non-stochastic steady-state relations, and an argument regarding the need of one non-tradable good in the model. We finish with a more detailed description of our data for Mexico and a study of the improvement in the quality of fit of the model brought by the inclusion of financial frictions.

A.1 Planner’s optimal allocation

Let $\lambda_n$ and $\lambda_d$ be the Lagrange multipliers associated with constraints (13) and (14), and $\bar{p} = \frac{\lambda_n}{\lambda_d}$. The planner’s problem defines a stochastic process for $x = (\hat{N}, \hat{D}, \hat{K}'_n, \hat{K}'_d, \hat{B}', L, L_d, L_n)$ and $\bar{p}$ that satisfies the following set of optimality conditions (assuming an interior solution):

$$U_C p_\mu K \left( 1 - \Psi_{D'} \right) e^g = \bar{\beta} E_S \left\{ U_C' \left[ C_{D'} + C_N \bar{p}' \left( 1 - \delta_d - \Psi_{D'} \right) \right] \right\}, \quad (A.1)$$

$$U_C p_\mu K \left( 1 - \Phi_{K_n} \right) e^g = \bar{\beta} E_S \left\{ U_C' \left[ C_{N'} \left[ F_{n,K'} + \bar{p}' \left( 1 - \delta_k - \Phi_{K_n'} \right) \right] \right\}, \quad (A.2)$$

$$U_C p_\mu K \left( 1 - \Phi_{K_d} \right) e^g = \bar{\beta} E_S \left\{ U_C' \left[ C_{N'} \left[ \bar{p}' \left( F_{d,K'} + 1 - \delta_k - \Phi_{K_d'} \right) + \Omega F_{d,K'} \right] \right\}, \quad (A.3)$$

$$U_C p_\mu N e^g = \bar{\beta} E_S \left\{ U_C' \left[ C_{N'} \bar{p}' \right] \right\}, \quad (A.4)$$

$$U_C p_\mu F_{n,L} = U_L, \quad (A.5)$$

$$F_{n,L} = (\bar{p} - \Omega) F_{d,L}, \quad (A.6)$$

$$\hat{N} + \Omega F_{d} = F_{n}, \quad (A.7)$$

$$e^g \left( \hat{D}' + \hat{K}'_n + \hat{K}'_d + q \hat{B}' \right) = F_d + (1 - \delta_k) (\hat{K}_n + \hat{K}_d) + (1 - \delta_d) \hat{D} - \Psi (\hat{D}', \hat{D}, g) - \Phi (\hat{K}_d', \hat{K}_d, g) - \Phi (\hat{K}_n', \hat{K}_n, g) + \hat{B}. \quad (A.8)$$

where $E_S = E[\cdot|S]$ is the conditional expectation operator, $U_C$ and $U_L$ are the marginal utilities of consumption and leisure, $C_D$ and $C_N$ are the derivatives of the consumption aggregator function (7) with respect to durables and nondurables, and $F_{i,K}$ and $F_{i,L}$ are the marginal products of capital and labor in sector $i$. Finally, $\Psi$ and $\Phi$ are the adjustment cost functions given by

$$\Phi (\hat{K}_i, \hat{K}_i, g) = \frac{\phi}{2} \left( e^g \frac{\hat{K}_i'}{\hat{K}_i} - \mu_g \right)^2 \hat{K}_i, \quad i \in \{n, d\}, \quad \text{and}$$

$$\Psi (\hat{D}', \hat{D}, g) = \frac{\psi}{2} \left( e^g \frac{\hat{D}'}{\hat{D}} - \mu_g \right)^2 \hat{D},$$
and \( \Phi_{K_i} \) and \( \Psi_{D'} \) denote their derivative with respect to their first argument. We represent the derivative of next-period adjustment costs \( \Phi(\hat{K}_i^n, \hat{K}_i', g') \) with respect to its second argument as \( \Phi'_{K_i} \). Similarly for \( \Psi'_{D'} \).

### A.2 The competitive equilibrium

Let \( \hat{w} \) be the detrended wage rate in units of nondurable goods and \( r_i \) be the rental price of capital in sector \( i \). Define \( p \) as the price of durable goods in terms of nondurables, and \( \pi_i \) as the profit in sector \( i \) (measure in terms of nondurable).

The firm’s problem in each sector is:

\[
\hat{\pi}_n = \max_{K_n, L_n} \left\{ e^{\hat{a}d(\hat{K}_n)} \alpha_n (e^g L_n)^{(1-\alpha_n)} - \hat{w} L_n - r_n \hat{K}_n \right\}, \quad (A.9)
\]

\[
\hat{\pi}_d = \max_{K_d, L_d} \left\{ (p - \Omega) e^{\hat{a}d(\hat{K}_d)} \alpha_d (e^g L_d)^{(1-\alpha_d)} - \hat{w} L_d - r_d \hat{K}_d \right\}, \quad (A.10)
\]

where \( x_i^f = (\hat{K}_i^f, L_i) \) is the demand of capital and labor in sector \( i \in \{n, d\} \). Let \( x_f = (x_n^f, x_d^f) \).

To define the representative household’s problem, let \( S^h = (\hat{D}, \hat{K}_d, \hat{K}_n, \hat{B}, z_d, z_n, g) \) and \( x^h = (\hat{N}, \hat{D}', \hat{K}_d', \hat{K}_n', \hat{B}', L) \). Thus, this problem can be represented by the following Bellman equation:

\[
V(S^h) = \max_{x^h} \left\{ \left( \hat{C}^\theta (1 - L)^{1-\theta} \right)^{1-\sigma} \frac{1}{1 - \sigma} + \hat{\beta} E \left[V(S'^h) | S^h \right] \right\} \quad (A.11)
\]

subject to

\[
\hat{N} + pe^g(\hat{D}' + \hat{K}_n' + \hat{K}_d' + q \hat{B}') = \hat{w} L + r_d \hat{K}_d + r_n \hat{K}_n + p(1 - \delta_k)(\hat{K}_n + \hat{K}_d) + p(1 - \delta_d) \hat{D} + \hat{\pi}_d + \hat{\pi}_n - p \left[ \Psi(\hat{D}', \hat{D}, g) + \sum_{i=d,n} \Phi(\hat{K}_i', \hat{K}_i, g) \right] + p \hat{B}, \quad (A.12)
\]

and stochastic processes (3)-(4) as well as standard non-negativity constraints.

**Definition 4** Given the bond price (11), a competitive equilibrium is a set of processes for allocations \( \{x^h, x^f\} \), profits \( \{\hat{\pi}_d, \hat{\pi}_n\} \) and prices \( \{\hat{w}, r_d, r_n, p\} \) such that

1. Given prices and profits, \( \{x^h\} \) solves the household’s problem characterized by the following optimality conditions:

\[
U_C C_{NP} (1 - \Psi_{D'}) e^g = \hat{\beta} E_S \left[U_C \left[ C_{D'} + C_{N'} p' \left( 1 - \delta_d - \Psi'_{D'} \right) \right] \right], \quad (A.13)
\]

\[
U_C C_{NP} (1 - \Phi_{K_i}) e^g = \hat{\beta} E_S \left[U_C C_{N'} \left[ r_{n'} + p' \left( 1 - \delta_k - \Phi'_{K_i} \right) \right] \right], \quad (A.14)
\]

\[
U_C C_{NP} (1 - \Phi_{K_d}) e^g = \hat{\beta} E_S \left[U_C C_{N'} \left[ r_{d'} + p' \left( 1 - \delta_k - \Phi'_{K_d} \right) \right] \right], \quad (A.15)
\]

\[
U_C C_{NP} q e^g = \hat{\beta} E_S \left[U_C C_{N'} p' \right], \quad (A.16)
\]

\[
U_C C_{N} \hat{w} = U_L, \quad (A.17)
\]

and household budget constraint (A.12).
2. Each period, given prices, $x^f$ solves the firms’ problems with associated profits $(\hat{\pi}_n, \hat{\pi}_d)$. This implies that $(x^f, \hat{\pi}_n, \hat{\pi}_d)$ satisfy the following conditions:

\[
\hat{w} = F_{n,L} = (1 - \alpha_n) \frac{F_n}{L_n}, \quad \text{(A.18)}
\]

\[
\hat{w} = (p - \Omega) F_{d,L} = (p - \Omega) \left(1 - \alpha_d\right) \frac{F_d}{L_d}, \quad \text{(A.19)}
\]

\[
\hat{r}_n = F_{n,K} = \alpha_n \frac{F_n}{K_n^f}, \quad \text{(A.20)}
\]

\[
\hat{r}_d = (p - \Omega) F_{d,K} = (p - \Omega) \alpha_d \frac{F_d}{K_d^f}, \quad \text{(A.21)}
\]

\[
\hat{\pi}_d = 0 \Rightarrow F_n = \hat{w} L_n + r_n \hat{K}_n^f, \quad \text{(A.22)}
\]

\[
\hat{\pi}_d = 0 \Rightarrow (p - \Omega) F_d = \hat{w} L_d - r_d \hat{K}_d^f. \quad \text{(A.23)}
\]

3. Markets clear each period:

\[
L_d + L_n = L, \quad \text{(A.24)}
\]

\[
\hat{K}_n^f = \hat{K}_n, \quad \text{(A.25)}
\]

\[
\hat{K}_d^f = \hat{K}_d, \quad \text{(A.26)}
\]

\[
\hat{N} + \Omega F_d = \hat{F}_n. \quad \text{(A.27)}
\]

A.3 Equivalence between the planner’s optimal allocation and the competitive equilibrium

We now demonstrate that the competitive equilibrium allocation and the planner’s optimal allocation are equivalent. In particular, we show that equilibrium conditions (A.12)-(A.27) boil down to the planner’s optimality conditions (A.1)-(A.8).

Claim 5 The planner’s optimal allocation $\{x\}$ coincides with competitive equilibrium allocation $\{x^h, x^f\}$, given the same initial conditions $S_0 = S_0^h$.

Proof. First, set $p = \tilde{p}$ and notice that equations (A.13), (A.16), (A.27) from the competitive equilibrium coincide with (A.1), (A.4), (A.7) from the planner’s problem. Furthermore, firms’ optimality conditions (A.18)-(A.19) yield $F_{n,L} = (\tilde{p} - \Omega) F_{d,L}$, which is precisely equation (A.6) from the planner’s problem. Next, substitute factor price equations (A.18), (A.20) and (A.21) into household’s optimality conditions (A.14), (A.15) and (A.17) which yields planner’s conditions (A.2), (A.3) and (A.5). Finally, notice that the household budget constraint (A.12) turns into the planner’s resource constraint (A.8) when using equilibrium conditions (A.22)-(A.27). To confirm this notice that

\[
\hat{\pi}_d + \hat{\pi}_n + \hat{w} L + r_d \hat{K}_d + r_n \hat{K}_n - \hat{N} = p \hat{Y}_d - \Omega \hat{Y}_d + \hat{Y}_n - \hat{N} = p \hat{Y}_d.
\]

Therefore, the system of equations (A.1)-(A.8) that determines the Pareto optimal allocation $\{x\}$ is the same as the reduced system of equations associated with the competitive equilibrium allocation $\{x^h, x^f\}$ after substituting prices and equilibrium conditions. Consequently, both allocations must be equivalent. ■
A.4 Steady-state conditions

The steady-state variables $\bar{q}, \bar{p}, \bar{L}_n, \bar{K}_n, \bar{K}_d, \bar{Y}_n, \bar{Y}_d, \bar{N}$, and $\bar{D}$ solve the following system of equations:

$$\bar{q} = \beta \mu \theta (1 - \sigma)^{-1},$$  \hspace{1cm} (A.28)

$$\bar{D} = \left( \frac{(1 - \bar{q})}{\mu \bar{p} (1 - \bar{q} (1 - \delta_d))} \right)^{\frac{1}{1+\gamma}} \bar{N},$$  \hspace{1cm} (A.29)

$$1 - \bar{L}_d = \left(1 + \frac{1}{\theta} \frac{C}{C_N (1 - \alpha_n) \bar{Y}_n} \right) \bar{L}_n,$$  \hspace{1cm} (A.30)

$$(1 - \alpha_n) \frac{\bar{Y}_n}{\bar{L}_n} = (\bar{p} - \Omega) (1 - \alpha_d) \frac{\bar{Y}_d}{\bar{L}_d},$$  \hspace{1cm} (A.31)

$$\frac{\bar{Y}_n}{\bar{K}_n} = \frac{\bar{p} (1 - (1 - \delta_k) \bar{q})}{\bar{q}},$$  \hspace{1cm} (A.32)

$$\frac{\bar{Y}_d}{\bar{K}_d} = \frac{\bar{p} (1 - (1 - \delta_k) \bar{q})}{\bar{q}},$$  \hspace{1cm} (A.33)

$$\bar{Y}_n = \bar{K}_n (\mu g \bar{L}_n)^{1 - \alpha_n},$$  \hspace{1cm} (A.34)

$$\bar{Y}_d = \bar{K}_d (\mu g \bar{L}_d)^{1 - \alpha_d},$$  \hspace{1cm} (A.35)

$$\bar{N} = \bar{Y}_n + (\bar{p} - \Omega) \bar{Y}_d + \bar{p} (1 - \delta_k - \mu g) (\bar{K}_n + \bar{K}_d +$$

$$\bar{p} (1 - \delta_d - \mu g) \bar{D} + \bar{p} (1 - \bar{q} \mu g) \bar{B},$$  \hspace{1cm} (A.36)

$$\bar{Y}_n = \bar{N} + \Omega \bar{Y}_d,$$  \hspace{1cm} (A.37)

where $\bar{B}$ is given by the assumption that $\bar{B} \bar{Y}_n + (\bar{p} - \Omega) \bar{Y}_d = 0.1$.

These equations come from imposing steady-state conditions (e.g., $N_t = N_{t+1} = N$) on system of equations (A.1)-(A.8). We also use production function equation (1) as well as consumption aggregator (7).

A.5 Tradability assumption

Here we argue why we need to make the assumption that one good must be non-tradable.\(^{38}\) First, let us look at the steady-state conditions above. In particular, consider equations (A.31)-(A.33). From the assumption of Cobb-Douglas technology, $\bar{Y}_i/\bar{L}_i$ and $\bar{Y}_i/\bar{K}_i$ are both functions of $\bar{K}_i/\bar{L}_i$, $i \in \{n, d \}$.

Let us argue by contradiction. Let both goods be tradable and the economy be in the deterministic steady state. In this case, $\bar{p}$ is exogenously given because of our small economy assumption. Moreover, $\bar{q}$ is given exogenously for the same reason. Therefore, the capital-labor ratios $\bar{K}_i/\bar{L}_i$ are pinned down by equations (A.32) and (A.33). As a result, both the LHS and RHS of equation (A.31), which determines wage equalization across sectors, are given. Both sides of this equation only depend on parameters and exogenous variables $\bar{p}$ and $\bar{q}$. Clearly, they need not be equal and, therefore, the economy may not be at the steady state.

\(^{38}\)We make this assumption also for the sake of simplicity since a more complicated model could certainly have both types of goods tradable. For instance, we could have a model with the following three goods: durable tradable, nondurable tradable and nondurable non-tradable. This, however, would complicate the analysis greatly.
We can follow a similar argument by looking at the equilibrium conditions in Appendix A.2. Again, if both goods were tradable, $p$ would be given and capital rental rates $r_n$ and $r_d$ would be pinned down by equations (A.14)-(A.16). In turn, equations (A.20) and (A.21) would determine the capital-labor ratio in each sector. As a result, equations (A.18) and (A.19) are not, in general, simultaneously satisfied. Hence, the economy is not in equilibrium.

Therefore, we have established that we need one of the two goods to be non-tradable. We choose nondurable goods because, besides being more in line with observed trade patterns as we mention in Section 3, if we were to choose the durable good as non-tradable, we would impose a strong restriction in the model. That is, the two production factors, labor and capital, would be non-mobile across borders, as capital only comes from durables. This tends to work against comovement between sectors because capital cannot be imported whenever households need to accumulate more capital in one or both sectors. There are two ways of increasing capital in either sector. Either households move capital from one sector to the other or output in the durable sector increases, or both. They tend to imply a negative relationship between sectoral outputs. In fact, when we parameterize this alternative environment, the model generates little sectoral comovement, which is counterfactual.

### A.6 Data Sources

Our Mexican data come from a variety of sources in addition to those mentioned in Section 2. Data for output (gross domestic product), private consumption, nondurable consumption, durable spending, investment (gross fixed capital formation), exports, and imports come from the national statistics tables published by INEGI - Instituto Nacional de Estadística y Geografía. All data is in thousands of Mexican pesos and in 1993 constant prices. Sectoral industrial output (volume index) comes from monthly data published by INEGI – Instituto Nacional de Estadística y Geografía – from Mexico, which we then transform to quarterly frequency. For the borrowing premium we collect data for sovereign interest rates (Emerging Markets Bond Index - EMBI) from Datastream, and U.S. consumer price inflation from the Bureau of Labor Statistics. We then constructed the expected real interest series using the method described in Neumeyer and Perri (2005).

### A.7 Quality of fit of models with and without financial frictions

In this section we describe the method to compare the quality of fit of the competing models which we use as baseline. The procedure is based on what was proposed in Schorfheide (2000).

We call model $M_1$ our model without financial frictions and model $M_2$ our model with financial frictions. We consider two sources of uncertainty when evaluating these models: sampling variability and simulation variability. The goal is to calculate a ranking of model 1 and model 2, conditional on the observed data sample and on the third model, $M_3$ (reference model). The ranking is based on how well each of the two DSGE models can match a set of moments $\mathbf{m}$, which we can only estimate with some uncertainty using model $M_3$. Each of the models is defined by a vector of parameters $\theta_i$, $i = \{1, 2, 3\}$. Schorfheide (2000) suggests a loss function-based approach to this problem which involves simulating a posterior distribution for the relevant moments according to each of the three models (see also Geweke, 2007, and DeJong and Dave, 2007). This is done in three steps:
Step 1. Estimate \( M_3 \) by OLS. We estimate a VAR(1) of output \((y)\), consumption \((c)\), nondurable consumption \((c_n)\), durable spending \((c_d)\), investment, and net exports-output ratio \((nx)\) using our sample for Mexico, from the first quarter of 1993 until the fourth quarter of 2007 \((T = 60)\). Therefore, the number of equations in the VAR is \( K = 6 \). The lag length \((p = 1)\) is chosen using the Bayesian Information Criterion (BIC).

Step 2. Draw 5,000 times, for each \( \theta_i, i = \{1, 2, 3\} \), from a normal-inverse Wishart distribution with mean \( \hat{\theta}_i \) and \( \Sigma_{\theta,i} \). For models \( M_1 \) and \( M_2 \), \( \hat{\theta} \) is the GMM estimator of the vector of parameters and \( \Sigma_{\theta,i} \) is the associated VARHAC matrix. For \( M_3 \), \( \hat{\theta} \) is the OLS estimator of the matrix of slope coefficients (we do not use intercepts since the series have been detrended and have mean zero) and \( \Sigma_{\theta,i} \) is drawn from an inverse-Wishart distribution with mean \( \Sigma_u (X'X)^{-1} \) and \( T - K \times p \) degrees of freedom.

Step 3. With a simulated sample of 5,000 observations, for each model, calculate the relevant moments \( m \). We choose these moments to be \([\sigma(c), \sigma(c_n), \sigma(c_d), \sigma(y), \sigma(nx), \rho(y,nx)]\). We end up with three empirical distributions for these moments, under each model. The ranking is decided by calculating a loss function for each model and the associated risk. We use the \( L_{\chi^2} \) measure proposed by Schorfheide (2000) and given by

\[
L_{\chi^2}(i,3) = \mathbb{I}\{C_{\chi^2}(m_3) < C_{\chi^2}(m_i)\}
\]

where \( C_{\chi^2}(m_i) \) is a weighted discrepancy between the average moments generated by each of the DSGE models and the moments generated by the reference model given by \( C_{\chi^2}(m_i) = (m_i - E(m_3))'V(m_3)^{-1}(m_i - E(m_3)) \). The indicator function \( \mathbb{I} \) counts the number of times the condition in (A.38) is met as a fraction of the 5,000 simulations. This amounts to 1 for model \( M_1 \) and 0.93 for \( M_2 \). That is, the reduced form model performs better than model \( M_1 \) 100 percent of the time, while it only does so 93 percent of the time relative to model \( M_2 \).

To calculate the degree of overlap between each distribution of moments under models \( M_1 \) and \( M_2 \) relative to that generated by model \( M_3 \), we calculate a 95 percent probability contour for model \( M_2 \) and count the fraction of points generated under each of the DSGE model is inside that contour. The 95 percent probability contour is given by \((x - E(m_3))'V(m_3)^{-1}(x - E(m_3)) - \chi^2_{0.05}(n)\), where \( n = 4 \) is the number of moments we are using. This amounts to 0 for model \( M_1 \) and 0.67 for \( M_2 \).

References


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\(^{39}\)This can be approximated by \( F(C_{\chi^2}(m_i)) \) where \( F(.) \) is the c.d.f. of a random variable distributed as \( \chi^2(4) \).