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Abstract

Understanding differences in business cycle phenomena between Emerging Market Economies (EMEs) and industrialized countries has been at the center of recent research on macroeconomic fluctuations. The purpose of this paper is to investigate the importance of certain credit market imperfections in different EMEs. To this end, we develop a small open economy Dynamic Stochastic General Equilibrium (DSGE) framework featuring both permanent and transitory productivity shocks, differentiated home and foreign goods, and endogenous exchange rate movements. Furthermore, our model incorporates liability dollarization as a particular form of financial frictions in EMEs. In this vein, we account for the fact that emerging markets traditionally have had difficulties in borrowing in domestic currency on international capital markets and thus allow for valuation effects in our analysis. We estimate our model using Bayesian techniques for a number of EMEs and thereby control for potential heterogeneity across countries. Contrary to previous studies in this strand of the literature, we include a (vector–)autoregressive measurement error component to capture off–model dynamics. Regarding business cycles in emerging markets, our main findings are that (i) even though we incorporate financial frictions in the framework, trend shocks are the main determinant of macroeconomic fluctuations, (ii) accounting for liability dollarization ameliorates the model fit, and (iii) valuation effects on average stabilize changes in the net foreign asset position.

1 Introduction

Over the last twenty years, the world economy has witnessed a growing importance of Emerging Market Economies (EMEs). While their share of global output at purchasing power parity was about 30 percent in 1990, it has risen to more than 50 percent by 2013 according to the International Monetary Fund (IMF).[1] As a consequence, EMEs have increasingly influenced the global business cycle and are catching up to the rich world at a remarkable pace. What is striking, however, is that business cycles in these countries reveal noticeably different patterns compared to developed economies. This naturally raises the questions of why do we observe these discrepancies.

In recent years, considerable attention in research on international macroeconomics has been devoted to understanding business cycle fluctuations in EMEs. Many researchers have documented certain empirical regularities among these countries (see Neumeyer and Perri 2005, Aguiar and Gopinath 2007, and García-Cicco *et al.* 2010). First, EMEs are generally exposed to more severe business cycle fluctuations than developed economies. Second, EMEs have strongly counter-cyclical net exports and their international capital inflows are subject to so–called "sudden stops" (see Calvo 1998, Calvo and Reinhart 2000, and Mendoza 2010). Third, consumption volatility exceeds income volatility.[2]

This paper develops a Dynamic Stochastic General Equilibrium (DSGE) model of a small open economy (SOE) to address these business cycle phenomena and the importance of credit market imperfections in EMEs. The basic structure of our framework goes back to the workhorse SOE real business cycle (RBC) model of Mendoza (1991). We build on Aguiar and Gopinath (2007) and introduce a permanent productivity shock in addition to a conventional transitory productivity shock in our theoretical economy. Moreover, we contribute to the existing RBC literature on emerging markets by featuring differentiated home and foreign goods as well as exogenous foreign demand shocks in our model. In this vein, we also incorporate endogenous real exchange rate fluctuations in our setup.

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[1] See *The Economist*, article "When giants slow down", July 27th, 2013.

[2] Another salient characteristic of emerging market business cycles is that real interest rates tend to be countercyclical, very volatile and lead the cycle (see Neumeyer and Perri 2005 and Uribe and Yue 2006). This feature, however, is not subject of the analysis in this paper.

As Chari *et al.* (2007) point out, one can think of the non–stationary technology component as efficiency wedge which captures various forms of market distortions. Nevertheless, since our analysis aims at investigating the role of specific financial frictions in emerging market business cycles we also augment our framework along this dimension. In particular, similar to García-Cicco *et al.* (2010) we introduce credit market imperfections in form of a debt–elastic country premium on the interest rate. Indeed, this reduced form financial friction is a convenient way to account for a positive link between higher external indebtedness and borrowing costs, which seems to be empirically plausible (see Uribe and Yue 2006 or Arellano 2008).

More importantly, a major contribution of our work is that we also analyze the phenomenon of *liability dollarization* as a further form of financial frictions in our framework.[3] Emerging markets have traditionally depended heavily on external funds in form of short–term debt to finance their growth opportunities (see Kose and Prasad 2010). In contrast to advanced economies, however, international capital market imperfections have impeded EMEs to issue debt denoted in their own currency. As a result, these countries have held the bulk of their external debt in major international currencies such as US dollars. The inability of borrowing abroad in domestic currency faced by emerging markets, which Eichengreen *et al.* (2005) refer to as the "Original Sin" phenomenon, is a well–known fact and has been documented in a number of previous studies (see Reinhart *et al.* 2003, Eichengreen and Hausmann 2005, and Lane and Shambaugh 2010).[4] Our paper does not investigate the reasons behind liability dollarization in emerging markets, but studies its implications. To this end, we extend our benchmark model and assume that the small open economy can only borrow in foreign currency.

In our empirical exercise, we apply a mixture of country–specific calibration and Bayesian estimation. Related studies have predominantly investigated particular emerging markets and partly tried to derive conclusions for EMEs in general.

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[3]The term "liability dollarization" was coined by Calvo (2001).

[4]In recent years, several emerging markets have implemented various policies to tackle dollarization. The process of dedollarization is generally protracted and in most cases incomplete (see Kokenyne *et al.* 2010). While some countries have been successful, others have failed to achieve persistent dedollarization (see Reinhart *et al.* 2014). Nevertheless, our empirical analysis uses data from a period in which liability dollarization was a prevalent feature of external finances in EMEs.

However, given the fact that EMEs share the aforementioned stylized business cycle features, we think it is crucial to expand the analysis to a broader selection of countries and thus also allow for potential heterogeneity. Therefore, we study the cases of Mexico, South Africa, and Turkey. Besides, we additionally estimate our benchmark model for a cohort of developed countries, namely Canada, Sweden, and Switzerland. This enables us to confront the results obtained for emerging and advanced economies.

To estimate our models, we take real time series data on output, consumption, interest rates, and exchange rates. A substantial contribution of our work is how we capture off–model dynamics in our estimation. In particular, we follow Sargent (1989) and Ireland (2004) by including a (vector–)autoregressive measurement error component. To our knowledge, this has not been done yet in this strand of the literature and goes beyond the procedures applied by existing studies (e.g. García-Cicco *et al.* 2010 or Chang and Fernández 2013).

Estimation results show that financial frictions are generally more pronounced in EMEs than in industrialized countries, which is in line with the conclusion of García-Cicco *et al.* (2010). Besides, off–model dynamics appear to be of minor importance for the dynamics of macroeconomic aggregates in general. This result suggests that our model is capable of explaining a great deal of the variation in the data. Moreover, we show that for the group of EMEs, the model with liability dollarization by and large outperforms the benchmark setup in capturing the dynamics in the variables we use for estimation. This outcome provides a strong argument in favor of the introduction of liability dollarization in the model.

Our analysis suggests that the co–existence of financial market imperfections and trend shocks helps us to explain macroeconomic fluctuations in emerging markets. In EMEs, the transitory productivity process is the driving force behind output in the short–run, whereas non–stationary technology shocks determine income fluctuations in the long–run. Contrary to that, transitory productivity shocks determine output fluctuations over all horizons in developed economies. Hence, although we incorporate various financial frictions in our model, we still find support for the famous hypothesis by Aguiar and Gopinath (2007) that *"the cycle is the trend"* in emerging markets. That said, our findings contradict the

conclusions of other studies, which argue that this notion rests upon the absence of certain market distortions. For instance, García-Cicco *et al.* (2010) and Chang and Fernández (2013) show that once one incorporates financial frictions in the framework, the permanent shock strongly loses importance. Likewise, a recent paper by Boz *et al.* (2011) studies a real business cycle model in which agents learn to differentiate between permanent and transitory disturbances. These authors argue that it is more severe informational frictions in EMEs that explain observed business cycle patterns even without a predominance of the non–stationary component in total factor productivity.[5]

Our work is also related to a currently active research area, which highlights the importance of fluctuations in exchange rates and asset prices for a country's external balance sheet (see Tille 2003, Gourinchas and Rey 2007a, Gourinchas and Rey 2007b, Lane and Milesi-Ferretti 2007, and Gourinchas *et al.* 2010). These changes in the net foreign asset position, which are not due to capital flows, are called *valuation effects* and drive a wedge between the change in the net foreign asset position and the current account. Accounting for the fact that EMEs are not able to borrow on international markets in their own currency, our model yields further interesting insights with respect to the role of external balance sheet effects, which, though investigated in other areas (see Céspedes *et al.* 2004, Tille 2008, or Nguyen 2011), has hitherto been unrecognized in this line of research. In particular, we find that valuation effects stabilize the change in the net foreign asset position induced by trend productivity shocks, whereas they amplify it after foreign demand shocks. In contrast, transitory technology shocks lead to valuation effects that may reinforce or mitigate the changes in the external balance sheet. Given that EMEs are characterized by a prevalence of trend shocks, we find that valuation effects act stabilizing on average.

Furthermore, the model featuring liability dollarization can account for vari-

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[5]Nevertheless, the notion of trend shocks as being the drivers of the business cycle can to some extent be supported by a closely related area of research in international macroeconomics. The literature on the empirics of the "intertemporal approach to the current account" highlights the importance of permanent shocks in explaining current account dynamics (see Glick and Rogoff 1995, Hoffmann 2001, Hoffmann 2003, Kano 2008, or Corsetti and Konstantinou 2012). In particular, Hoffmann and Woitek (2011) show that the world economy was predominantly characterized by permanent shocks in the period between World War I and World War II, exactly like today's emerging markets according to our findings.

ous business cycle phenomena in EMEs. In particular, our model generates more severe macroeconomic fluctuations in EMEs than in advanced economies, and predicts a volatility of consumption that exceeds the one of output. Moreover, the model produces a countercyclical trade balance. But based on our estimation, it fails to quantitatively match the strong countercyclicality of net exports observed in the data. Finally, we show that the model succeeds in reproducing the reversal of capital flows to Mexico during the Tequila Crisis between 1994 and 1995.

The remainder of the paper is structured as follows. In the next section, we start with some descriptive business cycle statistics of selected countries and briefly discuss certain empirical features of valuation effects in EMEs. Section 3 outlines our benchmark model as well as the setup with liability dollarization. In Section 4, we describe the data and introduce our calibration and estimation technique. Estimation results are presented in Section 5, while Section 6 discusses the dynamics of our model in greater detail. Some concluding remarks appear in Section 7. The Appendix to this paper is available upon request.

2   Descriptive Analysis

Before we introduce our theoretical framework, which we later use to investigate macroeconomic dynamics in EMEs, we take a look at some descriptive statistics first. We begin with illustrating the distinct empirical regularities about business cycles in EMEs contrary to industrialized countries. To this end, we calculate standard business cycle moments for numerous EMEs and compare them with those obtained for a group of developed small open economies. Subsequently, we document the stabilizing impact of valuation effects on the external balance sheet in EMEs.

2.1   Business Cycle Features

The now well–established term "Emerging Market" was originally introduced by Antoine van Agtmael in 1981, describing developing countries that experience rapid economic progress and potentially catch up with developed economies (see

Van Agtmael 2007). Today, there exists a wide range of definitions of an emerging market and numerous different classifications. For that reason, we rely on three well–known classifications and focus our descriptive analysis on the so–called BRIC (Brazil, Russia, India, China) and CIVETS (Columbia, Indonesia, Vietnam, Egypt, Turkey, South Africa) countries as well as selected economies from the list of emerging markets compiled by the Dow Jones Indexes.

At this point, we use annual data from the International Financial Statistics (IFS) on output, consumption, exports, imports, and the real exchange rate.[6] For the real exchange rate we construct an index, which we normalize to 100 in the year 2005. To derive real per capita variables for output and consumption, we divide each series by population and subsequently deflate output using the GDP deflator, and consumption using the Consumer Price Index (CPI). To study business cycle fluctuations, we detrend all variables except for the net exports to output ratio. For this purpose, we apply the Hodrick and Prescott (1997) (HP) filter on logged series with smoothing parameter 100.[7]

Descriptive sample statistics are displayed in Table 1. Various stylized business cycle facts are worth emphasizing.[8] First, fluctuations in macroeconomic aggregates in EMEs are generally more pronounced than in developed economies. For instance, our selected countries on the Dow Jones list exhibit average standard deviations of output, consumption and net exports that are more than twice as high as in the group of industrialized economies. This salient feature is visualized in Figure 1, which plots the cyclical component of GDP for each country. The graph clearly demonstrates the excess business cycle volatility in emerging markets relative to advanced economies. Second, consumption volatility exceeds output volatility in EMEs, whereas the standard deviation of consumption is on average lower than that of output in developed countries. Third, the net exports

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[6]We use real exchange rates vis–à–vis the US. The choice of annual rather than higher frequency time series enables us to investigate a longer time period. Nevertheless, we did the same exercise using quarterly data and found no qualitative difference in the results.

[7]We are aware of the shortcomings of this filtering method. Hence, we also looked at first differences of the logged series as well as cubically detrended logged series to check the robustness of our findings. Indeed, business cycle moments seem to be rather insensitive with respect to the filter choice.

[8]We confidently call certain business cycle patterns as "stylized facts" because they have already been documented in a number of earlier studies. See, among others, Neumeyer and Perri (2005), Aguiar and Gopinath (2007), García-Cicco *et al.* (2010), and Kose and Prasad (2010).

Table 1: Business Cycles in EMEs and Developed Economies

	$\sigma(Y)$	$\sigma(C)$	$\sigma\left(\frac{NX}{Y}\right)$	$\sigma(e)$	$\frac{\sigma(C)}{\sigma(Y)}$	$\rho\left(\frac{NX}{Y},Y\right)$	$\rho\left(\frac{NX}{Y},e\right)$
BRIC							
Brazil (BRA)	2.93	12.17	2.42	21.67	4.16	−0.30	−0.37
Russia (RUS)	5.64	8.51	4.80	17.79	1.51	−0.28	−0.75
India (IND)	2.16	4.00	1.37	6.13	1.85	−0.13	−0.32
China (CHN)	3.11	3.55	2.76	7.85	1.14	0.08	0.00
Mean	3.46	7.06	2.84	13.36	2.17	−0.16	−0.36
CIVETS							
Colombia (COL)	2.65	4.70	3.44	11.50	1.78	−0.27	−0.50
Indonesia (IDN)	3.89	4.80	3.47	15.58	1.23	−0.37	−0.28
Vietnam (VNM)	1.29	2.15	4.15	6.46	1.67	−0.50	−0.54
Egypt (EGY)	1.88	2.83	4.07	22.57	1.51	−0.42	−0.54
Turkey (TUR)	4.11	6.10	2.81	9.99	1.49	−0.66	−0.68
South Africa (ZAF)	2.02	3.35	3.70	10.94	1.66	−0.47	−0.21
Mean	2.64	3.99	3.61	12.84	1.56	−0.45	−0.46
Dow Jones List							
Argentina (ARG)	5.67	10.32	3.75	30.96	1.82	−0.76	−0.29
Chile (CHL)	5.55	7.66	36.56	19.77	1.38	−0.26	0.09
Malaysia (MYS)	3.82	6.06	9.80	7.33	1.58	−0.37	−0.31
Mauritius (MUS)	4.01	7.14	5.87	7.49	1.78	−0.23	−0.40
Mexico (MEX)	3.26	5.76	3.21	11.15	1.77	−0.27	−0.65
Morocco (MAR)	3.02	3.08	4.20	9.97	1.02	−0.06	−0.03
Thailand (THA)	4.13	4.31	5.50	7.10	1.04	−0.54	−0.38
Mean	4.21	6.33	9.84	13.40	1.48	−0.36	−0.28
Mean EMEs	3.48	5.68	5.99	13.19	1.67	−0.34	−0.36
Developed							
Australia (AUS)	1.66	1.40	1.26	8.54	0.84	−0.10	0.07
Austria (AUT)	1.57	2.08	2.30	11.72	1.32	0.00	−0.13
Canada (CAN)	2.19	2.24	1.94	4.97	1.02	0.03	−0.37
Sweden (SWE)	2.12	2.21	3.12	9.80	1.04	−0.03	−0.14
Switzerland (CHE)	2.21	1.89	3.60	11.40	0.86	−0.16	0.05
Mean	1.63	1.64	2.04	7.74	0.85	−0.04	−0.09

Notes: Data are annual and taken from the IFS. All series, except for the net exports to output ratio, are real per capita variables, have been logged and filtered using the HP filter with smoothing parameter $\lambda = 100$. Standard deviations are reported in percentage points. The samples are: Brazil, 1980–2010; Russia, 1995–2010; India, 1970–2010; China, 1986–2010; Colombia, 1970–2010; Indonesia, 1970–2010; Vietnam, 1995–2010; Egypt, 1982–2009; Turkey, 1987–2010; South Africa, 1960–2010; Argentina, 1970–2010; Chile, 1970–2009; Malaysia, 1970–2010; Mauritius, 1970–2010; Mexico, 1970–2010; Morocco, 1975–2008; Thailand, 1960–2010; Australia, 1960–2010; Austria, 1978–2010; Canada, 1950–2010; Sweden, 1950–2010; and Switzerland 1970–2010.

to output ratio tends to be fairly countercyclical. For instance, the mean correlation of GDP and the net exports to output ratio is as much negative as −0.45 for the CIVETS countries. By contrast, advanced economies exhibit a rather weak link between these variables. In fact, our calculations yield a correlation of merely −0.04 on average.

Figure 1: Business Cycles in Output
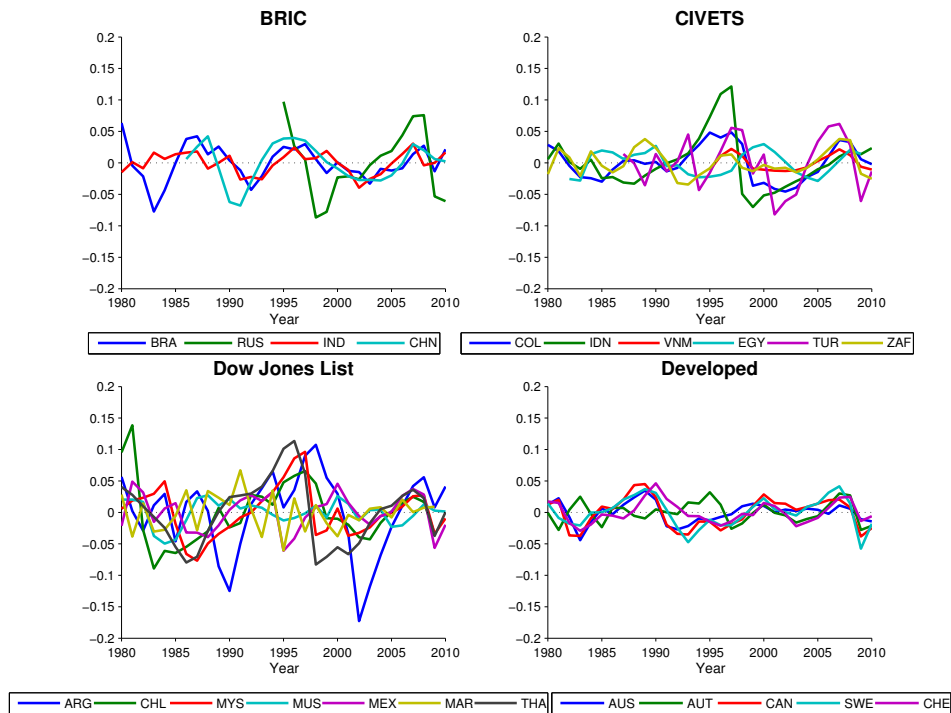
Notes: Deviations of logged real GDP per capita from HP trend. Table notes of Table 1 on data information apply here, too.

Somewhat surprisingly, previous studies in this line of research have not put particular focus on the business cycle features of the real exchange rate. Table 1 indicates that there are differences between EMEs and advanced countries along this dimension, too. The real exchange rate is more volatile in emerging markets than in developed economies. Moreover, real appreciations are associated with a fall in the trade balance to GDP ratio in EMEs. The mean correlation between these variables is −0.36 across all EMEs. On the other hand, the link between net exports and real exchange rates appears to be much weaker in the group of developed economies, for which we find basically no correlation on average.

The empirical regularities documented here are very robust. Nevertheless, we

also detect some minor differences within the cohort of emerging markets. For instance, the degree of countercyclicality of the net exports to output ratio varies across EMEs. While Turkish GDP is highly negatively correlated with the net exports to output ratio, there is hardly any relation between these two variables in China. Similar discrepancies can be found regarding the excess volatility of consumption. In Mexico, the standard deviation of consumption is almost twice as high as the standard deviation of GDP. Conversely, there is virtually no excess volatility of consumption in Thailand and Morocco. Furthermore, although real depreciations are generally attended by higher net exports in EMEs, we do not observe this particular feature in Chile, China, and Morocco.

A large literature has been devoted to analyzing these business cycle phenomena in emerging markets. Yet previous studies have predominantly focused on Latin American countries. Especially, Argentina (Kydland and Zarazaga 2002, Neumeyer and Perri 2005, and García-Cicco *et al.* 2010) and Mexico (Aguiar and Gopinath 2007, Boz *et al.* 2011, and Chang and Fernández 2013) have been at the center of earlier research. Given the potential heterogeneity across EMEs, we would like to contribute to the existing literature by investigating a broader selection of countries. In the empirical part of our paper in Sections 5 and 6, we therefore parametrize our DSGE model introduced below for the emerging markets of Mexico, South Africa, and Turkey as well as the advanced economies of Canada, Sweden, and Switzerland. This allows us to get more general insights into the different business cycle patterns in these two county groups.

2.2 Valuation Effects

Valuation effects refer to changes in a country's net foreign asset position that do not arise from cross–border financial flows but are due to movements in asset prices or exchange rates. Accordingly, valuation effects (VAL) are the difference between the change in the net foreign asset position (ΔNFA) and the current account (CA):

$$VAL = \Delta NFA - CA.$$

In this subsection, we investigate the relationship between valuation effects

Figure 2: Valuation Effects and the Current Account in Emerging Markets
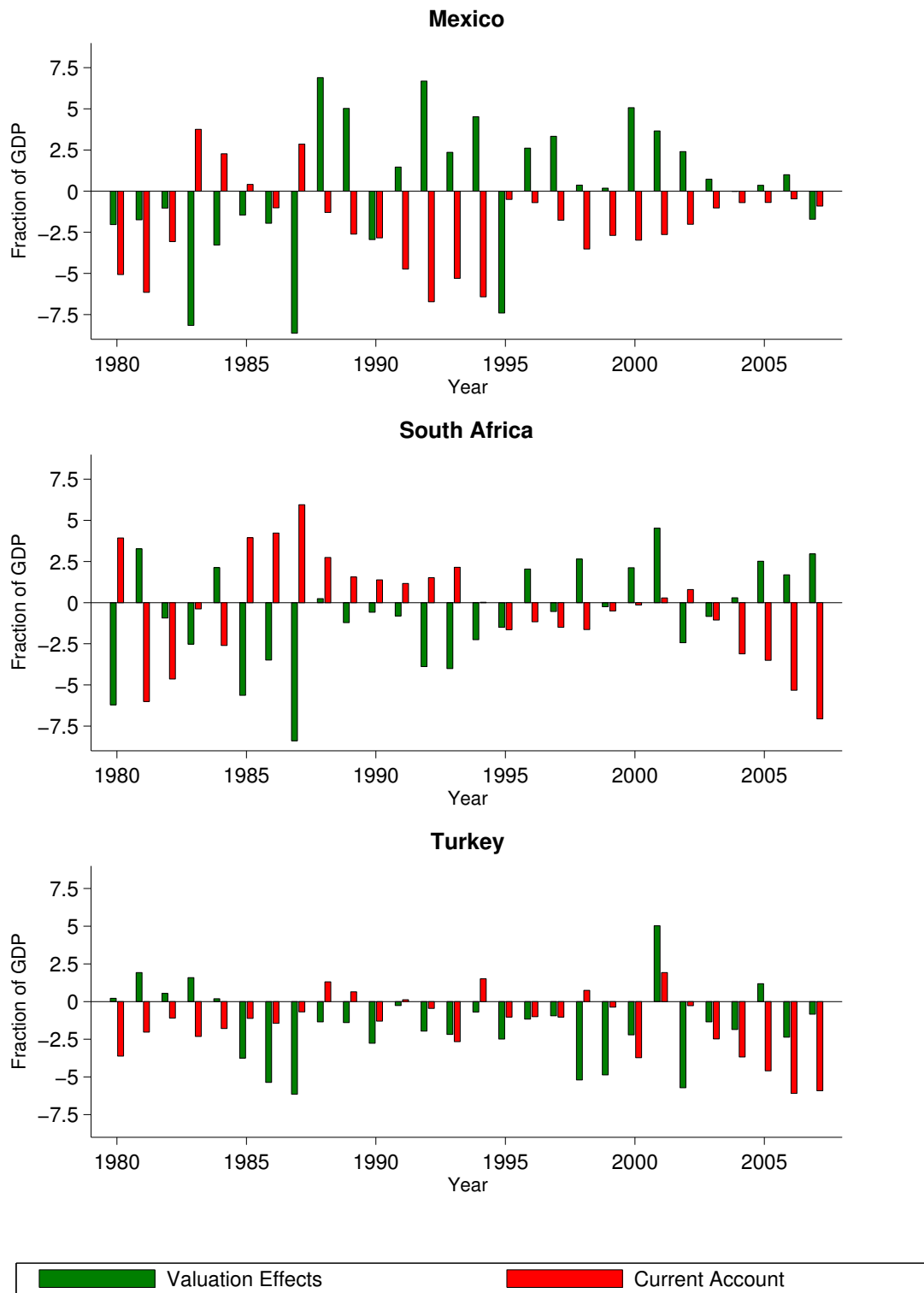
Notes: Valuation effects and the current account in Mexico, South Africa and Turkey as a percentage of GDP. To compute valuation effects, we subtract the current account from the negative change in foreign liabilities. Data on foreign debt are taken from Lane and Milesi-Ferretti (2007), while current account data are retrieved from the IFS database.

and the current account in EMEs. Our descriptive exercise relies on annual data on the stock of foreign liabilities in Mexico, South Africa, and Turkey over the time period from 1980 to 2007 provided by Lane and Milesi-Ferretti (2007). Current account data are taken from the IFS database. We use foreign debt instead of net foreign assets, because it is the empirical counterpart to the net foreign asset position in the theoretical model analyzed in this paper.[9] As a consequence, we calculate valuation effects simply by subtracting the current account from the negative change in the foreign debt position.[10]

Figure 2 portrays annual valuation effects as well as the current account, both as a percentage of current GDP. As is evident from the graph, there is a negative link between the current account and valuation effects. This is especially the case for Mexico and South Africa but less obvious for Turkey. The sample correlation between the two series is −0.58, −0.75, and −0.05 for Mexico, South Africa, and Turkey, respectively. This means that a current account deficit is associated with positive valuation effects, which actually dampens the deterioration of the net foreign asset position. Hence, our descriptive analysis hints at a stabilizing nature of valuation effects.

3   The Model

Consider a real business cycle model of a small open economy. The domestic economy is inhabited by a unit mass of atomistic, identical, and infinitely lived households. Agents form rational expectations and seek to maximize lifetime utility by consuming two differentiated commodities: a home–produced good as well as a foreign good imported from the rest of the world. Some key ingredients of our framework are borrowed from Aguiar and Gopinath (2007). In particular, production technology features both a permanent and a transitory stochastic

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[9]Note that foreign short–term debt traditionally accounts for a large part of the total external balance sheet in emerging markets (see Kose and Prasad 2010). Consequently, movements in the net foreign asset position in these countries essentially reflect changes in foreign liabilities. It is therefore not surprising that we obtained similar results when we performed this exercise based on the actual net foreign asset position.

[10]Lane and Milesi-Ferretti (2007) point out that differences between the change in the net foreign asset position and the current account may also arise from other factors than valuation effects, such as measurement errors or omissions in the data. Therefore, we have to be careful when interpreting the magnitude of valuation effects computed here.

component. In addition, we augment our setup with financial frictions as proposed by García-Cicco *et al.* (2010). That is, agents have access to an incomplete international credit market, on which the price of debt is determined according to a debt–elastic interest rate rule.

In what follows, we choose the domestically produced good as numéraire and normalize its price in the home country to one, i.e. $p_{H,t} = 1$. Thus, all variables are expressed in units of the home good. Section 3.1 presents our *benchmark model*. In Section 3.2, we introduce a further financial distortion in our framework by assuming that domestic agents can only borrow in foreign currency on international capital markets. We call this modified setup the *liability dollarization model*. Section 3.3 provides a summary of both models and shows how we solve them. A detailed description of the liability dollarization model including the derivation of optimality and steady state conditions is presented in the Appendix.

3.1   Benchmark Model

3.1.1   Producing Economy

The home economy produces a differentiated domestic final good in a perfectly competitive environment. Technology is described by a neoclassical production function of the form

$$Y_t = z_t K_t^\alpha (\Gamma_t l_t)^{1-\alpha}, \tag{1}$$

with Y_t, l_t, K_t, and α denoting aggregate output of the home good, labor input, aggregate capital, and the economy's capital share, respectively. Moreover, z_t and Γ_t describe two different exogenous technology processes. On the one hand, the economy is exposed to transitory fluctuations in total factor productivity captured by z_t, which follows a stationary first–order autoregressive (AR) process in logs:

$$z_t = z_{t-1}^{\rho_z} \exp(\epsilon_t^z), \quad \text{with} \quad \epsilon_t^z \sim \mathcal{N}(0, \sigma_z^2). \tag{2}$$

On the other hand, we build on Aguiar and Gopinath (2007) and assume that the producing economy is not only hit by transitory shocks but also by trend

shocks. For this reason, production technology features a non–stationary labor augmenting productivity component represented by Γ_t, which equals the cumulative product of growth shocks:

$$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^{t} g_s, \quad \text{where} \quad g_t = \mu_g^{1-\rho_g} g_{t-1}^{\rho_g} \exp(\epsilon_t^g), \quad \text{with} \quad \epsilon_t^g \sim \mathcal{N}(0, \sigma_g^2). \quad (3)$$

The underlying structure of the non–stationary technology process implies that a realization of g_s will never die out and therefore has a permanent impact on Γ_t, for all $t \geq s$. Parameters $|\rho_z| < 1$ and $|\rho_g| < 1$ determine the persistence of the two exogenous processes. ϵ_t^z and ϵ_t^g represent shocks to the transitory and permanent technology process, respectively, with σ_z^2 and σ_g^2 being the corresponding variances. Finally, μ_g refers to the long–term or steady state gross growth rate of the economy.

Let I_t denote investment in the capital stock at date t. The evolution of the capital stock is described by the following law of motion:

$$K_{t+1} = (1 - \delta)K_t + I_t - \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - \mu_g\right)^2 K_t. \quad (4)$$

The last term in equation (4) introduces quadratic capital adjustment costs. Parameter ϕ determines the weight of adjustment costs and δ is the depreciation rate.

3.1.2 Representative Household

The representative household's objective is to maximize expected lifetime utility

$$\mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(C_\tau, 1 - l_\tau), \quad (5)$$

where $\beta \in (0, 1)$ is the subjective discount factor, $u(.)$ is period utility, which is assumed to be increasing and strictly concave in both arguments, and $(1 - l_t)$ denotes time spent on leisure activities in period t. C_t is a composite consumption index characterized by a standard Dixit and Stiglitz (1977) Constant Elasticity of

Substitution (CES) aggregate:

$$C_t = \left[\theta^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\theta)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where $\theta \in (0,1)$ is the share of home goods in consumption, and $\eta \in (0,\infty)$ is the elasticity of intratemporal substitution between differentiated home and foreign goods. Consequently, $C_{H,t}$ and $C_{F,t}$ correspond to consumption of the home and foreign good, respectively.

We follow Aguiar and Gopinath (2007) and assume that preferences are described by a canonical Cobb–Douglas Constant Relative Risk Aversion (CRRA) utility function:[11]

$$u(C_t, 1-l_t) = \frac{\left[C_t^{\gamma}(1-l_t)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma},$$

where σ co–determines the degree of relative risk aversion, and $\gamma \in (0,1)$ describes the consumption weight in utility.[12]

Our theoretical economy features only one non–contingent financial asset. At each time t, the representative agent can issue D_{t+1} one–period bonds on international capital markets at a predetermined risk–free rate r_t. Accordingly, the household faces the following period resource constraint:

$$Y_t + D_{t+1} \geq p_t C_t + I_t + D_t(1 + r_{t-1}), \tag{6}$$

where p_t denotes the price of composite consumption. Equation (6) embeds the standard interpretation. It simply requires that total expenditures at date t in form of consumption, investment and debt repayments (RHS) are financed by income plus new loans (LHS).

Since variables Y_t, C_t, $C_{H,t}$, $C_{F,t}$, I_t, K_t, and D_t exhibit a stochastic trend, they

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[11]This instantaneous utility function is non–separable in consumption and leisure and thereby leads to income effects on labor supply. A number of studies in this strand of the literature (Mendoza 1991, Neumeyer and Perri 2005, García-Cicco *et al.* 2010, Boz *et al.* 2011, and Chang and Fernández 2013) use a quasi–linear period utility function pioneered by Greenwood *et al.* (1988), so–called GHH preferences, and generalized by Jaimovich and Rebelo (2009). A key characteristic of this preference specification is that it rules out any income effects on labor supply.

[12]Note that this functional form of utility implies that the Arrow–Pratt measure of relative risk aversion corresponds to $1 - \gamma(1-\sigma)$ rather than σ. Accordingly, the elasticity of intertemporal substitution is given by $\frac{1}{1-\gamma(1-\sigma)}$.

need to be detrended in order to ensure stationarity of the system. Let lower case letters x_t indicate the stationary counterpart of X_t. We can then detrend our relevant variables in a straightforward manner:

$$x_t \equiv \frac{X_t}{\Gamma_{t-1}}.$$

We can now return to the optimization rationale of the representative agent stated in (5). We can split the problem into two stages: *intratemporal* and *intertemporal* optimization. First, *intratemporal* household optimization yields the following demand functions for the home and foreign consumption good:

$$c_{H,t} = \theta p_t^{\eta} c_t, \tag{7}$$

and

$$c_{F,t} = (1-\theta)\left(\frac{p_t}{p_{F,t}}\right)^{\eta} c_t. \tag{8}$$

In addition, the price index of composite consumption is determined by

$$p_t = \left[\theta + (1-\theta)p_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}, \tag{9}$$

where $p_{F,t}$ denotes the price of the foreign good expressed in units of the home–produced good.

Next, we consider the *intertemporal* optimization problem. Final good producing firms are owned by the representative household, who hires labor and rents capital for which it pays competitive prices. Thus, we can combine the detrended versions of the production function (1), the law of motion of capital (4), and the aggregate resource constraint (6) to state the stationary maximization problem at time t as

$$\max_{\{c_\tau, l_\tau, k_{\tau+1}, d_{\tau+1}\}} E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} (\Gamma_{\tau-1}^{\gamma(1-\sigma)} u(c_\tau, 1-l_\tau))$$

s.t.

$$y_\tau + (1-\delta)k_\tau + g_\tau d_{\tau+1} \geq p_\tau c_\tau + g_\tau k_{\tau+1} + \frac{\phi}{2}\left(g_\tau \frac{k_{\tau+1}}{k_\tau} - \mu_g\right)^2 k_\tau + d_\tau(1 + r_{\tau-1}),$$

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taking as given k_t, d_t, as well as the transversality condition $\lim_{j \to \infty} \mathrm{E}_t \left[\prod_{s=0}^{j-2} \frac{d_{t+j}}{1+r_{t+s}} \right] = 0$. The solution to this maximization problem renders the following optimality conditions:

$$\frac{1}{c_t} \left(c_t^{\gamma} (1 - l_t)^{1-\gamma} \right)^{1-\sigma} = g_t^{\gamma(1-\sigma)-1} \beta \mathrm{E}_t \left[\frac{1}{c_{t+1}} \left(c_{t+1}^{\gamma} (1 - l_{t+1})^{1-\gamma} \right)^{1-\sigma} \right.$$

$$\left. \frac{p_t \left(\alpha \frac{y_{t+1}}{k_{t+1}} + (1 - \delta) + \phi \left(g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \mu_g \right) g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2} \left(g_{t+1} \frac{k_{t+2}}{k_{t+1}} - \mu_g \right)^2 \right)}{p_{t+1} \left(1 + \phi \left(g_t \frac{k_{t+1}}{k_t} - \mu_g \right) \right)} \right], \qquad (10)$$

$$\frac{1}{c_t} \left(c_t^{\gamma} (1 - l_t)^{1-\gamma} \right)^{1-\sigma} = \beta g_t^{\gamma(1-\sigma)-1} \mathrm{E}_t \left[\frac{1}{c_{t+1}} \left(c_{t+1}^{\gamma} (1 - l_{t+1})^{1-\gamma} \right)^{1-\sigma} \frac{p_t}{p_{t+1}} \right] (1 + r_t), \qquad (11)$$

and

$$p_t \frac{1 - \gamma}{\gamma} \frac{c_t}{1 - l_t} = (1 - \alpha) \frac{y_t}{l_t}. \qquad (12)$$

Equations (10) and (11) represent the intertemporal Euler Equations with respect to capital and bond holdings, respectively. Condition (12) specifies the standard labor–leisure trade–off.

3.1.3 International Prices and Trade

Interest Rates

We assume that the interest rate r_t on international debt borrowed at date t and due in period $t+1$ is increasing in expected future external debt relative to income:

$$r_t = r + \psi \left(\exp \left(\mathrm{E}_t \left[\frac{D_{t+1}}{Y_{t+1}} \right] - \frac{D}{Y} \right) - 1 \right). \qquad (13)$$

The reason why we introduce this interest rate rule in our setup is twofold. First, as Schmitt-Grohé and Uribe (2003) point out, it is a convenient way to make the deterministic equilibrium independent of initial conditions and thus to close the model. Second, it allows us to feature financial frictions in our theoretical economy in a reduced form.

According to equation (13), the cost of debt depends on the steady state interest rate r, the economy's steady state debt to GDP ratio $\frac{D}{Y}$, and the expected level of

debt over GDP in the next period $E_t\left[\frac{D_{t+1}}{Y_{t+1}}\right]$. Note that for ease of interpretation we use the debt to GDP ratio to determine the interest rate rather than the level of total debt. Intuitively, a country finds it hard to borrow on soft terms and is charged a premium over the equilibrium interest rate if it is expected to face high debt relative to the size of its economy in the future.[13]

In our benchmark setup, we follow García-Cicco *et al.* (2010) and interpret ψ as a catchall parameter for financial frictions and financial development. A high value of ψ implies that the interest rate reacts more sensitively to changes in the expected future debt to GDP ratio, which reflects severe capital market distortions in the economy.[14] García-Cicco *et al.* (2010) highlight the importance of the size of ψ for the analysis of business cycles in both developed economies and EMEs. In light of this, our empirical analysis below permits ψ to take on values that are substantially greater than zero. Therefore, we allow for variation in the interest rate, which entails important implications for the dynamics in our model.[15]

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[13]Admittedly, there is no micro foundation upon which we build our interest rate rule. Nevertheless, the imposed positive relationship between debt over GDP and borrowing costs in our framework is consistent with findings in the sovereign debt literature. For instance, Arellano (2008) develops a model, which shows how higher indebtedness increases the probability of default and thus raises the interest rate. Likewise, a large body of empirical research has emphasized the importance of a country's external debt in explaining interest rate spreads (see Uribe and Yue 2006). Furthermore, as Uribe (2006) demonstrates, we could also introduce a borrowing constraint in our small open economy framework to generate an endogenous country spread. In such a model, a premium over the equilibrium interest rate emerges if the debt ceiling is binding. In light of this, we believe that our interest rate rule provides a convenient way to capture credit market imperfections even though it leaves out an endogenous explanation within the model.

[14]At this point it is intuitive to look at the log–linearized version of the interest rate rule given by

$$\widehat{r_t}\, r = \frac{d}{y}\psi E_t\left[\widehat{d_{t+1}} - \widehat{y_{t+1}}\right] \qquad \Leftrightarrow \qquad \frac{\Delta r_t}{\Delta E_t\left[\left(\frac{d}{y}\right)_{t+1}\right]} \approx \psi,$$

where hatted variables denote log–deviations from steady state and Δ indicates absolute changes. Accordingly, $\widehat{r_t}\cdot r$ approximately corresponds to the absolute deviation of the interest rate from its steady state value r. Hence, we can identify the effective debt–elasticity of the interest rate as $\frac{\psi}{r}\cdot\frac{d}{y}$. More specifically, parameter ψ determines by how many percentage points the interest rate at date t increases if, *ceteris paribus*, we expect the debt to income ratio to rise by one percentage point in period $t + 1$.

[15]ψ needs to be positive in order to induce stationarity. However, Aguiar and Gopinath (2007) and other related studies set ψ equal to 0.001, i.e. virtually equal to zero. In doing so, these authors basically shut down interest rate changes and thereby eliminate any feedback effects from the interest rate on other macroeconomic variables (see García-Cicco *et al.* 2010).

Exchange Rate

The household's optimization problem abroad is analogous to the home country. Since we consider an SOE framework, the home economy is infinitesimally small relative to the rest of the world. That is, the foreign country is approximately closed and only consumes goods produced abroad. As a result, the foreign price index of the foreign consumption composite $p_t^\star$ boils down to the foreign price of goods produced in the rest of the world $p_{F,t}^\star$, i.e. $p_t^\star = p_{F,t}^\star$. We assume that the law of one price holds such that

$$p_{F,t} = \frac{p_{F,t}^\star}{s_t} = \frac{p_t^\star}{s_t},$$

where $s_t = p_{H,t}^\star$ defines the price of the home good in the foreign country. In fact, s_t can be interpreted as the "nominal exchange rate" determining the price of the domestic currency in terms of the foreign currency, since we have normalized the domestic price of the home good to one ($p_{H,t} = 1$). As a result, we can define the real exchange rate as the price of the domestic composite consumption good in units of the foreign composite consumption good:

$$e_t = \frac{p_t s_t}{p_t^\star} = \frac{p_t s_t}{p_{F,t}^\star} = \frac{p_t s_t}{p_{F,t} s_t} = \frac{p_t}{p_{F,t}}. \tag{14}$$

Net Exports and Current Account

We assume that the consumption index of agents abroad is also characterized by a CES aggregate. For simplicity, we also assume that variables in the domestic economy and the rest of the world exhibit the same stochastic trend component, i.e. $\Gamma_{t-1} = \Gamma_{t-1}^\star$. Let $c_t^\star$ denote detrended foreign consumption such that we can derive foreign demand for the home good, from the perspective of the home country, as

$$c_{H,t}^\star = \theta^\star p_{F,t}^{\eta^\star} c_t^\star, \tag{15}$$

where $\theta^\star \in (0,1)$ denotes the share of home goods in foreign consumption, and $\eta^\star \in (0,\infty)$ is the elasticity of intratemporal substitution abroad.

Consequently, net exports in the home economy can be easily calculated as the

difference between exports and imports:

$$nx_t = c^{\star}_{H,t} - p_{F,t}c_{F,t}. \tag{16}$$

Furthermore, the current account is given by the trade balance minus interest payments on external debt:

$$ca_t = -r_{t-1}d_t + nx_t. \tag{17}$$

As in any standard intertemporal model of the current account (see Obstfeld and Rogoff (1996)), the current account in our benchmark economy simply equals the change in the country's net foreign asset position:

$$\Delta nfa_{t+1} = -g_t d_{t+1} + d_t = ca_t. \tag{18}$$

3.1.4 General Equilibrium

In a general equilibrium, all markets have to clear. Equilibrium in the market for the home–produced good requires that output equals domestic absorption plus foreign demand:

$$y_t = c_{H,t} + i_t + c^{\star}_{H,t}. \tag{19}$$

Finally, foreign consumption is assumed to follow an exogenous first–order AR process in logs:

$$c^{\star}_{t+1} = (c^{\star}_t)^{\rho_c} \exp(\epsilon^c_{t+1}), \quad \text{with} \quad \epsilon^c_t \sim \mathcal{N}(0, \sigma^2_c). \tag{20}$$

This specification introduces external disturbances in our setup, which potentially allows foreign demand shocks, along with permanent and transitory productivity shocks, to drive the dynamics in the model.

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3.2 Liability Dollarization

A well–known characteristic of EMEs is that they have had difficulties in borrowing in their own currencies on international capital markets.[16] In fact, the bulk of external debt in these countries has traditionally been issued in major currencies like US dollar, euro, sterling, or Swiss francs (see Eichengreen *et al.* 2005). Being denominated in foreign currency, the amount of outstanding loans is subject to substantial exchange rate fluctuations which may induce non–negligible external balance sheet effects. In order to account for this phenomenon, which is often referred to as liability dollarization, we now extend our benchmark framework from the previous subsection along this dimension.

The basic structure of the model coincides with our benchmark model. Thus, most of equations and optimality conditions from Section 3.1 simply carry over. As we have set up our model in real terms, liability dollarization means that the home country can only borrow in units of foreign consumption. Accordingly, the resource constraint of the economy adjusts to[17]

$$Y_t + p_t \frac{D_{t+1}}{e_t} \geq p_t C_t + I_t + p_t \frac{D_t}{e_t}(1 + r_{t-1}). \tag{21}$$

This has an immediate impact on household optimization such that we obtain an intertemporal Euler Equation with respect to foreign debt of

$$\frac{1}{c_t}\left(c_t^\gamma(1-l_t)^{1-\gamma}\right)^{1-\sigma} = \beta g_t^{\gamma(1-\sigma)-1} \mathrm{E}_t\left[\frac{1}{c_{t+1}}\left(c_{t+1}^\gamma(1-l_{t+1})^{1-\gamma}\right)^{1-\sigma}\frac{e_t}{e_{t+1}}\right](1+r_t). \tag{22}$$

Note that liability dollarization changes the price of consumption at date t expressed in units of date $t+1$ relative to the benchmark case in equation (11). In particular, it alters the impact of the exchange rate fluctuations on the optimal intertemporal consumption allocation of the representative household.

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[16]This phenomena has been documented by an extensive literature. See, for instance, Reinhart *et al.* (2003), Lane and Shambaugh (2010) and contributions in Eichengreen and Hausmann (2005).

[17]Note that international debt D is expressed in units of the foreign composite consumption good such that $\frac{D}{e}$ is denoted in units of the domestic consumption good. Hence, we have to multiply $\frac{D}{e}$ by the price of domestic consumption p in order to obtain foreign debt expressed in units of the home–produced good.

In addition, our interest rate rule modifies to

$$r_t = r + \psi \left(\exp \left(E_t \left[\frac{p_{t+1} D_{t+1}}{e_{t+1} Y_{t+1}} \right] - \frac{pD}{eY} \right) - 1 \right). \tag{23}$$

It is worth emphasizing that with interest rates determined by equation (23), parameter ψ can no longer be interpreted as a catchall variable for financial frictions as we do in the benchmark economy (see equation (13)). When households issue new debt, they do not know how much they have to repay in the future because exchange rate variations change the value of outstanding debt. Hence, the fact that countries are forced to borrow in foreign currency itself represents a special form of capital market distortions. In the model at hand we can therefore encompass the extent of financial frictions by the interplay of liability dollarization and debt–elastic interest rates.[18]

Importantly, the value of outstanding international debt depends on the evolution of the real exchange rate. As a result, the change in the country's net foreign asset position no longer equals the current account but is now adjusted for valuation effects stemming from exchange rate changes. We can write the detrended current account as

$$ca_t = nx_t - r_{t-1} p_t \frac{d_t}{e_t}. \tag{24}$$

Moreover, we derive the change in detrended net foreign assets as the sum of the

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[18]Note that the log–linearized version of the interest rate rule is given by

$$\widehat{r_t}\, r = \frac{pd}{ey} \psi E_t \left[\widehat{p_{t+1}} + \widehat{d_{t+1}} - \widehat{y_{t+1}} - \widehat{e_{t+1}} \right] \qquad \Leftrightarrow \qquad \frac{\Delta r_t}{\Delta E_t \left[\left(\frac{pd}{ey} \right)_{t+1} \right]} \approx \psi.$$

The interpretation of the size of parameter ψ is the same as in the benchmark case.

current account and valuation effects:

$$\Delta nfa_t = -g_t p_t \frac{d_{t+1}}{e_t} + p_{t-1} \frac{d_t}{e_{t-1}} \tag{25}$$

$$\overset{(21)}{\Longleftrightarrow} \quad \Delta nfa_t = y_t - p_t c_t - i_t - r_{t-1} p_t \frac{d_t}{e_t} + p_{t-1} \frac{d_t}{e_{t-1}} - p_t \frac{d_t}{e_t}$$

$$\overset{(19)}{\Longleftrightarrow} \quad \Delta nfa_t = c^\star_{H,t} - p_{F,t} c_{F,t} - r_{t-1} p_t \frac{d_t}{e_t} + d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right)$$

$$\overset{(16)}{\Longleftrightarrow} \quad \Delta nfa_t = nx_t - r_{t-1} p_t \frac{d_t}{e_t} + d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right)$$

$$\overset{(24)}{\Longleftrightarrow} \quad \Delta nfa_t = ca_t + val_t.$$

Hence, the stationary version of valuation effects at date t is given by

$$val_t = d_t \left(\frac{p_{t-1}}{e_{t-1}} - \frac{p_t}{e_t} \right). \tag{26}$$

3.3 Model Solution

Once the variables incorporating the stochastic permanent component have been detrended, the models introduced above constitute stationary systems of non–linear expectational difference equations. In the benchmark model the system is featured by 18 variables $(y_t, c_t, r_t, e_t, i_t, l_t, c_{H,t}, c_{F,t}, c^\star_{H,t}, p_t, p_{F,t}, nx_t, ca_t, k_t, d_t, z_t, g_t, c^\star_t)$ in the stationary versions of equations (1), (2), (3), (4), (6), (7), (8), (9), (10), (11), (12), (13), (14), (15), (16), (17), (19), and (20). The model with liability dollarization forms a system of 20 variables $(y_t, c_t, r_t, e_t, i_t, l_t, c_{H,t}, c_{F,t}, c^\star_{H,t}, p_t, p_{F,t}, nx_t, ca_t, \Delta nfa_t, val_t, k_t, d_t, z_t, g_t, c^\star_t)$ in the detrended versions of equations (1), (2), (3), (4), (7), (8), (9), (10), (12), (14), (15), (16), (19), (20), (21), (22), (23), (24), (25), and (26).

For each setup, we use a first–order approximation of the respective model solution and log–linearize the system around its deterministic steady state. All equations being log–linearized, we end up with a linear system of first–order expectational difference equations, which we solve using the method proposed by Klein (2000). The solution yields a state space representation

$$\mathbf{y}_t = \mathbf{Z} \boldsymbol{\alpha}_t$$
$$\boldsymbol{\alpha}_t = \mathbf{T} \boldsymbol{\alpha}_{t-1} + \mathbf{R} \boldsymbol{\eta}_t, \tag{27}$$

where $\mathbf{y}_t$ is an $(n \times 1)$ vector of control variables and $\boldsymbol{\alpha}_t$ is the $(m \times 1)$ unobservable state vector, which is driven by the exogenous processes $\boldsymbol{\eta}_t$ of dimension $(x \times 1)$. Therefore, the matrix $\mathbf{R}$, which links the state variables to the exogenous processes, has dimension $(m \times x)$.[19] This representation enables us to estimate certain structural parameters of our models using country–specific data, which will be described in detail in the next section.

4   Estimation and Calibration

To gauge the models' ability to explain macroeconomic dynamics in EMEs, we quantify our theoretical economy for three EMEs: Mexico, South Africa, and Turkey. Furthermore, to assess the peculiarity of business cycles in emerging markets, we also parametrize the benchmark model for a group of developed small open economies, represented by Canada, Sweden, and Switzerland.

We choose a mixture of country–specific calibration and Bayesian estimation. In particular, we estimate the parameters determining the exogenous processes in the model as well as the debt–elasticity of the interest rate ψ. All other parameters are calibrated. Given our focus on the role of liability dollarization as a form of financial frictions in EMEs, we estimate both models for Mexico, South Africa, and Turkey, whereas for our developed economies, we only analyze the benchmark framework.

4.1   Data

The time unit t in our theoretical economy is counted as quarters. To estimate our linearized models, we use quarterly time series on real per capita GDP and consumption, real interest rates and real exchange rates. All data are taken from the IFS database. The time series of real per capita output and consumption are seasonally adjusted using the Census Bureau's X–12 ARIMA procedure. Our selection of countries and sample period is motivated by data availability and comparability with existing literature. Table 2 summarizes the sample period

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[19]Accordingly, in the benchmark model, we have $x = 3$, $m = 5$, and $n = 13$. In the liability dollarization model, we have $x = 3$, $m = 5$, and $n = 15$.

used for estimation for each country.

Table 2: Data for Estimation

EMERGING MARKETS		DEVELOPED ECONOMIES	
Mexico (MEX)	1981Q1–2011Q4	Canada (CAN)	1960Q1–2011Q4
South Africa (ZAF)	1960Q1–2011Q4	Sweden (SWE)	1981Q1–2011Q4
Turkey (TUR)	1987Q1–2011Q4	Switzerland (CHE)	1970Q1–2011Q3

Notes: All data are taken from the IFS database. Variables used for estimation are real GDP per capita, real consumption per capita, the real interest rate, and the real exchange rates.

To calculate real per capita variables, we divide the respective nominal series by population and subsequently deflate output using the GDP deflator and consumption using the CPI. Population data are only available on an annual frequency. Hence, we pin down population in the respective second quarter at the reported annual figure and interpolate missing data points using annual growth rates. Our construction of real interest rates is similar to the approach chosen by Neumeyer and Perri (2005). That is, we subtract domestic expected inflation based on the GDP deflator from the annual nominal interest rate, which is then transformed into a 3–month rate.[20] Expected inflation is calculated as the average of actual inflation in the current period and the three previous quarters. Finally, for each country we construct a real exchange rate index, which is normalized to 100 in 2005Q2 by multiplying the respective nominal US dollar exchange rate (US dollar per national currency) by the domestic CPI and dividing by the US CPI. Moreover, we follow García-Cicco *et al.* (2010) and filter our data prior to estimation by removing the cubic trend from the real series in logs.

4.2 Calibration

Table 3 reports the calibration of our parameters. We keep the majority of structural parameters constant across both models and countries, and assign conventional values suggested by previous literature. In doing so, we try to retain a

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[20]For Canada, Mexico, South Africa, Sweden, and Switzerland we use T–bill rates, whereas for Turkey we take the deposit rate. Note that Neumeyer and Perri (2005) subtract expected US inflation from the dollar interest rate based on the J.P. Morgan Emerging Market Bond Index (EMBI) spread. We use domestic expected inflation instead because our model describes the behavior of a domestic representative agent as opposed to an international investor.

high degree of comparability with earlier contributions. In particular, we follow Aguiar and Gopinath (2007) and set the subjective discount factor β equal to 0.98, the weight of consumption in the utility function γ equal to 0.36, the parameter governing the curvature of the utility function σ equal to 2, the weight of the adjustment costs ϕ equal to 4, the capital share in the production function equal to 0.32, and the rate of depreciation δ equal to 0.05. Without loss of generality, we normalize the mean value of both the transitory productivity process z and the foreign consumption process $c^\star$ to 1. There is no consensus in the literature concerning which value to choose for the elasticity of intratemporal substitution between home and foreign goods (see Obstfeld and Rogoff 2000). We assume that the price elasticity of goods is the same throughout the world and follow Corsetti and Pesenti (2001) by setting its value equal to unity, i.e. $\eta = \eta^\star = 1$. Moreover, we pin down $\theta = 0.8$ and $\theta^\star = 0.2$ to match a consumption import share both at home and abroad of 20 percent. This choice is motivated by empirical figures reported in Burstein *et al.* (2005).

Two parameters are fixed country–specifically. We calibrate the mean of the non–stationary productivity process μ_g at the average quarterly gross growth rate of real per capita GDP. We pin down the steady state external debt to GDP ratio at the average annual net foreign asset position.[21] That is, we set $\frac{D}{Y}$ in the benchmark model and $\frac{pD}{eY}$ in the model with liability dollarization equal to 35.63 percent, 24.36 percent, 23.20 percent, 31.08 percent, and 18.63 percent for Mexico, South Africa, Turkey, Canada, and Sweden, respectively. Switzerland is a net creditor to the rest of the world and thus exhibits a positive average net foreign asset position relative to GDP of 90 percent.

4.3 Estimation

Similar to recent studies in this field of research (e.g. García-Cicco *et al.* 2010 or Chang and Fernández 2013), we adopt a Bayesian viewpoint. Besides computational advantages, this allows us to incorporate prior beliefs about the structural parameters in a straightforward manner. As pointed out above, the size of param-

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[21] Average net foreign asset positions are calculated based on annual data between 1970 and 2007 collected by Lane and Milesi-Ferretti (2007).

Table 3: Calibrated Values

General Parameters					
β	discount factor	0.98	$\theta^\star$	foreign share of home goods	0.20
γ	consumption weight in utility	0.36	η	domestic elasticity of intratemporal	
σ	curvature of utility	2.00		substitution	1.00
ϕ	weight of adjustment costs	4.00	$\eta^\star$	foreign elasticity of intratemporal	
α	capital share	0.32		substitution	1.00
δ	depreciation rate	0.05	z	mean of z process	1.00
θ	domestic share of home goods	0.80	$c^\star$	mean of $c^\star$ process	1.00

Country–specific Parameters					
$\left(\frac{p}{e}\cdot\right)\frac{D}{Y}$	external debt ratio		μ_g	mean gross growth rate	
	MEX	0.36		MEX	1.0018
	ZAF	0.24		ZAF	1.0026
	TUR	0.23		TUR	1.0063
	CAN	0.31		CAN	1.0049
	SWE	0.19		SWE	1.0046
	CHE	−0.90		CHE	1.0029

Notes: In the benchmark model, we pin down $\frac{D}{Y}$. In the model with liability dollarization, we calibrate $\frac{pD}{eY}$ at the reported value of the external debt to income ratio.

eter ψ, which determines the debt–elasticity of interest rates, may have important implications for the dynamics in the model. However, ex–ante we do not have strong beliefs about the size of the debt–elasticity of interest rates. To this end, we estimate parameter ψ as well as the parameters governing the exogenous structural shocks in the model.

A major contribution of this work is that our estimation procedure allows for a dynamic structure in the "measurement error", which captures the off–model dynamics in the data. To our knowledge, this represents a novel approach in this strand of the literature. Related previous studies deal differently with the crucial issue on how to address these residual dynamics of our observable variables in the estimation.[22] Naturally, our SOE setup is too stylized to account for all the dynamics in real macroeconomic time series. Hence, we build on Sargent (1989) and Ireland (2004) and include a (vector–)autoregressive "measurement error" component to capture the dynamics in the data that cannot be replicated by the structural model itself. Accordingly, our state space representation in equation

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[22]For instance, García-Cicco *et al.* (2010) and Chang and Fernández (2013) impose a simple White Noise process on the measurement error. In addition, García-Cicco *et al.* (2010) tightly restrict the variance of the measurement error, so that it cannot explain more than 6 percent of the variation in the respective observable variable.

(27) modifies to

$$
\begin{aligned}
\mathbf{y}_t &= \mathbf{Z}\alpha_t + \epsilon_t \\
\alpha_t &= \mathbf{T}\alpha_{t-1} + \mathbf{R}\eta_t, & \eta_t &\sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}) \\
\epsilon_t &= \mathbf{A}\epsilon_{t-1} + \xi_t, & \xi_t &\sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Omega})
\end{aligned}
\tag{28}
$$

where ϵ_t is an ($n_{estimation} \times 1$) vector of measurement errors and $n_{estimation}$ denotes the number of observables we use for estimation, which is four in our case. We assume that the off–model dynamics inherent in each variable follow an autoregressive process such that all off–diagonal entries of the ($n_{estimation} \times n_{estimation}$) coefficient matrix $\mathbf{A}$ are restricted to zero.

We apply a Markov Chain Monte Carlo (MCMC) simulation using the Metropolis–Hastings algorithm within the Gibbs sampler to derive the posterior distributions of the parameters. First, we implement Gibbs sampling to simulate the posteriors of the parameters defining our exogenous processes $\rho_z, \sigma_z^2, \rho_g, \sigma_g^2, \rho_c$ and σ_c^2, $\mathbf{A}$, and $\boldsymbol{\Omega}$. Then, at each simulation iteration, conditional on the current Gibbs draw, we add a Metropolis–Hastings step in order to approximate the posterior distribution of ψ. We therefore apply a random walk Metropolis Hastings algorithm, in which we choose the variance of the proposal density such that we get an acceptance ratio of about 20 to 40 percent. We estimate the whole model with different starting values in order to control for the possibility of multiple modes in the posterior distribution.

Apart from the volatility in the off–model dynamics, our prior beliefs are constant across all models and countries. They are summarized in Table 4. We impose a normal distribution with mean 0.5 and variance 0.02 on the autoregressive coefficients of structural shocks. Regarding the persistence parameters of measurement errors, it is more difficult to come up with informative priors. Therefore, we implement rather diffuse priors and assume they follow a normal distribution with zero mean and variance 0.05. Since the normal distribution has infinite support, we enforce stationarity by restricting the AR coefficients to lie within the unit circle. Priors on the volatility of the structural exogenous processes are harmonized and are described by an inverse Gamma distribution with shape

parameter 2.05 and scale factor 0.0105.[23] Furthermore, we fix the prior distribution of the measurement error variance country–specifically such that its mean matches the variance of the respective observable time series used for estimation. Finally, we impose a fairly flat uniform distribution with support $[0.001, 5]$ on our financial frictions parameter ψ.

Table 4: Prior Distributions

	Prior Dist.	Prior 90% Bands	Prior Dist.	Prior 90% Bands	Prior Dist.	Prior 90% Bands
			HARMONIZED PRIORS			
ψ			$\mathcal{U}(0.001, 5)$	–		
ρ_z			$\mathcal{N}(0.5, 0.02)$	[0.269,0.733]		
ρ_g			$\mathcal{N}(0.5, 0.02)$	[0.269,0.733]		
ρ_c			$\mathcal{N}(0.5, 0.02)$	[0.269,0.733]		
ρ_{ϵ_y}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
ρ_{ϵ_c}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
ρ_{ϵ_r}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
ρ_{ϵ_e}			$\mathcal{N}(0, 0.05)$	[−0.367,0.367]		
σ_z^2			$\mathcal{IG}(2.05, 0.011)$	[0.002,0.028]		
σ_g^2			$\mathcal{IG}(2.05, 0.011)$	[0.002,0.028]		
σ_c^2			$\mathcal{IG}(2.05, 0.011)$	[0.002,0.028]		
			COUNTRY–SPECIFIC PRIORS			
	MEXICO		**SOUTH AFRICA**		**TURKEY**	
$\sigma_{\epsilon_y}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.002)$	[0.000,0.006]
$\sigma_{\epsilon_c}^2$	$\mathcal{IG}(2.01, 0.003)$	[0.001,0.010]	$\mathcal{IG}(2.00, 0.002)$	[0.000,0.006]	$\mathcal{IG}(2.01, 0.004)$	[0.001,0.012]
$\sigma_{\epsilon_r}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.001]
$\sigma_{\epsilon_e}^2$	$\mathcal{IG}(2.16, 0.021)$	[0.004,0.050]	$\mathcal{IG}(2.21, 0.025)$	[0.005,0.056]	$\mathcal{IG}(2.15, 0.020)$	[0.004,0.050]
	CANADA		**SWEDEN**		**SWITZERLAND**	
$\sigma_{\epsilon_y}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.003]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.004]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.001]
$\sigma_{\epsilon_c}^2$	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.002]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.003]	$\mathcal{IG}(2.00, 0.001)$	[0.000,0.001]
$\sigma_{\epsilon_r}^2$	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]	$\mathcal{IG}(2.00, 0.000)$	[0.000,0.000]
$\sigma_{\epsilon_e}^2$	$\mathcal{IG}(2.02, 0.007)$	[0.001,0.019]	$\mathcal{IG}(2.00, 0.022)$	[0.005,0.062]	$\mathcal{IG}(2.24, 0.028)$	[0.005,0.060]

5 Estimation Results

This section discusses the estimation results for the six countries under investigation. First, we present the posterior distributions of our estimated parameters. Then, we run a "horse race" between the benchmark model and the liability dollarization setup with respect to their ability to capture the dynamics in our four observable variables.

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[23]This prior distribution implies a mean of 0.01 and variance of 0.002.

5.1 Parameter Distributions

In the following, we focus on the estimation results concerning the structural part of the model. Table 5 displays the posterior distribution of the estimated structural parameters. A complete description of all estimated parameters, including those determining the off–model dynamics, can be found in the Appendix.

All results are based on 150,000 draws of which the initial 100,000 (125,000) draws were burned for EMEs (developed economies). We keep only every 25th (10th) draw for EMEs (developed economies) in order to avoid autocorrelation problems. Furthermore, we have performed a convergence test for each specification. Columns four and seven in Table 5 report the p–values of Geweke's χ^2–test (see Geweke 1992). We can never reject the null of convergence at conventional significance levels. Therefore, we are rather confident that our posterior distributions have converged.

Let us first consider the estimates of parameter ψ. We do not only find heterogeneity with respect to the choice of the model but also regarding the country group. What is striking is that ψ is considerably higher in the benchmark economy than in the model featuring foreign currency debt. Thus, once we introduce liability dollarization as a further form of capital market imperfections, the estimated debt–elasticity of interest rates becomes less pronounced.[24] This is particularly the case for the Mexican economy, where we observe an extreme discrepancy in ψ across models. For instance, evaluated at the median of the posterior distribution, a slight increase in the external debt to income ratio of merely one percentage point lifts the cost of borrowing by as much as 4.34 percentage points in the benchmark economy, whereas in the extended model interest rates rise by only 0.22 percentage points. In light of this simple numerical exercise, the model with foreign currency debt seems to deliver debt–elasticities that are more reasonable in terms of their economic significance.

Looking at the benchmark economy, our estimation results suggest that the

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[24]Admittedly, this finding is not very surprising. In the liability dollarization setup, variation in the interest rate can additionally be attributed to exchange rates fluctuations. Compare the interest rate rules in equations (13) and (23). Since real exchange rates in EMEs tend to be procyclical, volatility on the right–hand side of the interest rate rule unambiguously rises once we introduce liability dollarization, while it remains unchanged on the left–hand side such that factor ψ must decline.

Table 5: Posterior Distributions of Structural Parameters

	Posterior Median	Posterior 90% Bands	χ^2 Test	Posterior Median	Posterior 90% Bands	χ^2 Test
			EMERGING MARKET ECONOMIES			
			MEXICO			
		BENCHMARK			**LIABILITY DOLLARIZATION**	
ψ	4.342	[3.315,4.885]	0.27	0.216	[0.0880,0.488]	0.96
ρ_z	0.622	[0.487,0.744]	0.58	0.708	[0.5741,0.828]	0.50
ρ_g	0.751	[0.637,0.845]	0.58	0.790	[0.6316,0.890]	0.26
ρ_c	0.689	[0.458,0.875]	0.37	0.547	[0.3648,0.726]	0.21
σ_z^2	0.034	[0.028,0.043]	0.91	0.036	[0.0289,0.044]	0.79
σ_g^2	0.040	[0.031,0.052]	0.26	0.029	[0.0213,0.039]	0.83
σ_c^2	0.128	[0.082,0.201]	0.89	0.189	[0.1056,0.370]	0.45
			SOUTH AFRICA			
		BENCHMARK			**LIABILITY DOLLARIZATION**	
ψ	1.664	[1.115,2.668]	0.31	0.275	[0.1578,0.420]	0.93
ρ_z	0.918	[0.874,0.958]	0.50	0.782	[0.6795,0.863]	0.92
ρ_g	0.827	[0.767,0.886]	0.86	0.797	[0.6900,0.869]	0.95
ρ_c	0.626	[0.442,0.815]	0.43	0.654	[0.4663,0.798]	0.59
σ_z^2	0.015	[0.014,0.018]	0.85	0.020	[0.0172,0.023]	0.91
σ_g^2	0.012	[0.010,0.014]	0.22	0.016	[0.0123,0.021]	0.86
σ_c^2	0.082	[0.059,0.110]	0.34	0.086	[0.0579,0.137]	0.56
			TURKEY			
		BENCHMARK			**LIABILITY DOLLARIZATION**	
ψ	4.067	[2.743,4.830]	0.50	0.455	[0.1259,1.182]	0.86
ρ_z	0.691	[0.552,0.803]	0.25	0.648	[0.5124,0.763]	0.24
ρ_g	0.629	[0.508,0.741]	0.46	0.705	[0.5614,0.811]	0.10
ρ_c	0.646	[0.428,0.822]	0.49	0.507	[0.3384,0.655]	0.48
σ_z^2	0.062	[0.049,0.078]	0.87	0.059	[0.0455,0.075]	0.49
σ_g^2	0.080	[0.060,0.107]	0.14	0.074	[0.0528,0.101]	0.66
σ_c^2	0.201	[0.114,0.384]	0.12	0.192	[0.1026,0.428]	0.20
			DEVELOPED ECONOMIES			
		CANADA			**SWEDEN**	
ψ	2.335	[1.646,3.573]	0.14	2.490	[1.486,4.103]	0.89
ρ_z	0.901	[0.852,0.948]	0.38	0.885	[0.829,0.939]	0.95
ρ_g	0.757	[0.676,0.832]	0.91	0.597	[0.488,0.706]	0.15
ρ_c	0.920	[0.860,0.958]	0.53	0.738	[0.523,0.878]	0.53
σ_z^2	0.013	[0.011,0.015]	0.70	0.022	[0.018,0.025]	0.46
σ_g^2	0.009	[0.008,0.011]	0.56	0.018	[0.015,0.022]	0.80
σ_c^2	0.047	[0.038,0.058]	0.88	0.074	[0.055,0.102]	0.55
		SWITZERLAND				
ψ	0.165	[0.141,0.193]	0.54			
ρ_z	0.880	[0.826,0.931]	0.55			
ρ_g	0.596	[0.486,0.699]	0.52			
ρ_c	0.697	[0.515,0.835]	0.92			
σ_z^2	0.014	[0.013,0.016]	0.48			
σ_g^2	0.012	[0.010,0.014]	0.89			
σ_c^2	0.093	[0.067,0.129]	0.25			

Notes: Results are based on 150,000 draws from the posterior distribution of which for EMEs the first 100,000 and for developed economies the first 125,000 draws were burned. To avoid autocorrelation issues, we only keep every 10th draw for developed economies, and every 25th for EMEs. The χ^2 figure denotes the p–value of Geweke's χ^2–test for convergence (4% taper). Variances are reported in percentages.

magnitude of reduced form financial frictions is more severe in EMEs than in developed economies. In fact, apart from South Africa, the mode of the posterior distribution of ψ obtained for EMEs is greater than its counterpart in the group of developed countries. In general, our findings for EMEs are to some extent consistent with the results reported by García-Cicco *et al.* (2010). On the one hand, our estimates for Mexico and Turkey in the benchmark model indicate a perceptibly higher debt–elasticity of the interest rate compared to their study's findings for Argentina. On the other hand, the elasticity obtained in the liability dollarization framework is lower for all three EMEs than the one documented by García-Cicco *et al.* (2010).

Turning to the parameters of the structural processes, we find that autocorrelation coefficients tend to be relatively high. This is especially the case for South Africa. By and large, however, we do not find large differences in the persistence parameters both across models and countries. For the group of emerging markets, the median of ρ_g, the parameter governing the persistence of the non–stationary productivity process, ranges from about 0.6 to 0.8. These estimates are clearly higher than those reported by Aguiar and Gopinath (2007) and García-Cicco *et al.* (2010). Nonetheless, they fall into the range of the results obtained by Chang and Fernández (2013) and Boz *et al.* (2011) for Mexico as well as Nguyen (2011) for the United States.

Interestingly, the variances of our structural shocks seem to differ between models and country groups. Estimated variances of the two technology processes are generally higher in EMEs than in advanced economies. Aguiar and Gopinath (2007) highlight the necessity of a high standard deviation of the permanent relative to transitory productivity shock in their model in order to account for certain business cycle phenomena in EMEs. In the benchmark model, we indeed find a higher ratio of volatilities $\frac{\sigma_g}{\sigma_z}$ for EMEs, except South Africa, than for developed economies. However, our estimation exercise suggests a much lower relative volatility of trend shocks in EMEs compared to Aguiar and Gopinath (2007).[25] What is more, we find that the ratio of standard deviations at the median

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[25]Looking at the median of the posterior distributions, we calculate a ratio of volatilities $\frac{\sigma_g}{\sigma_z}$ equal to 0.8321, 0.9045, and 0.9258 for Canada, Sweden, and Switzerland, respectively. In the benchmark (liability dollarization) model, we get a ratio of 1.0847 (0.8975) for Mexico, 0.8944

of the posterior is even lower in the model with liability dollarization than in the benchmark model for Mexico and Turkey, while it is the same in both model versions for South Africa.[26] Nonetheless, as we will demonstrate in Section 6, our model with liability dollarization performs reasonably well in matching business cycle patterns in EMEs despite a relatively low $\frac{\sigma_g}{\sigma_z}$.

5.2   Model Fit

Next, we analyze the importance of the structural part relative to the off–model part in driving the dynamics of the observable variables. For this purpose, Figure 3 depicts the fraction of the forecast error variance attributed to structural shocks, i.e. permanent and transitory technology as well as foreign demand shocks, confronted to the fraction explained by the off–model dynamics. While evaluating the respective setup at the median of the posterior distribution, we compute the mean forecast error variance decomposition across all EMEs in both the benchmark economy and the model with liability dollarization. This allows us to study the extent to which our structural model is able to capture the dynamics in our observables. Hence, we can easily assess and compare the fit of our setups.

The graph reveals that the liability dollarization setup outperforms the benchmark model in accounting for the variation in output, consumption and real exchange rates at all forecast horizons. The superiority of the framework with liability dollarization is most perceivable for consumption. Yet we also observe that the benchmark model explains a larger portion of the variability in real interest rates. We explain this peculiar result for the real interest rate by a change in the importance of interest rate shocks once we augment the model with liability dollarization. Recall that both our models abstract from any exogenous disturbances

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(0.8944) for South Africa, and 1.1359 (1.1199) for Turkey. For a comparison, GMM estimates obtained by Aguiar and Gopinath (2007) imply ratios as high as 4.0189 for Mexico and as low as 0.7460 for Canada. To gauge the relative importance of trend shocks, these authors calculate the random walk component of the Solow residual, which also takes the persistence of shocks into account. The size of the random walk component in our estimation can be found in the Appendix.

[26]What is striking is that estimation results for South Africa are in various aspects different from those obtained for Mexico and Turkey. This peculiarity might be explained by the fact that in contrast do other emerging markets, South Africa has for decades had deep and well developed financial markets. Also, as pointed out by Eichengreen and Hausmann (2005), it is one of the few emerging markets, which traditionally has been able to issue bonds denoted in their own currency on international capital markets.

Figure 3: Forecast Error Variance Decomposition – Model Comparison
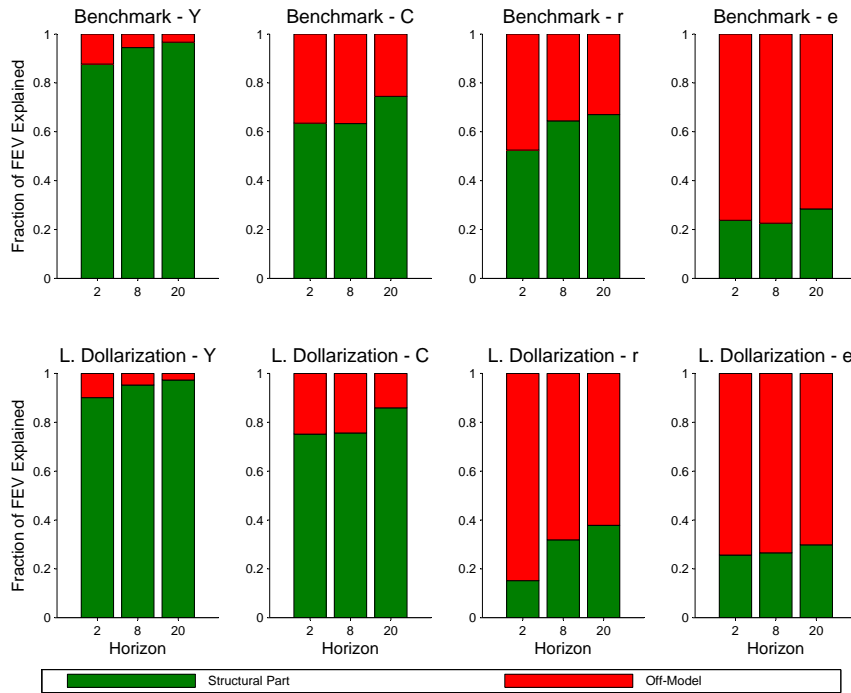
Notes: Mean forecast error variance decomposition across all EMEs. Results are based on median outcomes of the respective posterior distributions.

in the interest rate like world interest rate or country premium shocks. Nonetheless, our estimation procedure implicitly controls for such interest rate shocks by the inclusion of a dynamic measurement error. In light of this interpretation, our exercise suggests that once countries can only borrow in foreign currency, interest rate shocks apparently become more important.[27] By and large, we therefore infer that the model with liability dollarization fits the data in EMEs better than the benchmark setup.

Furthermore, estimation results are generally in strong favor of our theoretical framework. Though being quite stylized, the structural model performs very well, especially in capturing the dynamics of the main macroeconomic aggregates, i.e. output and consumption. Regarding exchange rates, we observe that only about 20 to 30 percent of the variation can be attributed to shocks characterized in the

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[27]Neumeyer and Perri (2005), Uribe and Yue (2006), García-Cicco *et al.* (2010), and Chang and Fernández (2013) have augmented their SOE models with interest rate shocks. These authors stress the merits of this model extension for explaining macroeconomic fluctuations in emerging markets. In particular, Chang and Fernández (2013) show that interest rate shocks are amplified by financial frictions. This underpins our finding that the off–model dynamics of interest rates play a greater role in the setup with liability dollarization.

theoretical model. This finding is owed to the fact our models cannot produce such high volatilities in exchange rates we observe in the data.

6 Model Analysis

This section examines in how far our theoretical model helps us in understanding macroeconomic dynamics in emerging markets. As the previous section has demonstrated, the model with liability dollarization outperforms the benchmark setup in fitting the data. Hence, we confidently treat the liability dollarization framework as the more appropriate model for EMEs and focus on the analysis of the extended setup for this country group. For comparison, we analyze the benchmark model for EMEs in the Appendix.

We begin with implementing a forecast error variance decomposition to assess the relative importance of different shocks in explaining macroeconomic fluctuations. We then turn to an impulse response analysis of the three structural shocks in our liability dollarization setup. Subsequently, we compare model implied business cycle moments with their empirical counterparts to demonstrate that our model succeeds in replicating various stylized business cycle facts. Finally, we show the model's ability to account for the sudden stop in Mexico's capital inflows during the Tequila Crisis of 1994–1995.

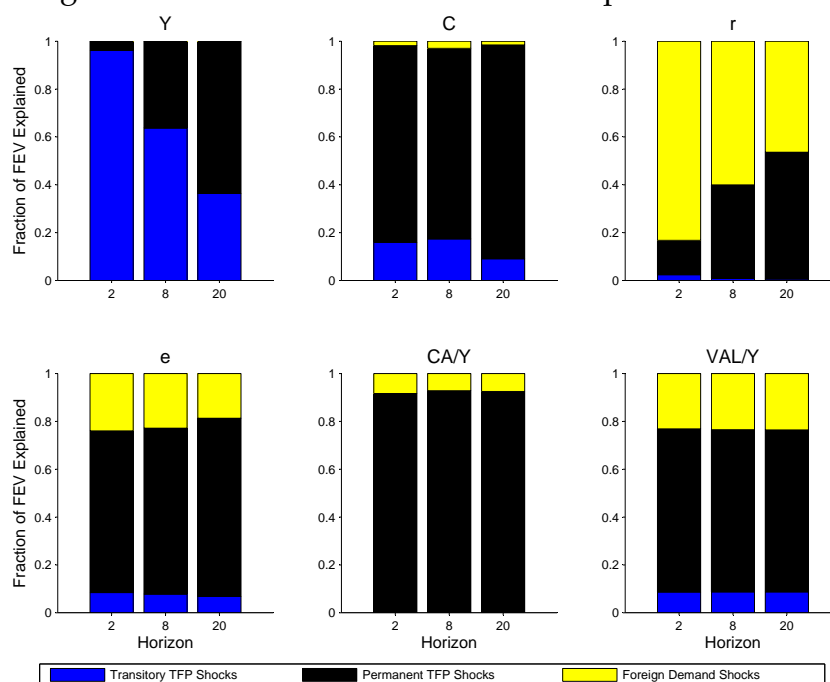## 6.1 Forecast Error Variance Decomposition

In what follows, we study the relative contribution of various shocks in driving the dynamics in our theoretical economy. For this purpose, we perform a forecast error variance decomposition of the structural part of our model, evaluated at the median of the posterior distributions for each country.

Figures 4 and 5 plot the average forecast error variance decomposition of selected variables across all EMEs and developed countries, respectively.[28] Certain patterns are worth emphasizing. First, in both emerging markets and developed countries, transitory shocks are the driving force behind output in the short–run.

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[28]Forecast error variance decompositions for all six countries, as well as for both models for the cohort of EMEs, can be found in the Appendix.

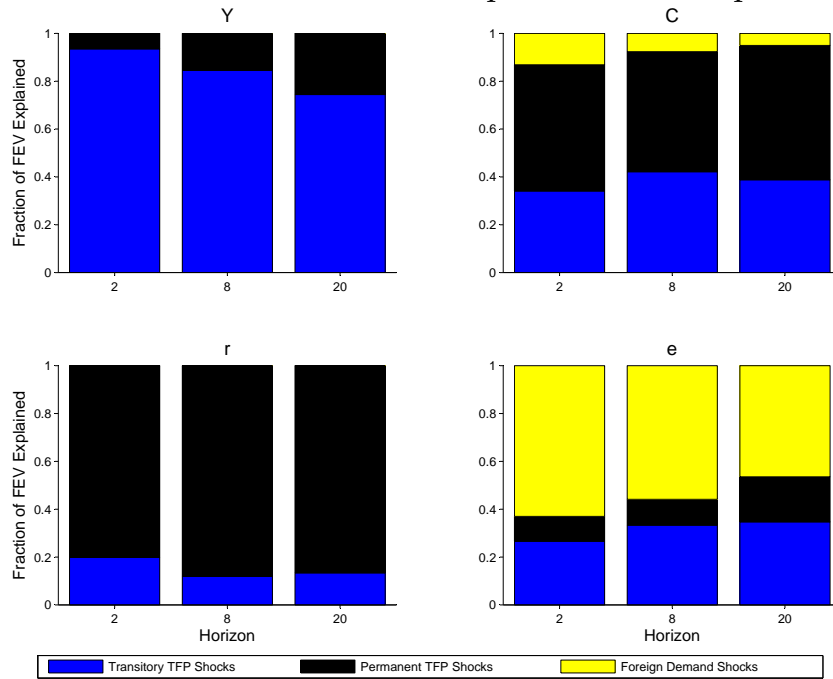Figure 4: Forecast Error Variance Decomposition – EMEs

Notes: Mean forecast error variance decomposition across all EMEs for the model with liability dollarization. Results are based on median outcomes of the respective posterior distributions.

Looking at the developed world, we observe this particular feature not only in the short–run but also in the long–run. In EMEs, on the contrary, the permanent productivity process gains importance over longer horizons and eventually becomes the major determinant of output fluctuations in the long–run. Moreover, in both cohorts, trend shocks predominantly account for consumption variation over all forecast horizons. But permanent shocks are relatively more important for consumption fluctuations in EMEs than in advanced economies.

Second, transitory technology disturbances generally play a minor role for the dynamics in the cost of borrowing. It is essentially growth shocks that account for interest rate variations in advanced countries. In EMEs, however, foreign demand shocks also seem to govern interest rate dynamics to a non–negligible extent, especially in the short–run. This finding indicates that changes in external demand may have important feedback effects on the interest rate in emerging markets.

Third, both transitory productivity and foreign demand disturbances explain a considerable share of the variation in the real exchange rate in industrialized

Figure 5: Forecast Error Variance Decomposition – Developed Economies

Notes: Mean forecast error variance decomposition across all developed countries. Results are based on median outcomes of the respective posterior distributions.

economies. By contrast, it is permanent shocks that dominate relative international price movements in EMEs over all forecast horizons.

Finally, this predominance of trend shocks in emerging markets is even more striking if we look at the forecast error variance decomposition of the current account to output ratio. Figure 4 suggests that virtually all fluctuation in $\frac{CA}{Y}$ can be attributed to permanent productivity shocks. Similarly, more than 60 percent of the forecast error variance of the valuation effects to GDP ratio is determined by innovations to the non–stationary technology process. Foreign demand shocks account for about one third of the variation in $\frac{VAL}{Y}$, while the influence of transitory technology shocks again is trifling.

In a nutshell, our exercise suggests that transitory productivity shocks are far more important in explaining fluctuations of macroeconomic aggregates in industrialized countries compared to EMEs. As opposed to García-Cicco *et al.* (2010) and Chang and Fernández (2013), we conclude that even though we account for financial frictions in our model, both transitory and, above all, permanent disturbances play a role in explaining business cycle variations in EMEs. This in

turn is concurrent with the findings of Aguiar and Gopinath (2007), who argue that macroeconomic fluctuations in EMEs are mainly driven by trend shocks. Thus, we largely find support for their famous hypothesis that *"the cycle is the trend"*.[29]

6.2 Impulse Response Analysis

Next, we shed more light on the mechanics of our model describing EMEs. To this end, we parametrize the liability dollarization setup at the median of the posterior distributions and compute impulse responses to the three structural shocks for each country.

Permanent versus Transitory Productivity Shocks

Figures 6 and 7 plot selected impulse responses to a one percent permanent and transitory productivity disturbance, respectively.

A positive trend shock leads to an increase in consumption and foreign debt relative to income. On the contrary, the effects on $\frac{C}{Y}$ and $\frac{D}{Y}$ are reverse following a positive transitory shock. These opposite responses follow from the optimal savings behavior of the representative consumer and have the same interpretation as in the model of Aguiar and Gopinath (2007). After a positive growth shock, households do not only realize higher income today but also anticipate higher income in the future. The expectation of higher future income is due to the fact that (i) the positive impact on productivity is permanent and does not vanish over time, (ii) adjustment costs imply a gradual change in capital, and, (iii) in addition, growth shocks are persistent ($\rho_g > 0$). Since agents prefer a smooth consumption path over time, it is optimal to raise consumption by more than the initial increase in output. In fact, households borrow on international capital markets in order to finance their optimal consumption plan and additional investment, which explains the excess response of debt relative to GDP. In contrast, this consumption

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[29]In a recent study, Naoussi and Tripier (2013) estimate the framework of Aguiar and Gopinath (2007) for a number of developed, emerging markets, and developing economies. They find that permanent shocks are much more important in developing countries and emerging markets than in advanced economies. Therefore, their results corroborate the notion that *"the cycle is the trend"*, too.
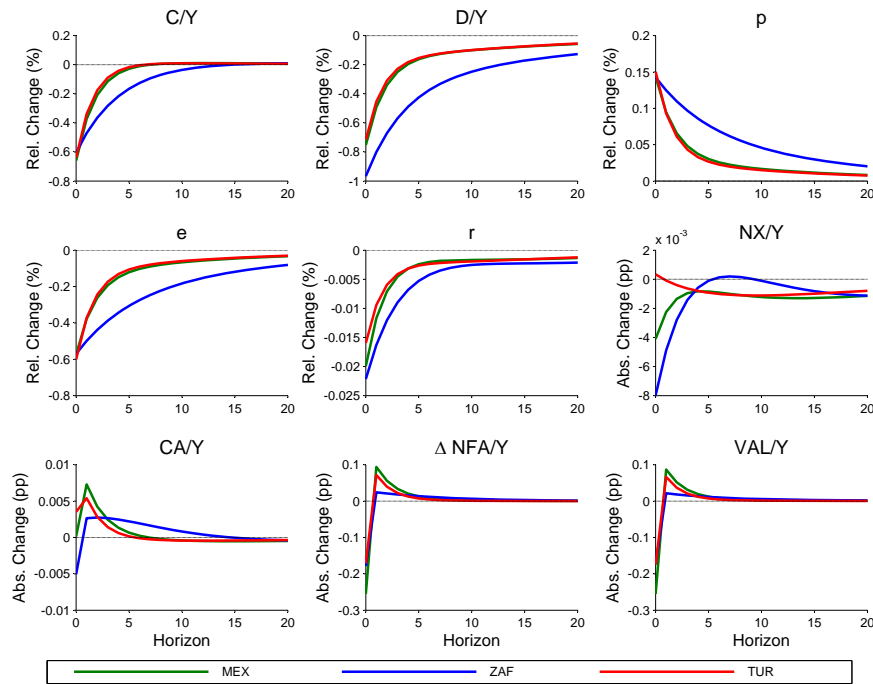
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Figure 6: Impulse Responses – Permanent Shock
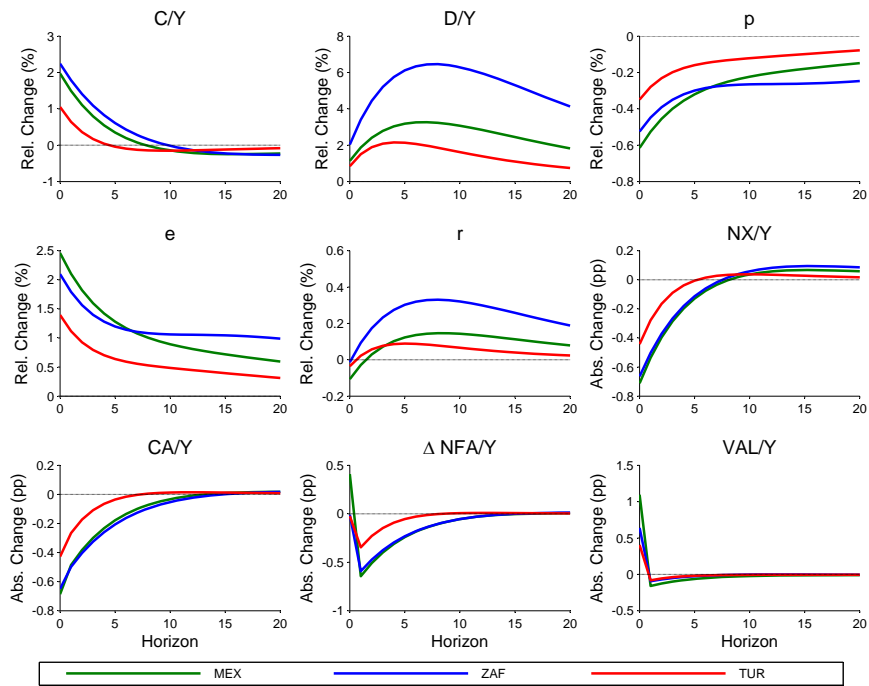
Notes: Impulse responses to a one percent permanent productivity shock in the model with liability dollarization for all EMEs evaluated at the median of the respective posterior distribution.

Figure 7: Impulse Responses – Transitory Shock

Notes: Impulse responses to a one percent transitory productivity shock in the model with liability dollarization for all EMEs evaluated at the median of the respective posterior distribution.

smoothing rationale also induces households to curb international borrowing, i.e. they save after a positive transitory shock, because income is expected to revert to its long–run equilibrium path in the future. As a result, consumption reacts less strongly than output such that $\frac{C}{Y}$ falls on impact.

A permanent shock also reduces the price of the composite consumption good p, whereas a temporary productivity innovation raises the price level. This can be explained as follows. Positive technology shocks lead to instantaneous jumps in income. As explained above, if shocks are permanent, people do not only benefit from higher income today but also anticipate even higher income in the future. Hence, households sharply raise their demand for home–produced goods (in form of consumption and investment) on impact. This increase in demand actually overshoots the initial rise in supply, which drives up the price of home–produced goods. As a consequence, the relative price of composite consumption expressed in terms of home–produced goods p falls. On the contrary, the initial increase in demand falls short of the one in supply after a transitory shock, such that the price of home–produced goods must decline in equilibrium and the relative price of total consumption p rises.

Due to imperfect substitutability between home and foreign goods the relative change of the domestic price of the foreign good p_F must always be stronger than the one of the price of the overall consumption index p. This follows immediately from the definition of the price index in equation (9). As a consequence, the real exchange rate in equation (14) appreciates (depreciates) following a positive trend (transitory) productivity shock.

The response of the real interest rate is in principle ambiguous. A higher expected debt to income ratio after a permanent shock puts an upward pressure on the interest rate. At the same time, however, the associated real appreciation reduces the debt burden, which dampens the increase in the interest rate. Interestingly, our results suggest that the real appreciation effect outweighs the debt to income ratio effect in the case of Mexico, while the effects largely offset each other in South Africa and Turkey. Regarding the reaction after a temporary productivity shock, we witness a fall in the real interest rate in all three countries.

Irrespective of its nature, a positive productivity shock induces households

to consume more. Consequently, consumption of both home and foreign goods goes up, too. As described above, the price of foreign goods relative to home goods p_F falls after a positive trend shock. This means that the rest of the world experiences a real depreciation and thus demands less goods produced in the home country $c_H^\star$ (see equation (15)). In sum, the home country exports less while at the same time the value of its imports increases such that net exports decline. In contrast, domestic exports rise after a transitory shock because of a real appreciation abroad. Hence, the increase in both imports and exports leave the overall impact on the trade balance unclear. In our exercise at hand, these two counteracting effects largely cancel out such that we observe a rather weak response of the net exports to output ratio.

The deterioration of the trade balance together with higher interest payments on foreign debt translates into a worsening of the current account to income ratio after a trend shock. Furthermore, the associated real appreciation reduces the amount of outstanding foreign debt and therefore initially generates positive valuation effects (see equation (26)). The change in the net foreign asset position in (22) is given by the sum of the current account and valuation effects. As a result, positive valuation effects in fact dampen the negative change in foreign assets induced by the fall in the current account. In the case of Mexico, these valuation effects exceed the drop in the current account such that the value of net foreign assets actually goes up on impact.

The response of $\frac{CA}{Y}$ to a transitory shock is slightly positive in Mexico and Turkey, but negative in South Africa. In Mexico, for instance, the fall in interest payments on foreign debt obligations more than compensates the deterioration of the trade balance such that there is a positive reaction of the current account. Likewise, the real depreciation leads to negative valuation effects, which have a negative impact on the net foreign asset position. What is striking is that these external balance sheet effects are strong enough to generate a fall in net foreign assets in countries where we observe an initial increase in the current account, namely Mexico and Turkey.

Foreign Demand Shock

Figure 8 displays impulse responses to a one percent increase in foreign consumption. By and large, outcomes do not vary substantially across countries.

Figure 8: Impulse Responses – Foreign Demand Shock
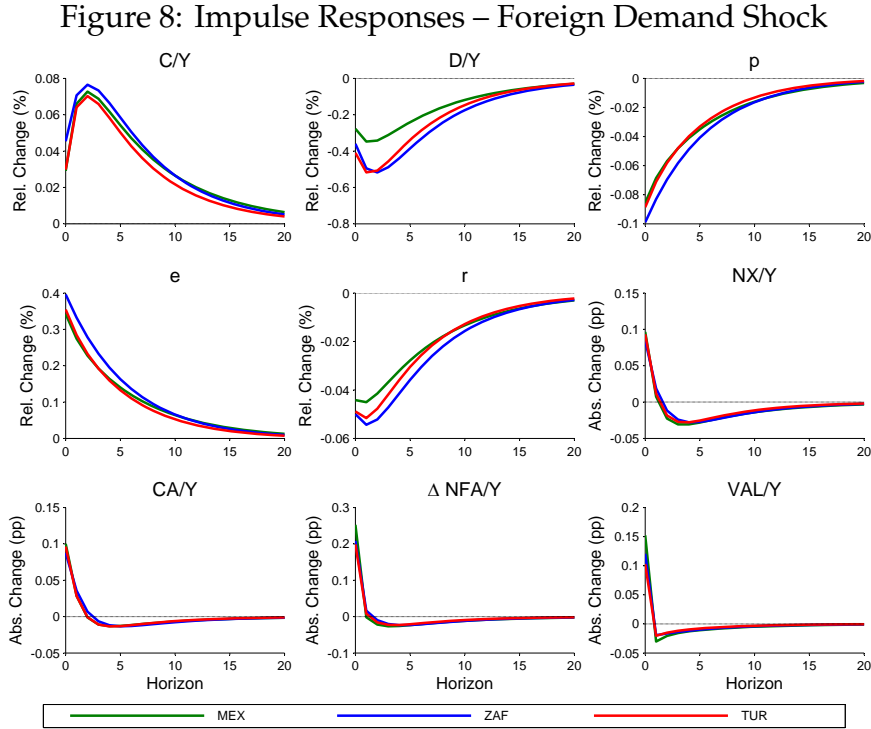
Notes: Impulse responses to a one percent foreign demand shock in the model with liability dollarization for all EMEs evaluated at the median of the respective posterior distribution.

A positive shock to foreign consumption $c^\star$ directly translates into a rise in domestic exports $c_H^\star$. Consequently, net exports increase on impact. Furthermore, higher demand for domestically produced goods, *ceteris paribus*, puts an upward pressure on the price of home goods such that the relative prices of foreign goods p_F and composite consumption p fall. Since the relative drop in p_F prevails the decrease in p, the real exchange rate appreciates.

The favorable movement in the real exchange rate entails a positive wealth effect, which induces domestic households to consume more. As a matter of fact, the relative increase in consumption c is larger than the one in output y such that the consumption to GDP ratio rises.[30] Also, households substitute consumption of

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[30]The increase in output initiated by higher foreign demand for home–produced goods is dampened by lower domestic absorption (i.e. lower domestic consumption of the home good and lower investment).

relatively more expensive home goods c_H for relatively cheaper foreign goods c_F. This somewhat dampens the positive reaction of the trade balance and explains its reversal in the periods after the shock.

In addition, the external debt to income ratio falls. Although consumption becomes cheaper, real appreciation drives up the price of consumption today expressed in units of consumption tomorrow (see equation (22)). Agents know that the demand shock is only temporary and anticipate a real depreciation in the future. Therefore, they have an incentive to save more, i.e they reduce their international debt holdings.[31] A lower $\frac{D}{Y}$, along with an appreciated real exchange rate, pushes down the real interest rate. The resulting cut in interest payments plus higher net exports lead to an increase in the current account, which in turn increases the domestic foreign asset position. Positive valuation effects, originated by real appreciation, eventually boost the improvement of the external balance sheet.

Stabilizing or Destabilizing Valuation Effects?

Our impulse response analysis illustrates that the impact of valuation effects on the net foreign asset position depends on the nature of the underlying shock. On the one hand, valuation effects mitigate the change in net foreign assets induced by the decline in the current account following a permanent productivity shock. Hence, they have a stabilizing impact on the external balance sheet in this case. On the other hand, valuation effects amplify the influence of the current account on net foreign assets after a foreign demand shock. Regarding transitory technology shocks, the effect is generally unclear. In our exercise, transitory productivity shocks entail external balance sheet effects that counteract the reaction of the current account in Mexico and Turkey, but reinforce it in South Africa. Having said this, our findings conflict with the implications of the model of Nguyen (2011), which predicts stabilizing (amplifying) valuation effects after a transitory (permanent) technology shock.

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[31]We can think of domestic households investing in foreign goods by reducing the amount of international debt. In other words, they go long in foreign goods.

6.3 Business Cycle Moments

In this subsection, we gauge our structural model's ability to reproduce various business cycle patterns. To this end, we simulate the respective model evaluated at the median of the posterior distributions for each country. We generate data covering a time span of 100 periods and subsequently compute various moments based on the detrended series of our variables. On the whole, we repeat this exercise 5,000 times. Table 6 compares empirical moments with their model generated counterparts, which correspond to the median across all simulations. Empirical moments are calculated using quarterly real data from the IFS, apart from those involving valuation effects for which only annual data from Lane and Milesi-Ferretti (2007) are available. All series, except for the net exports to output ratio and valuation effects, have been logged, seasonally adjusted and filtered using the HP filter with smoothing parameter 1,600.

Consistent with the data, the model predicts generally higher standard deviations of income, consumption, and the net exports to output ratio in EMEs than in advanced economies. Hence, our theoretical economy can well account for the empirical regularity that macroeconomic fluctuations are more severe in emerging markets as compared to developed countries.

Furthermore, the model is not only able to generate excess volatility in consumption relative to output in EMEs, but also matches relative consumption volatilities in advanced countries quite well. This observation raises the question of why? On the one hand, as shown in Section 6.1, our estimation results suggest that macroeconomic dynamics in EMEs are predominantly driven by the non–stationary productivity component. On the other hand, the preceding subsection has demonstrated that consumption overshoots output after a permanent technology shock. It is the interplay of these two features that explains the excess volatility of consumption.

Our model also succeeds in generating a negative correlation between the net exports to GDP ratio and income in EMEs. Yet it struggles to match this moment from a quantitative point of view. In fact, the model understates the countercyclicality of the net exports to output ratio in EMEs, but it also overstates

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this countercyclicality for the cohort of advanced economies, except Switzerland. Recall that permanent technology shocks induce households to purchase more foreign goods, while the real depreciation experienced by the rest of the world cuts the external demand for home goods. This leads to a deterioration of the home country's trade balance and explains why our model generates a negative correlation between the net exports to GDP ratio and income. The fact that we cannot replicate the high degree of countercyclicality of $\frac{NX}{Y}$ in EMEs is due to the relatively persistent non–stationary productivity process. Indeed, the higher the autocorrelation of the permanent technology process, the weaker the counter-cyclicality of the trade balance. As a matter of fact, if trend shocks are persistent enough, the income effect on labor supply induces households to work less after a positive permanent shock. In this scenario, output falls, which actually implies a positive correlation between income and net exports.[32]

Our model suggests that real exchange rates are in general more volatile in EMEs than in developed economies. This prediction is in line with what we observe in the data. Furthermore, the model reproduces the negative correlation between the real exchange rate and the net exports to output ratio in EMEs. In contrast, the benchmark model has difficulties in replicating the weak relationship between these two variables in the group of industrialized countries.

A key contribution of the paper by García-Cicco *et al.* (2010) is that their model can account for the empirically observed downward sloping autocorrelation function of $\frac{NX}{Y}$. Interestingly, our benchmark model exhibits a fairly low first–order serial correlation of the net exports to income ratio in developed economies, whereas the liability dollarization setup matches this moment better for EMEs. As García-Cicco *et al.* (2010) point out, it is important to allow for a ψ that is significantly different from zero in order to obtain a falling autocorrelation function of $\frac{NX}{Y}$. The reason for that is as follows. For instance, after a positive permanent shock, households increase their international debt holdings and run a trade balance deficit. In case of a high debt–elasticity ψ, the rise in debt relative to GDP

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[32]Accordingly, our model's weak performance regarding the countercyclicality of the trade balance might be explained by our preference specification. As we have already mentioned in Section 3, our choice of Cobb–Douglas period utility implies an income effect on labor supply. In contrast, other researchers in this strand of the literature use GHH preferences, which do not feature income effects on labor supply.

in turn raises the real interest rate. This induces households to consume less and save more, which leads to an improvement of the trade balance. On the other hand, if ψ is close to zero (as for example in the calibration of Aguiar and Gopinath 2007) the feedback effect of changes in $\frac{D}{Y}$ on the cost of borrowing is virtually shut down, which results in an autocorrelation function of $\frac{NX}{Y}$ that resembles a near unit root process. In fact, our estimates of ψ in the benchmark economy are quite high compared to our liability dollarization framework. This might help us to explain why the model understates the first–order autocorrelation of $\frac{NX}{Y}$, especially for advanced economies.

Table 6: Business Cycle Moments

	Data	Model	Data	Model	Data	Model
	EMERGING MARKET ECONOMIES					
	MEXICO		**S. AFRICA**		**TURKEY**	
$\sigma(Y)$	2.42	5.31	1.60	4.25	3.70	6.30
$\sigma(C)$	3.68	6.71	2.46	5.08	5.72	7.65
$\sigma(NX/Y)$	6.63	1.58	4.04	0.95	3.42	1.46
$\sigma(e)$	9.63	7.71	8.70	5.05	9.54	7.47
$\sigma(C)/\sigma(Y)$	1.52	1.57	1.54	1.41	1.55	1.45
$\rho(NX/Y,Y)$	−0.17	−0.10	−0.40	−0.19	−0.56	−0.27
$\rho(e,NX/Y)$	−0.31	−0.62	−0.12	−0.43	−0.45	−0.48
$\rho((NX/Y)_t,(NX/Y)_{t-1})$	0.97	0.69	0.85	0.67	0.84	0.57
$\rho((VAL/Y)_t,(CA/Y)_t)$	−0.58	−0.34	−0.75	−0.30	−0.05	−0.38
$\rho((VAL/Y)_t,e_t)$	0.45	0.29	−0.31	0.28	0.19	0.30
	DEVELOPED ECONOMIES					
	CANADA		**SWEDEN**		**SWITZERLAND**	
$\sigma(Y)$	1.42	4.13	1.75	4.57	1.76	3.68
$\sigma(C)$	1.36	4.12	1.51	4.00	1.44	3.11
$\sigma(NX/Y)$	1.96	0.54	2.77	0.45	3.74	0.65
$\sigma(e)$	3.41	5.34	8.81	4.61	7.94	5.53
$\sigma(C)/\sigma(Y)$	0.96	1.00	0.86	0.77	0.82	0.71
$\rho(NX/Y,Y)$	0.01	−0.36	−0.01	−0.39	−0.17	0.27
$\rho(e,NX/Y)$	−0.03	−0.21	−0.07	−0.14	−0.02	−0.59
$\rho((NX/Y)_t,(NX/Y)_{t-1})$	0.93	0.28	0.94	0.15	0.84	0.49

Notes: Standard deviations are expressed in percentages except for the model implied standard deviation of the net exports to output ratio, which is expressed in percentage points. Empirical moments are calculated using quarterly data taken from the IFS, apart from those involving valuation effects for which only annual data from Lane and Milesi-Ferretti (2007) are available. All series, except for the net exports over output ratio and valuation effects, are real per capita variables, have been logged, seasonally adjusted and filtered using the HP filter with smoothing parameter $\lambda = 1,600$. Theoretical moments are based on sample moments of model generated data. For the group of EMEs, we have used the liability dollarization framework. Each theoretical economy is simulated 5,000 times with a sample size of 100. Median outcomes are reported.

Table 6 also provides meaningful insights with respect to the role of valuation effects in EMEs. Not surprisingly, they are positively correlated with the real exchange rate in our model. This feature is consistent with our descriptive findings for Mexico and Turkey. More importantly, our model predicts a negative relationship between valuation effects and the current account in all three EMEs. As a matter of fact, this is line with the negative correlation between $\frac{VAL}{Y}$ and $\frac{CA}{Y}$ in the data, especially for Mexico and South Africa. Consequently, we find that, on average, valuation effects have a stabilizing impact on the net foreign asset position. In light of our discussion in Section 6.2, this outcome can be explained by the fact that EMEs are predominantly exposed to trend shocks.

6.4 Mexico's Tequila Crisis

Finally, we investigate the performance of our model in crisis times. Over the last two decades, many EMEs have experienced severe balance of payments (BOP) crises, such as Mexico during the Tequila crisis of 1994–1995; Indonesia, Korea, Malaysia, the Philippines, and Thailand during the Asian crisis of 1997; or Argentina in 2001. A typical feature of BOP crises in emerging markets is the sudden stop in capital inflows, which usually brings about a reversal in current accounts and net exports, a drop in output, consumption, and investment, as well as exchange rate depreciations (see Mendoza (2010)).

In what follows, we examine whether our theoretical framework is capable of replicating Mexico's sudden stop during the Tequila Crisis of 1994–1995. To do so, we adopt a similar approach as in Aguiar and Gopinath (2007). We calibrate our liability dollarization model at the median of the posterior distributions for Mexico. We use data on output, consumption, real interest rates, and real exchange rates and implement the Kalman filter to generate the unobservable state variables. Subsequently, we feed the obtained states into the model to compute time series for our control variables.

Figure 9 shows the true and predicted net exports to output ratio in Mexico between 1993Q1 and 1997Q4. As is evident from the figure, our model can reproduce the reversal in the Mexican trade balance between 1994 and 1995. At

a first glance, however, our model seems to struggle to quantitatively match the dramatic change in $\frac{NX}{Y}$. It predicts an increase in the net exports to output ratio by 2.2 percentage points between the third quarter of 1994 and the second quarter of 1995, whereas the actual net exports to output ratio increased by as much as 7.7 percentage points. Note, however, that the steady state level of the trade balance to GDP ratio is much lower than its empirical counterpart.[33]. If we look at the change of $\frac{NX}{Y}$ relative to its long–run mean rather than the absolute change, we actually find that our model performs quite well also from a quantitative point of view.

Figure 9: Mexico's Tequila Crisis of 1994–1995
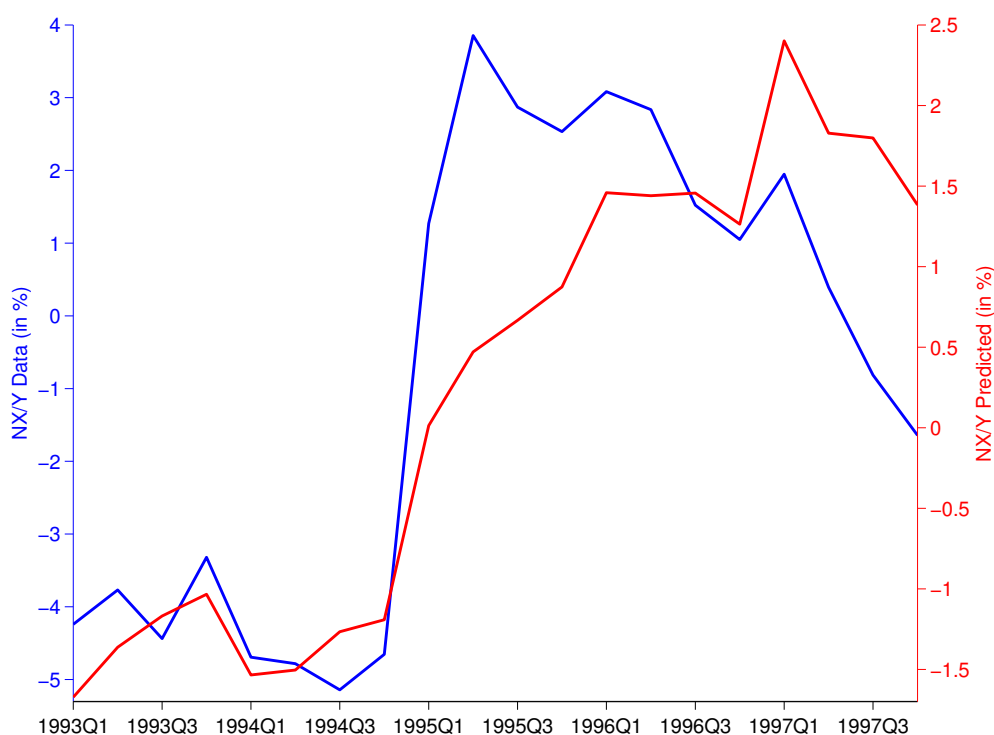
Notes: Actual versus predicted net exports to output ratio for the Mexican economy between the first quarter of 1993 and the fourth quarter of 1997.

The remaining question is then why does our framework succeed in explaining the sudden stop in capital flows. The shock series produced by the Kalman filter indicate that the Mexican economy was hit by a strong negative permanent shock in the fourth quarter of 1994. As we have discussed in Section 6.2, a negative

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[33]Recall from Section 4.2 that we do not pin down the steady state net exports to output ratio in our calibration exercise.

trend shock leads to an increase in the net exports to output ratio. In addition, a large negative permanent shock causes a sharp fall in output and consumption, as well as a real depreciation, which is also in line with what we observe in the data. What is more, our liability dollarization model suggests that sudden stops are associated with negative valuation effects. As a result, balance sheet effects actually dampened the increase in Mexico's net foreign asset position during the Tequila crisis according to the model.

7   Conclusion

We develop a small open economy DSGE model featuring a non–stationary productivity process, differentiated home and foreign goods, and endogenous exchange rate movements to study the importance of financial frictions and trend shocks in explaining macroeconomic dynamics in EMEs. We also extend our benchmark setup and introduce liability dollarization as a special form of financial market distortions in emerging markets. This model modification allows us to analyze the impact of valuation effects on the external balance sheet in these countries.

In the empirical part of the paper, we estimate our model using Bayesian techniques for a group of EMEs. Furthermore, in order to investigate the difference between emerging and advanced economies, we perform our estimation exercise also for a group of developed countries. We account for off–model dynamics by allowing for a (vector–)autoregressive measurement error in our estimation procedure. As a matter of fact, this constitutes to a novel approach in this strand of the literature.

Our results show that the co–existence of financial frictions and trend shocks helps to explain macroeconomic dynamics in EMEs. In particular, incorporating liability dollarization in our framework improves the model fit. Our analysis suggests that trend shocks are the driving force behind macroeconomic fluctuations in EMEs. Therefore, we find support for the famous hypothesis that *"the cycle is the trend"*, even though we include financial market distortions in our setup.

Our liability dollarization model succeeds in replicating certain stylized facts

about emerging market business cycles: (i) it predicts more severe macroeconomic fluctuations in EMEs than in developed countries, (ii) it matches the excess volatility of consumption relative to output, (iii) it qualitatively reproduces the countercyclicality of the net exports to output ratio, although it falls short to match this moment on a quantitative basis, and (iv) it can replicate the sudden stop of capital inflows during the Mexican Tequila Crisis between 1994 and 1995. Interestingly, our liability dollarization framework suggests that valuation effects on average have a stabilizing impact on the net foreign asset position in EMEs. In this vein, we also contribute to a currently active line of research on external balance sheet effects, which so far has mainly focused on developed economies.

Admittedly, the introduction of liability dollarization as a from of financial frictions in our model is fairly simple. One could go one step further and study the implications liability dollarization in the presence of other credit market distortions. In particular, we could build on the literature on credit frictions in macroeconomics (see Kiyotaki and Moore 1997, Bernanke *et al.* 1999) and incorporate collateral constraints in the model. In that case, the amount of debt depends on the agent's net worth, which is subject to exchange rate variations due to liability dollarization. It would then be interesting to see how the combination of amplification effects, resulting from the imposition of collateral constraints, and liability dollarization affects macroeconomic dynamics in EMEs.

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