Business Cycles in Emerging Markets: the Role of Liability Dollarization and Valuation Effects*

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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 have 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 among 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) trend shocks are the main determinant of macroeconomic fluctuations, (ii) accounting for liability dollarization ameliorates the model fit, and (iii) valuation effects are on average stabilizing.

Keywords: Emerging Markets, Liability Dollarization, Valuation Effects, Financial Frictions, Real Business Cycles, DSGE Model, Bayesian Estimation.

JEL Classification: E13, E44, F32, F34, F41, F44, F47, O11.

1 Introduction

Over the last two decades, Emerging Market Economies (EMEs) have accounted for an ever increasing share of world output and are catching up to the rich world at a remarkable pace. Waves of financial liberalization and integration throughout the globe not only have promoted this development, but also led to a substantial growth of external balance sheets. Furthermore, the currency composition of foreign assets and liabilities opens additional channels through which exchange rate fluctuations affect macroeconomic dynamics in emerging markets. What is striking, business cycles in these countries reveal remarkably different patterns compared to developed economies. This naturally raises the questions of why do we observe these discrepancies and what is the role of exchange rate movements in this context.

In recent years, a large body of research in international macroeconomics has been devoted to studying business cycle fluctuations in EMEs. This literature highlights that there are certain empirical regularities among these countries. In particular, EMEs are generally exposed to more severe business cycle fluctuations than their developed counterparts. Their net exports tend to be strongly countercyclical and consumption volatility exceeds income volatility (Aguiar and Gopinath, 2007a; García-Cicco *et al.*, 2010). In addition, Neumeyer and Perri (2005) and Uribe and Yue (2006) find that real interest rates are countercyclical and lead the cycle.

In this paper, we use a Dynamic Stochastic General Equilibrium (DSGE) framework to address these business cycle phenomena and the importance of credit market imperfections in EMEs. The basic structure of our underlying small open economy model goes back to Mendoza (1991) and Schmitt-Grohé and Uribe (2003). Following Aguiar and Gopinath (2007a), our theoretical economy features both a transitory and a permanent productivity shock. Similar to García-Cicco *et al.* (2010) and Chang and Fernández (2010), we also augment our benchmark model with financial frictions. In particular, we incorporate credit market imperfections characterized by a debt–elastic country premium on the interest rate. Indeed, this reduced form financial friction is a convenient way to account for a positive impact of higher external indebtedness on borrowing costs, which seems to be empirically plausible (Uribe and

Yue, 2006; Arellano, 2008). Moreover, we would like to add to the existing literature by introducing differentiated home and foreign goods as well as exogenous foreign demand shocks. In this vein, we allow for endogenously determined real exchange rate fluctuations.

A major contribution of our work is that we also analyze the phenomenon of liability dollarization in our theoretical framework. In contrast to advanced economies, international capital market imperfections impede EMEs to issue debt denoted in their own currency. As a result, these countries hold the bulk of their external debt in major international currencies such as U.S. 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 (Reinhart *et al.*, 2003; Eichengreen and Hausmann, 2005; Lane and Shambaugh, 2010). For that reason, we extend our benchmark model and assume that the small open economy can only borrow in foreign currency. By doing so, we introduce a further form of financial friction in our setup along with a debt–elastic interest rate. More importantly, our extended model highlights the potential role of valuation effects, which, though investigated in other areas (Céspedes *et al.*, 2004; Nguyen, 2011), has been hitherto unrecognized in this line of research.

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 conclusion for EMEs in general. 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. For this purpose, we take data on output, consumption, interest rates, exchange rates, and debt to GDP ratios. A substantial contribution of our work is that we capture off–model dynamics in our estimation. Accordingly, we follow Sargent (1989) and Ireland (2004) by including a (vector–)autoregressive measurement error component. In fact, this goes beyond the procedure applied by existing studies in this strand of the literature. Besides, we additionally estimate the 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.

Our findings suggest that the interplay of financial market imperfections and trend shocks play a non–negligible role for explaining business cycle patterns in emerging markets. For all 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, results differ significantly for developed economies. In particular, it is transitory productivity shocks, which determine output fluctuations over all horizons. On the one hand, our results support the hypothesis by Aguiar and Gopinath (2007a) and Aguiar and Gopinath (2007b) that *"the cycle is the trend"* in emerging markets. On the other hand, they contradict García-Cicco *et al.* (2010), who find that once one incorporates financial frictions in the framework, the permanent shock strongly loses importance. Nevertheless, our paper underpins the findings of a closely related area of the empirical macroeconomic research. Employing the simple model of the intertemporal approach to the current account as an identification device, this literature highlights the importance of permanent shocks in explaining current account dynamics (Glick and Rogoff, 1995; Hoffmann, 2001, 2003, 2013). 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.

Estimation results suggest that financial frictions are generally more pronounced in EMEs than in industrialized countries, which corroborates the finding of García-Cicco *et al.* (2010). Moreover, off–model dynamics appear to be of minor importance for the dynamics of macroeconomic aggregates in general. This result represents a strong argument in favor of our structural models' ability in fitting the data. More importantly, the model featuring liability dollarization in EMEs not only improves the overall fit of the model, but also ameliorates the performance of the structural model in matching key business cycle moments of interest.

Our paper 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 (Gourinchas and Rey, 2007a,b; Lane and Milesi-Ferretti, 2007; Gourinchas *et al.*, 2010). These so–called valuation effects 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 domestic currency, our model yields further interesting insights with respect to the role of external balance sheet effects. In particular, we find that valuation effects are stabilizing after a trend shock. That is, positive trend shocks lead to a decrease in the current account as well as a domestic real appreciation. Since debt is denominated in foreign currency, an appreciation entails positive valuation effects. This in turn mitigates the impact on the net foreign asset position induced by changes in the current account. On the other hand, foreign demand and transitory productivity shocks yield de–stabilizing effects. Interestingly, this finding challenges to some extent the results by Nguyen (2011), who argues that transitory (permanent) technology shocks lead to stabilizing (amplifying) valuation effects in advanced economies. All in all, given that EMEs are characterized by a prevalence of trend shocks, we find that valuation effects act stabilizing on average.

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 use later to investigate macroeconomic dynamics in EMEs, we take a look at some descriptive statistics first. On the one hand, this section sheds light on distinct empirical regularities about business cycles in EMEs contrary to industrialized countries. To this end, we calculate standard business cycle moments of selected EMEs and compare them with those obtained for a group developed small open economies. On the other hand, we document the stabilizing nature of valuation effects in EMEs.

2.1 Business Cycle Features

The term "Emerging Market" was originally introduced by Antoine van Agtmael several decades ago, 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 BRIC and CIVETS countries as well as several selected economies from the Dow Jones list of emerging markets.

At this point, we use annual data from the International Financial Statistics (IFS) on output, consumption, exports, imports, and the real exchange rate.[1] The choice of annual rather than higher frequency time series enables us to investigate a longer time horizon. Nevertheless, we did the same exercise using quarterly data and found no significant difference with respect to business cycle patterns documented here. 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 the 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 but 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.[2]

Descriptive sample statistics are displayed in Table 1. Various stylized business cycle facts are worth emphasizing.[3] First, fluctuations in macroeconomic aggregates

[1]We use real exchange rates vis–à–vis the U.S.

[2]We are aware of the potential pitfalls associated with this specific 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. Our results suggest that business cycle moments reported here are not substantially sensitive to the choice of the filter.

[3]We confidently call certain business cycle patterns as "stylized facts" because they have already

Table 1: Business Cycles in EMEs and Developed Economies

	$\sigma(Y)$	$\sigma(C)$	$\sigma\left(\frac{NX}{Y}\right)$	$\sigma(e)$	$\frac{\sigma(C)}{\sigma(Y)}$	$\rho\left(\frac{NX}{Y}, Y\right)$	$\rho(e, Y)$	$\rho\left(\frac{NX}{Y}, e\right)$
BRIC								
Brazil (BRA)	2.93	12.17	2.42	21.67	4.16	−0.30	0.34	−0.37
Russia (RUS)	5.64	8.51	4.80	17.79	1.51	−0.28	0.38	−0.75
India (IND)	2.16	4.00	1.37	6.13	1.85	−0.13	0.14	−0.32
China (CHN)	3.11	3.55	2.76	7.85	1.14	0.08	0.25	0.00
Mean	3.46	7.06	2.84	13.36	2.17	−0.16	0.28	−0.36
CIVETS								
Colombia (COL)	2.65	4.70	3.44	11.50	1.78	−0.27	0.58	−0.50
Indonesia (IDN)	3.89	4.80	3.47	15.58	1.23	−0.37	0.68	−0.28
Vietnam (VNM)	1.29	2.15	4.15	6.46	1.67	−0.50	0.44	−0.54
Egypt (EGY)	1.88	2.83	4.07	22.57	1.51	−0.42	0.62	−0.54
Turkey (TUR)	4.11	6.10	2.81	9.99	1.49	−0.66	0.68	−0.68
South Africa (ZAF)	2.02	3.35	3.70	10.94	1.66	−0.47	0.07	−0.21
Mean	2.64	3.99	3.61	12.84	1.56	−0.45	0.51	−0.46
Dow Jones List								
Argentina (ARG)	5.67	10.32	3.75	30.96	1.82	−0.76	0.26	−0.29
Chile (CHL)	5.55	7.66	36.56	19.77	1.38	−0.26	0.52	0.09
Malaysia (MYS)	3.82	6.06	9.80	7.33	1.58	−0.37	0.67	−0.31
Mauritius (MUS)	4.01	7.14	5.87	7.49	1.78	−0.23	0.33	−0.40
Mexico (MEX)	3.26	5.76	3.21	11.15	1.77	−0.27	0.72	−0.65
Morocco (MAR)	3.02	3.08	4.20	9.97	1.02	−0.06	0.27	−0.03
Thailand (THA)	4.13	4.31	5.50	7.10	1.04	−0.54	0.67	−0.38
Mean	4.21	6.33	9.84	13.40	1.48	−0.36	0.49	−0.28
Mean EMEs	3.48	5.68	5.99	13.19	1.67	−0.34	0.45	−0.36
Developed								
Australia (AUS)	1.66	1.40	1.26	8.54	0.84	−0.10	−0.07	0.07
Austria (AUT)	1.57	2.08	2.30	11.72	1.32	0.00	0.26	−0.13
Canada (CAN)	2.19	2.24	1.94	4.97	1.02	0.03	0.07	−0.37
Sweden (SWE)	2.12	2.21	3.12	9.80	1.04	−0.03	0.12	−0.14
Switzerland (CHE)	2.21	1.89	3.60	11.40	0.86	−0.16	−0.06	0.05
Mean	1.63	1.64	2.04	7.74	0.85	−0.04	0.05	−0.09

Notes: Data are annual and taken from the IFS. All series, except for the net exports over 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.

in EMEs are generally more pronounced than in developed economies. For instance, regarding our selected countries on the Dow Jones list, the average standard deviation of all variables is at least twice as high as in the group of industrialized economies. This observation is also underpinned in Figure 1, which plots the cyclical component of GDP for each group of countries. Moreover, the graph suggests that the "Great Moderation" of macroeconomic variability in the industrialized world from the early 1980s until the mid 2000s seems to be absent in most of our EMEs.[4] Second, consumption volatility exceeds output volatility. In contrast, standard deviations of consumption and output seem to be roughly the same for the majority of developed countries. Third, the net exports to output ratio tends to be fairly countercyclical. The mean correlation of GDP and the net exports to output ratio is as much negative as -0.45 for CIVETS countries, whereas advanced economies exhibit a rather weak relation between these variables.

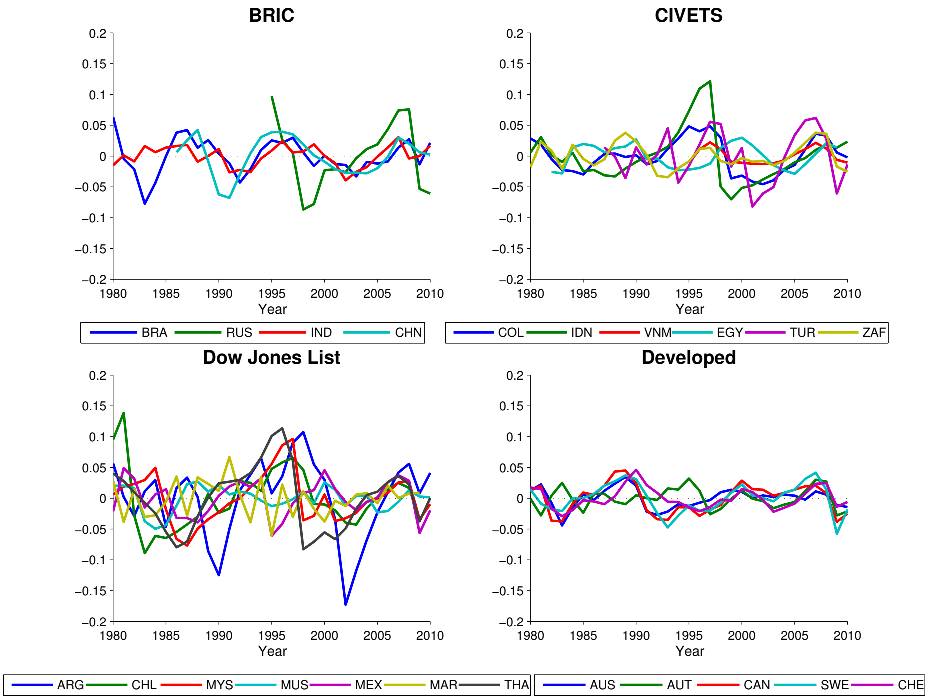
Previous contributions in this line of research have not focused on business cycle features of the real exchange rate. In fact, we observe that they are different for EMEs compared to developed economies. First, real exchange rate volatility is higher in EMEs than in developed economies. Moreover, they tend to be procyclical in EMEs as opposed to the developing world, in which there exists at most a very weak positive correlation between output and the real exchange rate. Likewise, only a slightly negative correlation between the net exports to output ratio and the real exchange rate can be found in industrialized countries, whereas this negative relationship is more pronounced in the emerging world.

Although the empirical regularities documented here are very robust, we can still detect minor differences both within and across country categorizations. In particular, the degree of countercyclicality of the net exports to output ratio varies substantially across countries. For instance, 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 are detected regarding the excess

been documented in a number of earlier studies. See among others, Neumeyer and Perri (2005), Aguiar and Gopinath (2007a), García-Cicco *et al.* (2010), and Kose and Prasad (2010).

[4]See Summers (2005) for cross–country evidence on the decline in macroeconomic volatility in the industrialized world. A comprehensive overview on the causes and implications of the "Great Moderation" can be found in Stock and Watson (2002).

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.

volatility of consumption. In Mexico, standard deviation of consumption is almost twice as high as standard deviation of GDP. Conversely, there is practically no excess volatility of consumption in Thailand or Morocco. Moreover, exchange rates tend to be strongly procyclical in Turkey, while that is not necessarily the case for South Africa. Similar differences exist regarding the correlation of net exports with the real exchange rate. While in Mexico a real depreciation is attended by positive net exports, this comovement cannot be observed in China, where no correlation exists.

So far, some studies have analyzed these business cycle phenomena in emerging markets, but predominantly focussed on Latin American countries. Especially, Argentina (Kydland and Zarazaga, 2002; Neumeyer and Perri, 2005; García-Cicco *et al.*, 2010) and Mexico (Aguiar and Gopinath, 2007a; Chang and Fernández, 2010) have been at the center of previous research. Given our observed heterogeneity in the descriptive statistics, we would like to contribute to the existing literature by investigating a broader selection of countries of which some have not yet been assessed intensively. In the empirical exercise of our paper, we therefore look at the emerging markets of Mexico, South Africa, and Turkey and compare them to Canada, Sweden, and Switzerland representing developed small open economies in our analysis.

2.2 Valuation Effects

To analyze valuation effects 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, retrieved from Lane and Milesi-Ferretti (2007). We use foreign debt instead of net foreign assets, because it is the counterpart to the net foreign asset position in our theoretical model introduced below.[5] Also, we take current account data from the IFS and calculate valuation effects simply as the difference between the change in the foreign debt position and the current account, both as a percentage of current GDP.[6]

Figure 2 portrays the resulting annual valuation effects as well the current account. The graph indicates that there is a negative relationship between the current account and valuation effects. The sample correlation between these variables is -0.58, -0.75, and -0.05 for Mexico, South Africa, and Turkey, respectively. In fact, this result highlights a potential stabilizing nature of valuation effects, especially in Mexico and South Africa. In these countries, a current account deficit is associated with positive valuation effects, which actually dampens the deterioration of the net foreign asset position.

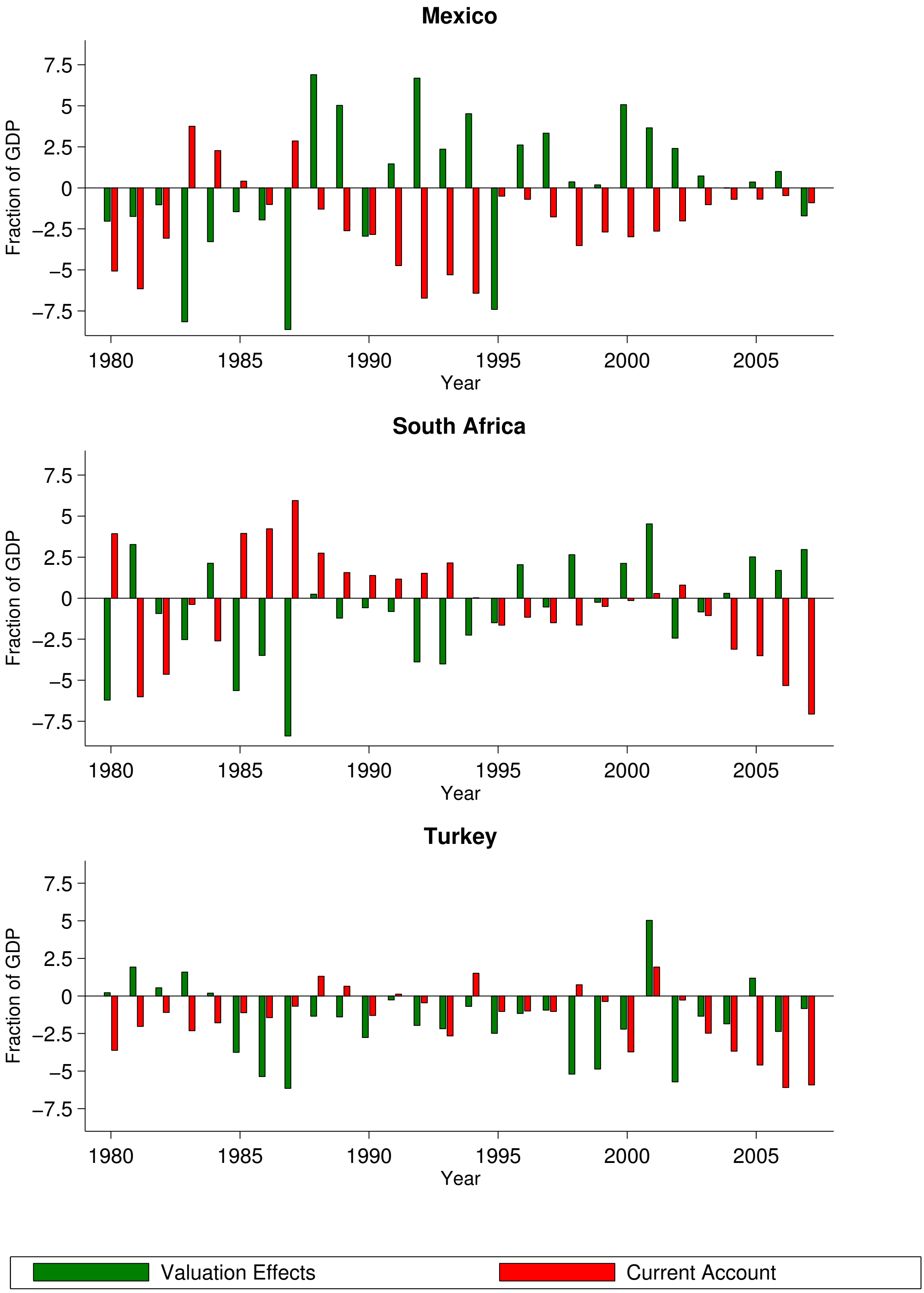
3 The Model

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 house-

[5]Note that foreign liabilities on average account for more then three quarters of the total external balance sheet in our countries under investigation. Consequently, the time series of the net foreign asset position and foreign liabilities are positively correlated. Notwithstanding, we have also performed this exercise based on the net foreign asset position and found no qualitative differences in our results.

[6]Lane and Milesi-Ferretti (2007) point out that differences between the change in the net foreign asset position and the current account may also be ascribed to other factors than valuation effects like errors or omissions in the data. Therefore, we have to be careful with interpreting the magnitude of valuation effects computed here. Nevertheless, we are confident that part of the changes in the net foreign asset position not captured by the current account is indeed due to "pure" 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 change in foreign liabilities. Data on the net foreign asset position are retrieved from Lane and Milesi-Ferretti (2007), while current account data are taken from the IFS database.

holds. 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 (2007a). In particular, production technology features both a permanent and a transitory stochastic 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 extend our framework and assume that the domestic economy can only borrow in foreign currency on international capital markets. Section 3.3 provides a summary of each model and specifies the technique we apply to solve them for estimation and later analysis. An extensive description of both model versions including the set 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:

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

On the other hand, we build on Aguiar and Gopinath (2007a) and assume that the producing economy is not only hit by transitory shocks, but also by trend shocks. For this reason, we include a non–stationary labor augmenting component of total factor productivity represented by Γ_t, which equals the cumulative product of growth shocks:

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

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 $|\rho_z|, |\rho_g| < 1$ 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 can then be described by the following law of motion:

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

The last term in (4) introduces quadratic capital adjustment costs, 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

$$\mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(C_t, 1 - l_t), \tag{5}$$

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 (2007a) and assume that preferences are described by a canonical Cobb–Douglas Constant Relative Risk Aversion (CRRA) utility function:[7]

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

where σ is the inverse of the elasticity of intertemporal substitution and governs the degree of relative risk aversion, and $\gamma \in (0,1)$ determines the consumption weight in utility.[8]

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

[7]This functional form of instantaneous utility, non–separable in consumption and leisure, ensures that substitution and income effects of real wage changes on labor cancel out in the deterministic equilibrium. Therefore, it is consistent with a balanced growth path (King *et al.*, 1988). A number papers in this strand of the literature use a quasi–linear period utility function pioneered by Greenwood *et al.* (1988), which rules out any income effects on labor supply (see for instance Mendoza (1991), Neumeyer and Perri (2005), García-Cicco *et al.* (2010), or Chang and Fernández (2010)).

[8]Note that the Arrow–Pratt measure of relative risk aversion corresponds to $(\sigma\gamma + 1 - \gamma)$.

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 trend, they 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:

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

Now, we can return to the optimization rationale of the representative agent stated in (5). It consists of two stages. First, *intratemporal* household optimization yields demand functions for the home and foreign consumption good of

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

and

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

respectively, and determines a consumption price index given 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

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

$$\text{s.t.}$$

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

taking as given k_t, d_t, as well as the transversality condition $\lim_{j\to\infty} \mathrm{E}_t \left(\frac{d_{t+j}}{\prod_{s=0}^{j}(1+r_s)}\right) = 0$. Solution to this problem renders the following optimality conditions:

$$\mathrm{E}_t\left[\frac{c_{t+1}}{c_t}\left(\frac{c_t^\gamma(1-l_t)^{1-\gamma}}{c_{t+1}^\gamma(1-l_{t+1})^{1-\gamma}}\right)^{1-\sigma}\right] = g_t^{\gamma(1-\sigma)-1}\beta \cdot$$
$$\mathrm{E}_t\left[\frac{p_t\Big(\alpha\frac{y_{t+1}}{k_{t+1}} + (1-\delta) + \phi\Big(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\Big)g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \frac{\phi}{2}\Big(g_{t+1}\frac{k_{t+2}}{k_{t+1}} - \mu_g\Big)^2\Big)}{p_{t+1}\Big(1+\phi\Big(g_t\frac{k_{t+1}}{k_t} - \mu_g\Big)\Big)}\right], \tag{10}$$

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

and

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

Equations (10) and (11) represent the intertemporal Euler Equations regarding 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:

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

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 closes 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 next period $\mathrm{E}_t\left[\frac{D_{t+1}}{Y_{t+1}}\right]$. 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 if it is expected to face high debt relative to the size of its economy in the future.[9]

In our benchmark setup, we follow García-Cicco *et al.* (2010) and interpret ψ as a catchall parameter for financial frictions and financial development. It determines the extent of capital market imperfections in the economy, i.e. a high value of ψ implies that the interest rate reacts more sensitively to changes in the expected future debt to GDP ratio.[10] 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, we let ψ take on values that are substantially greater than zero and thereby allow for variation in the interest rate which entails important implications

[9]Indeed, 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 demonstrates how higher indebtedness increases the probability of default and thus raises the interest rate. Furthermore, a large body of empirical research has emphasized the importance of a country's external debt in explaining interest rate spreads (Uribe and Yue, 2006). In light of this, we think of our interest rate rule as a nice approach to capture such credit market imperfections in a simple manner even though it leaves out an endogenous explanation within the model.

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

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

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 $\psi \cdot r \cdot \frac{d}{y}$. More specifically, parameter ψ determines by how many percentage points the interest rate at date t increases if, *ceteris paribus*, the expected debt to income ratio in period $t+1$ rises by one percentage point.

for the dynamics in our model.[11]

Exchange Rate

The household's optimization problem abroad is analogous to the home country. Since we deal with a small open economy 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 that the consumption index of agents abroad is also characterized by a CES aggregate. Moreover, variables in the domestic economy and the rest of the world share a common 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

[11] ψ needs to be positive to induce stationarity. However, among others, Aguiar and Gopinath (2007a) 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 (García-Cicco *et al.*, 2010).

home good, from the perspective of the home country, as

$$c^{\star}_{H,t} = \theta^{\star} p^{\eta^{\star}}_{F,t} c^{\star}_{t}, \tag{15}$$

with $\theta^{\star} \in (0,1)$ denoting the share of home goods in foreign consumption, and $\eta^{\star} \in (0,\infty)$ being 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, current account is given by the sum of negative interest payments on external debt and the trade balance:

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

As in the standard model of the "intertemporal approach to 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 process of the form

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

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.

3.2 Liability Dollarization

An extensive literature documents that developing countries and EMEs have difficulties to borrow in their own currencies on international capital markets.[12] In fact, the bulk of external debt in these countries is issued in major currencies like U.S. Dollar, Euro, Sterling, or Swiss Francs (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 and introduce valuation effects.

The basic structure of the model with liability dollarization coincides with our benchmark model. Thus, most of equations and optimality conditions from Section 3.1 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

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

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

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

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). This attributes an important role to exchange rate fluctuations for the optimal intertemporal consumption allocation of the representative household.

[12] See, for instance, contributions in Eichengreen and Hausmann (2005).

In addition, our interest rate rule modifies to

$$r_t = r + \psi\left(\exp\left(\mathrm{E}_t\left[\frac{D_{t+1}}{e_{t+1}Y_{t+1}}\right] - \frac{D}{eY}\right) - 1\right). \tag{23}$$

It is worth highlighting 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)). The fact that countries can only borrow in foreign currency itself represents a special form of capital market imperfections. Thus, in the model at hand, we can encompass the extent of financial frictions by the interplay of liability dollarization and debt–elastic interest rates.[13]

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 corrected for valuation effects originated by exchange rate changes. First, we can write the detrended current account as

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

Next, we derive the change in detrended net foreign assets as

$$\begin{aligned}
& \Delta nfa_t = -g_t\frac{d_{t+1}}{e_t} + \frac{d_t}{e_{t-1}} && (25)\\
\stackrel{(21)}{\Longleftrightarrow}\quad & \Delta nfa_t = y_t - p_t c_t - i_t - r_{t-1}\frac{d_t}{e_t} + \frac{d_t}{e_{t-1}} - \frac{d_t}{e_t} \\
\stackrel{(19)}{\Longleftrightarrow}\quad & \Delta nfa_t = c^{\star}_{H,t} - p_{F,t}c_{F,t} - r_{t-1}\frac{d_t}{e_t} + d_t\left(\frac{1}{e_{t-1}} - \frac{1}{e_t}\right) \\
\stackrel{(16)}{\Longleftrightarrow}\quad & \Delta nfa_t = nx_t - r_{t-1}\frac{d_t}{e_t} + d_t\left(\frac{1}{e_{t-1}} - \frac{1}{e_t}\right) \\
\stackrel{(24)}{\Longleftrightarrow}\quad & \Delta nfa_t = ca_t + val_t.
\end{aligned}$$

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

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

Similar to the benchmark case, the effective debt–elasticity of the interest rate is defined as $\psi \cdot r \cdot \frac{d}{ey}$.

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

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

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 19 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, Δnfa_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), (18), (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, Δnfa_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).

We use a first–order approximation of the respective model solution and log–linearize each 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 by using the method proposed by Klein (2000). The solution yields a state space representation of the form

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

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 by driven 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 $(m \times x)$. This representation enables us to estimate the structural parameters of the model using country–specific data, which will be described in detail in the next section.

4 Estimation and Calibration

To gauge our models' potential in mimicking business cycle patterns in EMEs and developed economies, we next assign parameter values. To this end, we quantify our theoretical economy for both a group of EMEs, consisting of Mexico, South Africa, and Turkey, as well as a cohort of developed small open economies, represented by Canada, Sweden, and Switzerland. In particular, we choose a mixture of country–specific calibration and Bayesian estimation to make the framework accessible to empirical analysis. Given our focus on the potential 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 our benchmark framework.

4.1 Data

The time unit t in our theoretical economies 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 seasonally adjusted and taken from the IFS database. Our selection of countries and sample period is purely motivated by data availability and comparability to existing literature. Table 2 summarizes the sample period 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
Variables used for estimation: Real GDP p.c., real consumption p.c., real interest rates, and real exchange rates.			

Notes: All data are taken from the IFS database.

To calculate real per capita variables, we divide the respective nominal series by population and subsequently deflate using the GDP deflator for output and the CPI for consumption. 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 described in 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.[14] Expected inflation is calculated as the average of actual inflation today 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 exchange rate to the U.S. Dollar (U.S. Dollar per national currency) by the domestic CPI and dividing by the U.S. 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 values of our calibrated parameters. A set of structural parameters we keep constant across all countries and choose conventional values suggested by the literature. By doing so, we retain a high degree of comparability with previous contributions. In particular, we follow Aguiar and Gopinath (2007a) 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 (Obstfeld and Rogoff, 2000). We assume that the price elasticity of goods is the same all over the world and

[14]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 U.S. 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 behaviour of a domestic representative agent as opposed to an international investor.

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).

In order to account for potential heterogeneity across countries, we decide to calibrate two parameters country–specifically. The mean of the non–stationary productivity process μ_g is calibrated at the average quarterly gross growth rate of real per capita GDP. What is more, we use data on annual net foreign asset positions over the period from 1970 to 2007 collected by Lane and Milesi-Ferretti (2007), to calculate an external debt over GDP ratio $\frac{d}{y}$ of 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.

Table 3: Calibrated Values

	General Parameters				
β	discount factor	0.98	θ	domestic share of home goods	0.80
γ	consumption weight in utility	0.36	$\theta^\star$	foreign share of home goods	0.20
σ	curvature of utility	2.00	η	domestic elast. of intratemp. subst.	1.00
ϕ	weight of adjustment costs	4.00	$\eta^\star$	foreign elast. of intratemp. subst.	1.00
α	capital share	0.32	z	mean of z process	1.00
δ	depreciation rate	0.05	$c^\star$	mean of $c^\star$ process	1.00
	Country–specific Parameters				
$\frac{d}{y}$	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

4.3 Estimation

Similar to recent studies in this field of literature (e.g. García-Cicco *et al.* (2010) or Chang and Fernández (2010)), 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 parameter

ψ, which affects 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 the financial frictions parameter ψ as well as the parameters governing the exogenous structural shocks in the economy.

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.[15] Naturally, our small open economy 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 (27) modifies to

$$\begin{aligned}
\mathbf{y}_t &= \mathbf{Z}\boldsymbol{\alpha}_t + \boldsymbol{\epsilon}_t \\
\boldsymbol{\alpha}_t &= \mathbf{T}\boldsymbol{\alpha}_{t-1} + \mathbf{R}\boldsymbol{\eta}_t, \qquad \boldsymbol{\eta}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}) \\
\boldsymbol{\epsilon}_t &= \mathbf{A}\boldsymbol{\epsilon}_{t-1} + \boldsymbol{\xi}_t, \qquad \boldsymbol{\xi}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Omega})
\end{aligned} \tag{28}$$

where $\boldsymbol{\epsilon_t}$ 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 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 posterior distributions of the parameters. First, we implement Gibbs sampling to simulate the posteriors of

[15] For instance, García-Cicco *et al.* (2010) and Chang and Fernández (2010) 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.

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 $\mathbf{\Omega}$. 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.[16] 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.

5 Estimation Results

This section presents the estimation results for our six countries under investigation.

5.1 Parameter Distributions

In the following, we focus on the estimates concerning the structural part of our model. Table 5 displays the posterior distribution of the estimated structural pa-

[16]This prior distribution yields a mean of 0.01 and variance 0.002.

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]

rameters. A complete description of all estimated parameters, including those determining the off–model dynamics, can be found in the Appendix.

In all specifications, we keep only every 10^{th} draw in order to avoid autocorrelation problems. For EMEs, results are based on 150,000 draws from the posterior distribution after in the benchmark (liability dollarization) model the initial 100,000 (115,000) draws were burned. For developed economies, results are also based on 150,000 draws from the posterior distribution after the first 125,000 draws were discarded. Furthermore, we have performed a diagnostic 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 focus on the estimates of parameter ψ. We do not only find heterogeneity with respect to the choice of the model, but also with respect to the country

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	0.409	[0.162,0.873]	0.94
ρ_z	0.622	[0.487,0.744]	0.58	0.706	[0.566,0.833]	0.59
ρ_g	0.751	[0.637,0.845]	0.58	0.796	[0.638,0.896]	0.58
ρ_c	0.689	[0.458,0.875]	0.37	0.550	[0.371,0.738]	0.54
σ_z^2	0.034	[0.028,0.043]	0.91	0.036	[0.029,0.046]	0.32
σ_g^2	0.040	[0.031,0.052]	0.26	0.029	[0.022,0.039]	0.98
σ_c^2	0.128	[0.082,0.201]	0.89	0.138	[0.081,0.247]	0.72
			SOUTH AFRICA			
		BENCHMARK			**LIABILITY DOLLARIZATION**	
ψ	1.664	[1.115,2.668]	0.31	0.447	[0.282,0.595]	0.40
ρ_z	0.918	[0.874,0.958]	0.50	0.820	[0.725,0.891]	0.44
ρ_g	0.827	[0.767,0.886]	0.86	0.805	[0.719,0.871]	0.16
ρ_c	0.626	[0.442,0.815]	0.43	0.663	[0.487,0.803]	0.15
σ_z^2	0.015	[0.014,0.018]	0.85	0.021	[0.018,0.024]	0.11
σ_g^2	0.012	[0.010,0.014]	0.22	0.016	[0.013,0.020]	0.54
σ_c^2	0.082	[0.059,0.110]	0.34	0.071	[0.051,0.103]	0.98
			TURKEY			
		BENCHMARK			**LIABILITY DOLLARIZATION**	
ψ	4.067	[2.743,4.830]	0.50	1.079	[0.324,2.374]	0.92
ρ_z	0.691	[0.552,0.803]	0.25	0.653	[0.515,0.774]	0.60
ρ_g	0.629	[0.508,0.741]	0.46	0.701	[0.558,0.809]	0.55
ρ_c	0.646	[0.428,0.822]	0.49	0.516	[0.365,0.663]	0.37
σ_z^2	0.062	[0.049,0.078]	0.87	0.060	[0.047,0.077]	0.54
σ_g^2	0.080	[0.060,0.107]	0.14	0.081	[0.057,0.114]	0.19
σ_c^2	0.201	[0.114,0.384]	0.12	0.138	[0.082,0.269]	0.80
			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 in the benchmark (liability dollarization) model 100,000 (115,000), and for developed economies the first 125,000 draws were burned. To avoid autocorrelation issues, we only keep every 10^{th} draw in all specifications. The χ^2 figure denotes the p–value of Geweke's χ^2–test for convergence (4 % taper). Variances are reported in percentages.

selection. What is striking is that ψ is considerably higher in the benchmark economy than in the model incorporating foreign currency denoted 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.[17] 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 0.41 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.

What is more, our results suggest that the magnitude of reduced form financial frictions in the benchmark economy seems to be 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. As pointed out by Eichengreen and Hausmann (2005), South Africa is one of the few emerging markets, which is at least to some degree able to issue bonds denoted in South African Rand on international capital markets. This observation might explain the peculiarity of South Africa with respect to the estimated ψ. In general, findings for our EMEs are to some extent concurrent with the results reported by García-Cicco *et al.* (2010), who estimate their model for the Argentine economy. Nevertheless, it is worth mentioning that our estimates of the benchmark model suggest a perceptibly higher debt–elasticity of the interest rate compared to their results. Conversely, the posterior distribution of ψ in the framework augmented by liability dollarization exhibits a lower elasticity than the one documented by García-Cicco *et al.* (2010).

Turning to the parameters of the structural processes, we find that autocorrelation

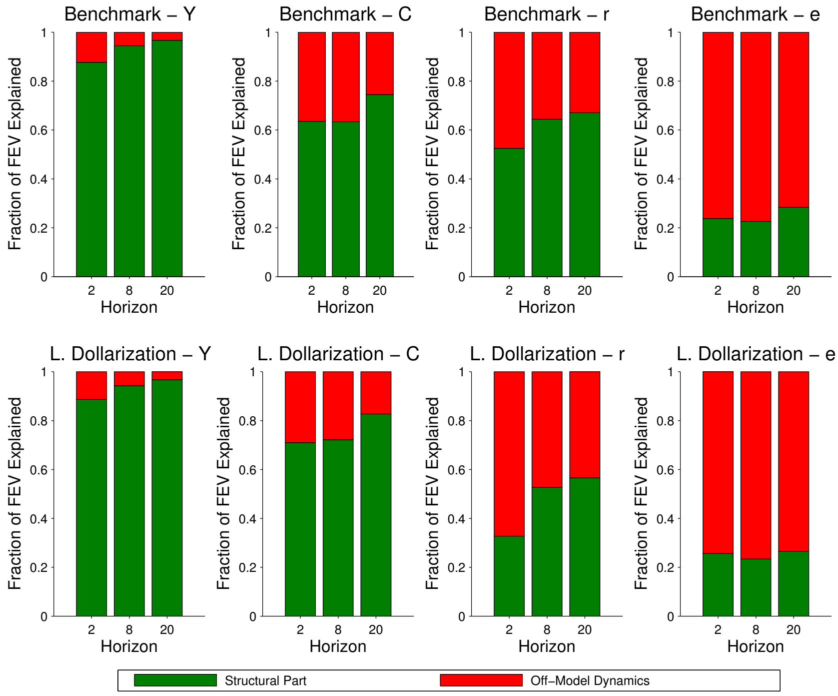
[17] Admittedly, this finding is not very surprising. In our extended setup, variation in interest rates can additionally be attributed to exchange rates fluctuations. Given the fact that real exchange rates in EMEs are procyclical, volatility on the right–hand side of the interest rate rule equation (13) or (23) unambiguously rises, while it remains unchanged on the left–hand side, such that factor ψ must decline.

coefficients tend to be relatively persistent, especially for South Africa. Ranging from about 0.65 to 0.85 and thus being rather high, our estimates of ρ_g, the parameter governing the persistence of the non–stationary productivity process, differ from the ones reported by García-Cicco *et al.* (2010). Nonetheless, they fall into the range of the results documented by Aguiar and Gopinath (2007a) and Chang and Fernández (2010) for Mexico as well as Nguyen (2011) for the United States. In addition, we do not find substantially different persistence parameter both across models and countries. Interestingly, this does not hold true with respect to the variances of our structural shocks. Looking at the median of the relative variance of the permanent productivity shocks σ_g^2/σ_z^2, we observe a lower relative volatility of trend shocks in the model with liability dollarization for Mexico and South Africa, while the reverse is true for Turkey. To be more precise, for Mexico and South Africa, this relative volatility drops from 1.18 and 0.80 in the benchmark model to 0.81 and 0.76 in the extended setup, whereas for Turkey this ratio actually increases from 1.29 to 1.35. This finding is in contrast to Aguiar and Gopinath (2007a), who highlight the necessity of a high relative variance of trend shocks in their model in order to account for certain stylized business cycle facts in EMEs. As we will demonstrate in subsection 6.3, particularly our model with liability dollarization succeeds in matching these business cycle patterns despite a relatively low σ_g^2/σ_z^2.

5.2 Model Fit

Next, we analyze the importance of the structural part relative to the off–model part in driving the dynamics in 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 off–model dynamics. While evaluating the respective setup at the median values of the posterior distribution, we compute the mean forecast error variance decomposition across all EMEs in both the benchmark economy as well as the model with liability dollarization. This allows us to study the extent to which our structural model is capable to capture the dynamics in our observables. Hence, we can assess and confront the model fits of both our benchmark and liability dollarization framework in a straightforward manner.

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 this sense, the structural model with liability dollarization performs better in accounting for the dynamics in output, consumption and exchange rates at all forecast horizons. This observation is especially perceivable for consumption. However, the reverse is true regarding real interest rates. Our explanation for this exception is the fact that both structural models neglect any exogenous country premium shocks in the interest rate. Nonetheless, we implicitly control for such a country spread shock by the inclusion of dynamic measurement errors in the estimation.[18] In light of this interpretation, our exercise suggests that once countries can only borrow in foreign currency, interest rate shocks apparently become more important. By and large, we infer that the model with liability dollarization fits the data in EMEs better than the benchmark setup.

Furthermore, estimation results in general are in strong favor of our theoretical

[18] Several papers have pointed out the importance of country risk shocks in explaining macroeconomic fluctuations in emerging markets. See, for instance, Neumeyer and Perri (2005) and Uribe and Yue (2006).

framework. Though being quite stylized, the structural models perform very well, especially in capturing the dynamics of the main macroeconomic aggregates 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 theoretical model. This finding is owed to the fact our models cannot produce such high volatility in exchange rates we generally observe in the data.

6 Model Analysis

So far, we have presented our theoretical framework and discussed its quantification. This section examines in how far our model helps us in understanding macroeconomic dynamics, in particular in EMEs. First, we implement a forecast error variance decomposition to assess the relative importance of different shocks in explaining macroeconomic fluctuations. Then, we turn to an impulse response analysis of our liability dollarization setup. Finally, we compare model implied business cycle moments with their empirical counterparts to determine to what extent our theoretical economy succeeds in replicating various stylized business cycle facts.

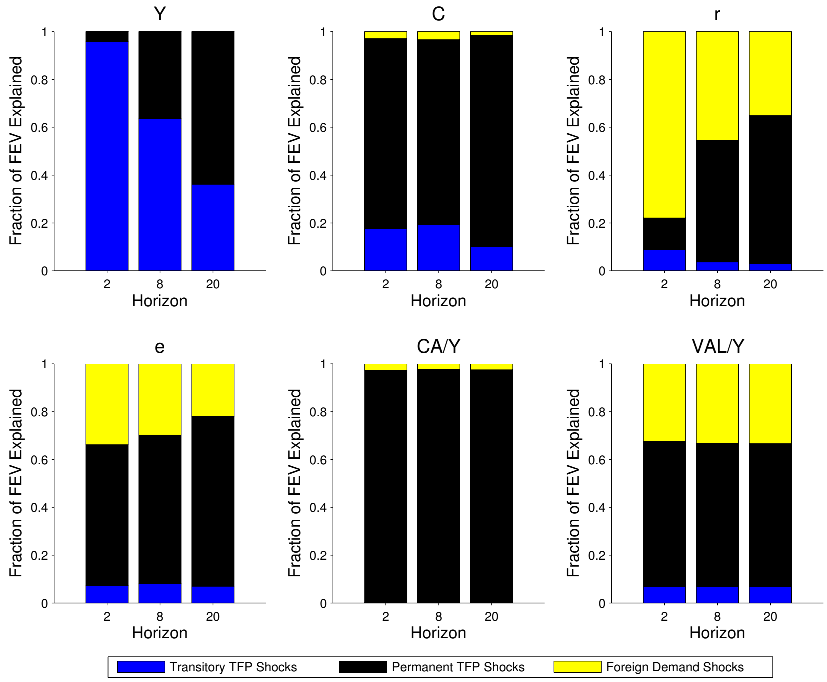
6.1 Forecast Error Variance Decomposition

We start by studying the relative contribution of various shocks in driving the dynamics in our theoretical economy. As we have shown above, the model with liability dollarization outperforms the benchmark setup in fitting the data in EMEs. As a consequence, we confidently treat the liability dollarization framework as the "true" underlying model for EMEs and thereby only present the forecast error variance decomposition of the extended setup in this country group.[19]

Second, transitory technology disturbances are generally not important for the dynamics in the cost of borrowing. It is essentially growth shocks, which account for interest rate variations in advanced countries over all forecast horizons. In EMEs, however, foreign demand shocks also seem to govern interest rate dynamics to

[19]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 – Emerging Market Economies



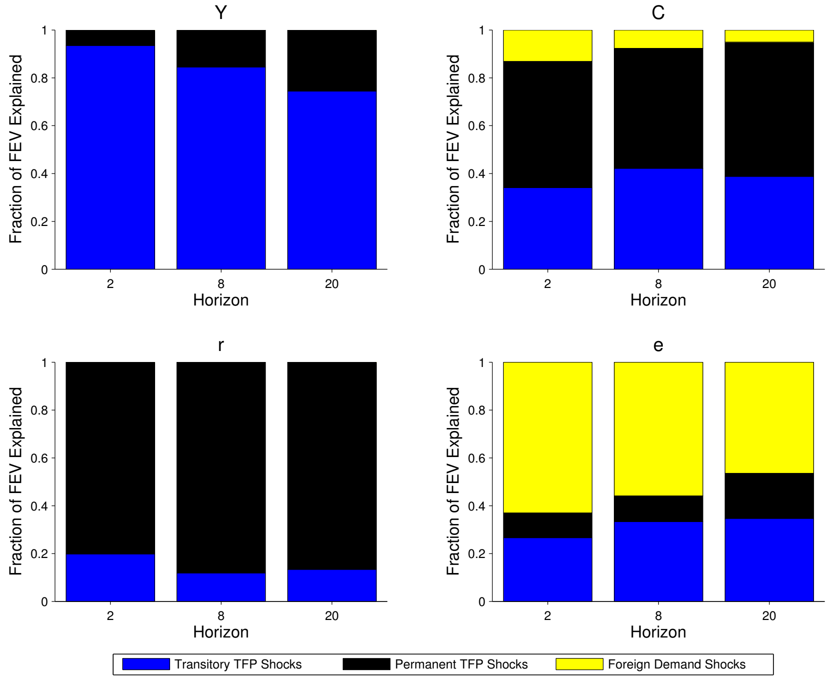
Notes: Mean forecast error variance decomposition across all EMEs for the model with liability dollarization. Results are based on median outcomes of the respective posterior distributions.

a non–negligible extent, especially in the short–run. This finding highlights 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 exchange rate in industrialized economies. By contrast, it is again the permanent shock that dominates relative international price movements in EMEs.

This predominance of trend shocks in the liability dollarization setup 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 in the valuation effects to GDP ratio is determined by innovations to the permanent productivity process. Foreign demand shocks after all account for about one third of the variation in $\frac{VAL}{Y}$, while the influence of transitory technology shocks again is trifling.

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.

In a nutshell, our analysis suggests that transitory productivity shocks are far more important in explaining fluctuations of macroeconomic aggregates in industrialized countries as compared to EMEs. As opposed to García-Cicco *et al.* (2010), we conclude that even though we account for financial frictions in our model, both permanent and transitory exogenous disturbances play a role in explaining business cycle variations in EMEs. This in turn is concurrent with the finding of Aguiar and Gopinath (2007a), who argue that macroeconomic fluctuations in EMEs are mainly driven by trend shocks. Thus, we largely find support for their hypothesis that *"the cycle is the trend"*.

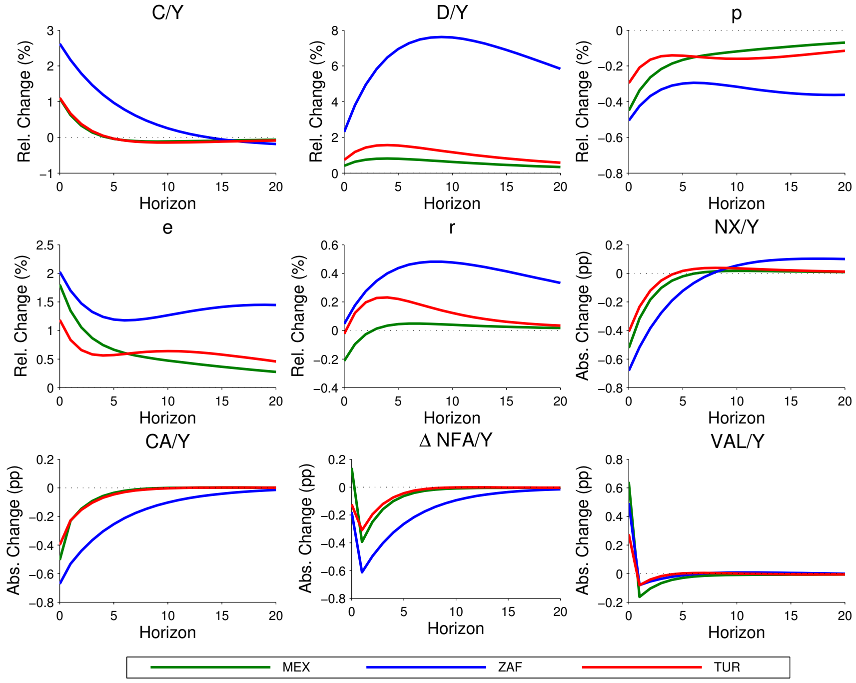
6.2 Impulse Response Analysis

Next, we shed more light on the dynamics of our model describing EMEs. To this end, we use the liability dollarization setup – again parametrized at the median of the posterior distributions – and compute impulse responses to our 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. By and large, the picture is rather similar across all EMEs.

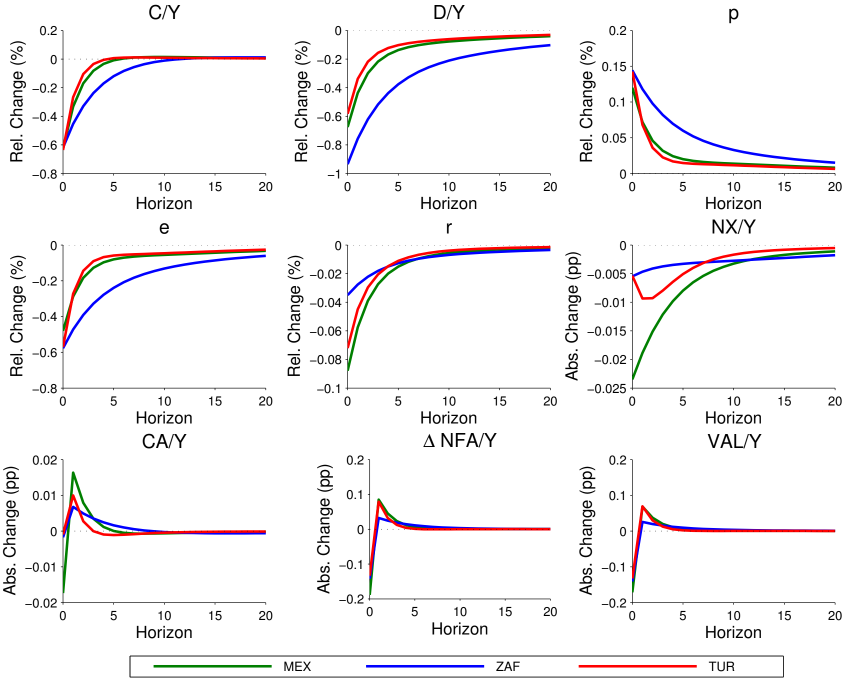
Figure 6: Impulse Responses – Permanent Shock



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

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 have already been explained in various previous contributions (Glick and Rogoff, 1995; Hoffmann, 2001; Aguiar and Gopinath, 2007a). 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 ($\rho_g >$

Figure 7: Impulse Responses – Transitory Shock



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

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 smoothing rationale also induces households to curb international borrowing, i.e. save today 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 raises the price p of the composite consumption good, whereas a temporary productivity innovation reduces the price level. This can be explained as follows. Both types of shocks lift the marginal productivity of labor (MPL). As we know, the increase in consumption overshoots the one in output after a positive trend shock such that the marginal rate of substitution between labour and leisure (MRS) rises strongly. Accordingly, the representative agent's willingness to pay for an additional marginal unit of leisure (given by the MRS) *ceteris paribus* exceeds the price of leisure (given by the MPL divided by the price of consumption, i.e. the real wage). Thus, optimality requires an increase in the price of consumption in order to equalize the household's marginal willingness to pay for leisure and the real wage.[20] On the other hand, transitory shocks lead to a drop in $\frac{C}{Y}$ such that the price of consumption must increase in equilibrium.

Due to imperfect substitutability between home and foreign goods the relative change of the domestic price of the foreign good $p_{F,t}$ must always be stronger than the one of the price of the overall consumption index p_t. This immediately follows 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 debt to income ratio effect outweighs the real appreciation effect in particular in the case of South Africa, while the reverse is true for Mexico, where we actually observe a negative response of r. 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

[20] At this point it is intuitive to re–write the labor–leisure trade–off in equation (12) as

$$\underbrace{\frac{1-\gamma}{\gamma}\frac{c_t}{1-l_t}}_{\text{MRS}} = \frac{1}{p_t}\underbrace{(1-\alpha)\frac{y_t}{l_t}}_{\text{MPL}},$$

where the left–hand side determines the marginal rate of substitution between labor and leisure, and the right–hand side shows the marginal productivity of labor divided by the price of consumption, which is the real wage. Note that with Cobb Douglas preferences productivity shocks entail both an income and a substitution effect on labor supply. In fact, labor supply declines after a positive permanent shock, which eventually attenuates the drop in the price level because the income effect predominates the substitution effect. On the contrary, with Greenwood *et al.* (1988) quasi–linear preferences the income effect is absent such that the reaction of p_t would be more pronounced.

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 in 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. For 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.

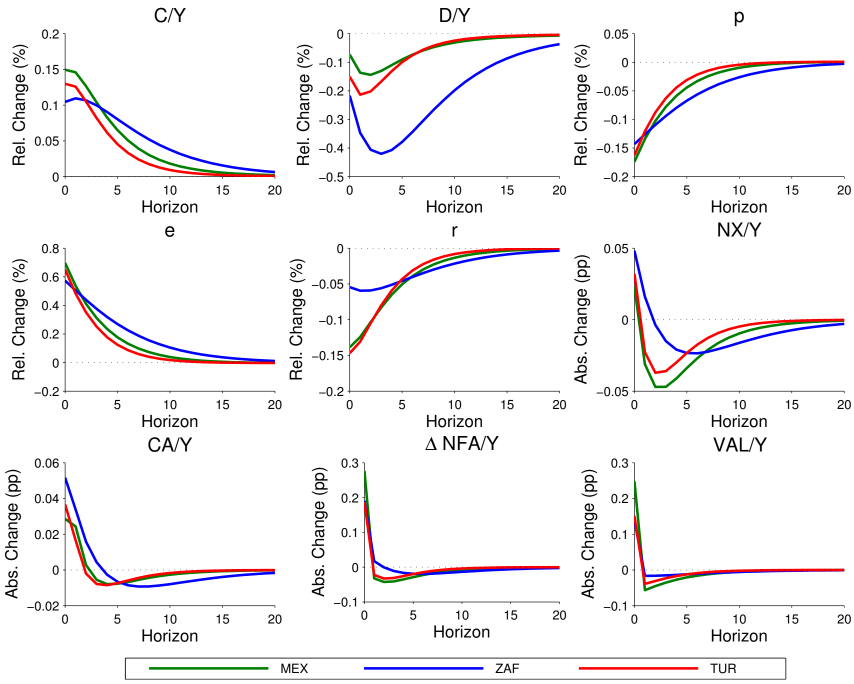
In response to a transitory shock, the initial change in $\frac{CA}{Y}$ is slightly negative. This is because the drop in $\frac{NX}{Y}$ on impact more than compensate the fall in interest payments, whereas it is the other way round in subsequent periods until the effect of the shock dies out eventually. Likewise, real depreciation leads to negative valuation effects. Indeed, these negative balance sheet effects are strong enough to generate a negative change in the net foreign asset position on impact.

Foreign Demand Shocks

Figure 8 displays impulse responses to a one percent shock in foreign demand. From a qualitative point of view, outcomes do not vary across our three countries under investigation.

An exogenous jump in 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 price of foreign goods

Figure 8: Impulse Responses – Foreign Demand Shock



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

p_F falls. This in turn reduces the price p of the composite consumption bundle. Nonetheless, the relative drop in p_F prevails the decrease in p, which causes the real exchange rate to appreciate.

Households substitute consumption of relatively more expensive home goods c_H for relatively cheaper foreign goods c_F. On the whole, the favorable movement in the real exchange rate entails a positive wealth effect, which induces 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.[21]

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 hold-

[21]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).

ings.[22] 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 versus De–stabilizing Valuation Effects

In light of the above analysis, we conclude that depending on the nature of the underlying shock, valuation effects have a different impact on the net foreign asset position. 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 reinforce the influence of the current account on net foreign assets and are therefore amplifying after a transitory productivity or foreign demand shock. In a way, this finding conflicts with the model by Nguyen (2011), which predicts stabilizing (amplifying) valuation effects after a transitory (permanent) technology shock.

6.3 Business Cycle Moments

Finally, we gauge our structural model's ability in reproducing various business cycle patterns. To this end, we draw 5,000 times from the posterior distributions of each country. Conditional on every draw, we use our model to generate data covering a time span of 200 periods, and subsequently compute business cycle moments of interest. Table 6 compares empirical moments with their model generated counterparts, which correspond to the median across all simulations of the respective specification. Empirical moments reported are based on quarterly data, apart from those involving valuation effects for which only annual data are available.

Consistent with the data, our model predicts higher macroeconomic volatility in EMEs as compared to developed economies. Likewise, once we introduce liability

[22] We can think of domestic households investing in foreign goods by reducing the amount of international debt. That is, they go long in foreign goods.

Table 6: Business Cycle Moments

	Data	Liability Dollar.	Bench–mark	Data	Liability Dollar.	Bench–mark	Data	Liability Dollar.	Bench–mark
Emerging Market Economies									
		Mexico			**S. Africa**			**Turkey**	
$\sigma(Y)$	2.42	0.36	0.32	1.60	0.22	0.37	3.70	0.61	0.43
$\sigma(C)$	3.68	0.52	0.44	2.46	0.26	0.38	5.72	0.85	0.53
$\sigma(NX/Y)$	6.63	0.02	0.01	4.04	0.01	0.00	211.69	0.02	0.01
$\sigma(e)$	9.63	0.63	0.42	8.70	0.26	0.42	1.79	0.79	0.43
$\sigma(C)/\sigma(Y)$	1.52	1.34	1.35	1.54	1.17	1.03	1.55	1.36	1.26
$\rho(C,Y)$	0.74	0.82	0.91	0.67	0.85	0.91	0.62	0.89	0.93
$\rho(NX/Y,Y)$	−0.17	−0.15	−0.46	−0.40	−0.21	−0.31	−0.56	−0.30	−0.49
$\rho(e,\Delta Y)$	0.28	0.40	0.39	0.17	0.32	0.34	0.26	0.38	0.34
$\rho(e,\Delta C)$	0.35	0.55	0.52	0.30	0.46	0.43	0.06	0.52	0.48
$\rho(e,NX/Y)$	−0.31	−0.55	−0.24	−0.12	−0.31	−0.05	−0.45	−0.42	−0.22
$\rho(Y_t,Y_{t-1})$	0.78	0.91	0.88	0.81	0.93	0.97	0.73	0.87	0.85
$\rho(C_t,C_{t-1})$	0.75	0.86	0.83	0.83	0.89	0.91	0.70	0.82	0.77
$\rho((NX/Y)_t,(NX/Y)_{t-1})$	0.97	0.67	0.30	0.85	0.65	0.32	0.84	0.53	0.18
$\rho(e_t,e_{t-1})$	0.79	0.85	0.78	0.80	0.87	0.83	0.62	0.84	0.78
$\rho((VAL/Y)_t,(CA/Y)_t)$	−0.58	−0.36	–	−0.75	−0.24	–	−0.05	−0.43	–
$\rho((VAL/Y)_t,e_t)$	0.45	0.28	–	−0.31	0.25	–	0.19	0.29	–
Developed Economies									
		Canada			**Sweden**			**Switzerland**	
$\sigma(Y)$	1.42		0.20	1.75		0.21	1.76		0.16
$\sigma(C)$	1.36		0.21	1.51		0.16	1.44		0.12
$\sigma(NX/Y)$	1.96		0.00	2.77		0.00	3.74		0.00
$\sigma(e)$	3.41		0.37	8.81		0.20	7.94		0.35
$\sigma(C)/\sigma(Y)$	0.96		1.02	0.86		0.78	0.82		0.74
$\rho(C,Y)$	0.75		0.90	0.44		0.92	0.72		0.80
$\rho(NX/Y,Y)$	0.01		−0.36	−0.01		−0.39	−0.17		0.25
$\rho(e,\Delta Y)$	0.03		0.32	−0.03		0.26	−0.09		−0.43
$\rho(e,\Delta C)$	0.04		0.39	−0.04		0.36	0.00		0.02
$\rho(e,NX/Y)$	−0.03		−0.19	−0.07		0.14	−0.02		−0.59
$\rho(Y_t,Y_{t-1})$	0.83		0.94	0.80		0.91	0.82		0.89
$\rho(C_t,C_{t-1})$	0.78		0.87	0.78		0.82	0.69		0.86
$\rho((NX/Y)_t,(NX/Y)_{t-1})$	0.93		0.28	0.94		0.16	0.84		0.49
$\rho(e_t,e_{t-1})$	0.81		0.88	0.83		0.83	0.96		0.68

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. All series, except for the net exports over output ratio, are real per capita variables, have been logged and filtered using the HP filter with smoothing parameter $\lambda = 1,600$. Theoretical moments are based on sample moments of model generated data. Each theoretical economy is simulated 5,000 times with a sample size of 200. Median outcomes are reported.

dollarization in our framework, standard deviations of macroeconomic variables increase for Mexico and Turkey. This finding is in line with evidence documented by Eichengreen *et al.* (2005), who report higher volatility of income and real exchange rates in countries that suffer most from the "Original Sin" phenomenon.

Furthermore, our model is not only capable of generating excess volatility in consumption relative to output in EMEs, but also matches relative consumption volatility in advanced countries quite well. This observation directly raises the question of why? As discussed in Section 6.1, estimation results we obtain for EMEs attribute an important role for the non–stationary productivity component in driving the model dynamics. In addition, the preceding subsection has demonstrated how consumption overshoots output in response to trend shocks, which explains the excess variability of consumption. Note that this effect is even more pronounced in the framework with liability dollarization. Changes in the real exchange rate following trend shocks entail wealth effects, which actually amplify the response of consumption relative to income. This explains why our extended setup exhibits a standard deviation of consumption relative to output that is closer to its empirical counterpart as compared to the benchmark model. This is particularly true for the South African and Turkish economy.

As outlined before, the fact that permanent technology shocks induce households to raise external debt implies a deterioration of the country's current account. Therefore, our table shows a negative correlation between the net exports to output ratio and income in all three EMEs, which is largely in line with what we see in the data. However, the degree of countercyclicality implied by the model for EMEs generally understates the one empirically observed. For the cohort of advanced economies, the model predicts a too strong negative relationship between $\frac{NX}{Y}$ and GDP, except for Switzerland. Indeed, data rather suggest a correlation close to zero in our developed economies.

Interestingly, our benchmark model exhibits a fairly low first–order serial correlation of the net exports to income ratio, whereas the extended setup with liability dollarization matches this moment better. 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 downward sloping autocorrelation function of $\frac{NX}{Y}$ consistent with the data. 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 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 Aguiar and Gopinath (2007a)) the feedback effect of changes in $\frac{D}{Y}$ on the cost of borrowing is virtually shut down, resulting in an autocorrelation function 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 especially our benchmark model understates the first–order autocorrelation of $\frac{NX}{Y}$.

Regarding exchange rate dynamics, our liability dollarization framework matches various empirical moments of interest quite convincingly. As in the data, real exchange rates are positively correlated with both output and consumption growth, while being negatively correlated with the net exports to output ratio in EMEs. Interestingly, our benchmark model struggles in replicating the weak relationship between exchange rates and both macroeconomic growth and the trade balance to GDP ratio in the group of industrialized countries.

Finally, Table 6 yields meaningful insights about the role of valuation effects in EMEs. As we would expect from our discussion above, they are positively correlated with the real exchange rate. Furthermore, it is important to highlight that our model exhibits a negative relationship between valuation effects and the current account. In this sense, our model corroborates the empirically observed negative correlation between $\frac{VAL}{Y}$ and $\frac{CA}{Y}$. Consequently, one can conclude that on average valuation effects entail stabilizing effects with respect to changes in the net foreign asset position. As we have discussed before, this finding can be attributed to the fact that EMEs are predominantly exposed to trend shocks.

By and large, our analysis suggests that the model featuring liability dollarization is not only able to reconcile with various stylized business cycle facts, but also delivers interesting results regarding external balance sheet effects in emerging markets.

7 Conclusion

We develop a small open economy DSGE model featuring a stochastic trend, differentiated home and foreign goods, and endogenous exchange rate movements to study the importance of financial frictions in explaining business cycle patterns in EMEs. We also extend our benchmark setup by introducing liability dollarization, which allows us to analyze the impact of valuation effects on the macroeconomic dynamics in these countries.

In the empirical part of the paper, we estimate our model using Bayesian techniques for a group of three EMEs. Furthermore, 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. In order to investigate the difference between emerging and advanced countires, we also perform our estimation excersice for a group of developed countries.

Our results emphasize that the co–existence of financial market imperfections and trend shocks helps to explain business cycle patterns in EMEs. Besides, once we account for foreign currency denominated debt, the model's overall performance generally improves. Interestingly, our liability dollarization framework suggests that valuation effects on average yield stabilizing effects 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 focussed on developed economies.

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