Uncertainty Shocks, Financial Frictions and Business Cycle Asymmetries Across Countries[†]

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Abstract

Uncertainty shocks trigger sharper declines in consumption, investment, GDP and stronger countercyclical response in trade-balances in emerging countries compared to advanced economies. I propose a novel framework incorporating nonlinear interactions between higher-order moments and financial frictions to reconcile these facts. Estimating this model using data for 8 countries I find heightened uncertainty is common across advanced and emerging countries during recessions however higher financial frictions is key towards generating the observed excess-volatility in emerging countries. Estimated parameters suggest borrowing costs are 5.92% higher for emerging countries in downturns providing evidence in support of the proposed interaction between uncertainty and fundamentals.

JEL Classification Codes: C40, E32, F41, F32, F44, C32

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1 Introduction

The emphasis on understanding the role of macroeconomic uncertainty in generating business cycle fluctuations has become particularly important in the years following the Great Recession with a seminal contribution by Bloom (2009). Studies documenting the impact of uncertainty suggests certain stylized facts that describe the impact of uncertainty shocks across countries. First, changes in aggregate uncertainty trigger a simultaneous decline in consumption, investment and output (Basu and Bundick (2017)). Second, emerging countries are more vulnerable to changes in uncertainty with upward surges in uncertainty triggering a sharper decline followed by a weaker recovery (Carrière-Swallow and Céspedes (2013)). The intensity of decline and the pace of recovery is strongly affected by the degree of openness - countries that are more open experience a stronger countercyclical response in trade balances along with a larger decline in activity and slower recovery (Chatterjee (2018)). Finally, the effects of uncertainty are countercyclical and more important during downturns (Chatterjee (2018)). I present these facts in figure 1.

In this paper I propose and estimate a two-good small open economy model with financial frictions, foreign currency denominated debt and uncertainty shocks to provide a micro-founded explanation that drives the difference in the response of real variables to uncertainty shocks across advanced and emerging countries. I unify the two approaches that traditionally describe the causes of excess volatility in emerging countries – differences in fundamental features (financial frictions) versus differences in exogenous processes (uncertainty shocks). By exploiting the nonlinear interaction between uncertainty shocks, financial frictions and foreign currency debt, I propose a novel channel that simultaneously explains the heightened sensitivity of macro variables as well as the countercyclicality in trade balances in emerging countries.

In the theoretical specification of my model, uncertainty stems from the time-varying volatility of aggregate productivity (see Bloom (2009), Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2018)). The stochastic volatility interpretation of uncertainty has also been adopted in earlier work by Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011), Fernández-Villaverde, Guerrón-Quintana, Kuester,

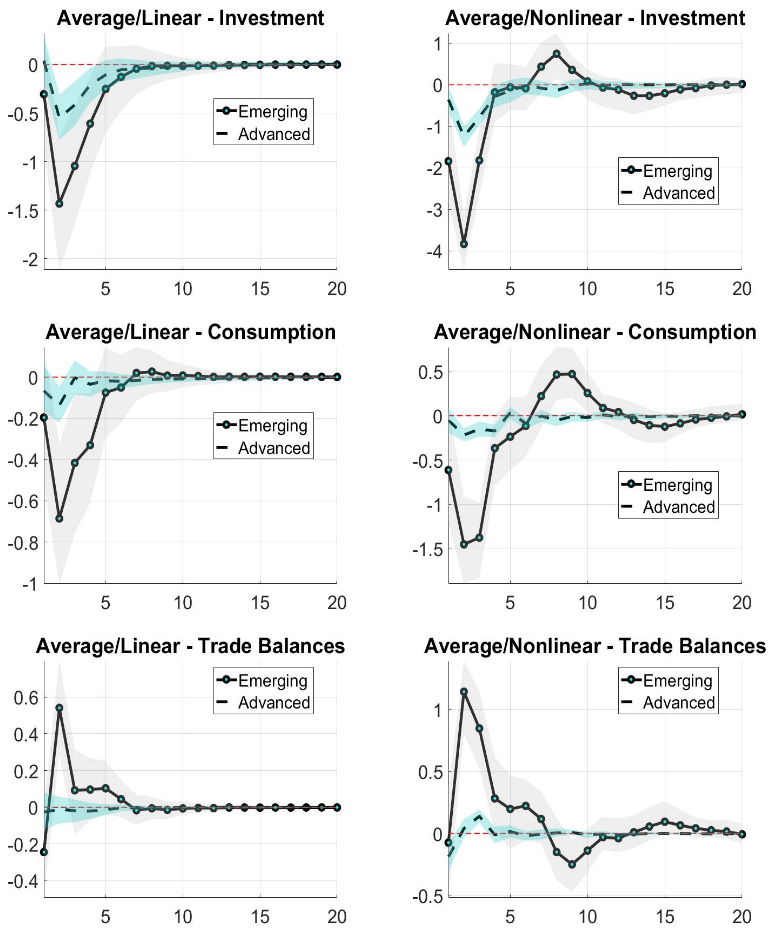

Figure 1: X-axis - horizon, Y-axis - impulse response in %. Comparing the average effect of a 1% shock to uncertainty across advanced and emerging countries and different model specifications (linear versus nonlinear). The linear model refers to results from a SVAR model. The non-linear model refers to the results from the recessionary regime of the Smooth Transition Vector Auto Regression (STVAR) model. The linear model clearly underestimates the effect for advanced and emerging countries alike. Emerging countries, on average experience deeper and longer recessions compared to advanced countries, when subject to a 1% shock to uncertainty. The sample of countries used include the U.S., the U.K., Canada and France as advanced countries and Mexico, Chile, Argentina and South Korea as emerging countries. The comparison highlights the countercyclical nature of uncertainty shocks and the need to condition for recessions when evaluating the impact on macroeconomic variables. Uncertainty is measured using the volatility of daily stock market returns for each country. The quarterly measure has been created by averaging the monthly measures of uncertainty. I estimate both the SVAR and STVAR models for each country, construct impulse responses to a 1% shock to country-specific uncertainty and subsequently average across country groups to generate the figures. See Chatterjee (2018) for details.

and Rubio-Ramírez (2015) and Basu and Bundick (2017).[1] Financial frictions in this paper, have motivated by the approach in Neumeyer and Perri (2005) and implemented using the small open economy version of the financial accelerator of Gertler, Gilchrist, and Natalucci (2007). The framework takes a rigorous approach in modelling the open economy features that govern the dynamics of trade balances in the model. The small-open economy environment uses a two-good model with nominal rigidities and foreign currency denominated debt.

There are many ways to capture differences in fundamental features across advanced and emerging countries. I argue that financial frictions can potentially capture many of these channels. Ordoñez (2013) for instance shows that there is negative correlation between lending rates and the levels of financial development as well as between lending rates and monitoring costs. Ciocchini, Durbin, and Ng (2003) establish a positive link between corruption scores and risk premium international credit markets for emerging countries. Furthermore, role of financial frictions in the transmission of uncertainty has been emphasized in speeches by policymakers (Fisher (2013), Lagarde (2015)). Caldara, Fuentes-Albero, Gilchrist, and Zakrajšek (2016) empirically demonstrate that uncertainty shocks can be an important source of business cycle fluctuations, however, the severity of the impact increases when allowed to interact with financial frictions. The analysis in Caldara, Fuentes-Albero, Gilchrist, and Zakrajšek (2016) is carried out for the US, however, given the differences in financial conditions[2] across advanced and emerging countries, this channel therefore becomes a particularly important candidate towards understanding the heightened sensitivity of macro variables to changes in uncertainty for emerging market countries.

The stochastic volatility interpretation of uncertainty allows me to directly examine the nonlinear interaction between financial frictions and changes in higher moments - however, it also imposes computational challenges. To make the solution sensitive to the effects of uncertainty, I deviate from traditional approaches using first-order approxima-

[1] Uncertainty stems from time variations in the volatility of borrowing costs in Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011). In Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015), uncertainty is modelled as time variations in the volatility of fiscal expenditure, and in Basu and Bundick (2017) it originates from time variations in the volatility of shocks to aggregate demand.

[2] See figure 1 in section 3 of the appendix.

tions. I solve the model using perturbation methods, in particular, a third-order Taylor series expansion as suggested in Andreasen, Fernández-Villaverde, and Rubio-Ramírez (2018). I subsequently use this nonlinear solution to estimate the parameters of interest. The estimation uses the Impulse Response Function Matching technique and minimizes the distance between the DSGE model implied impulse responses and the empirical impulse responses. The empirical impulse responses are calculated by using the recession-specific shock to uncertainty from a Smooth Transition Vector Auto Regression model and generalized impulse responses using the local projection technique from Jordà (2005). Finally, I estimate the model for the representative advanced and emerging country by averaging across a sample of 4 advanced (U.S., U.K., Canada, France) and 4 emerging countries (Mexico, Chile, Argentina and South Korea).

The main results I present in this paper are threefold. First, the model can generate the key stylized fact about uncertainty shocks in a small open economy set-up with higher uncertainty leading to a simultaneous decline in consumption, investment and output. This simultaneous decline in macro variables is generated by the initial precautionary response by agents to an uncertainty shock in the model. With sticky prices, when faced with higher uncertainty, retailers increase their mark-up endogenously in response to a precautionary decline in aggregate demand and in process demand less labor. Households engage in precautionary savings, increase their labor supply and reduce consumption. In equilibrium, hours decline on impact. Given that an uncertainty shock leaves the level of productivity unchanged and capital cannot adjust instantly, the decline in hours triggers a decline in the marginal productivity of capital, hence a decline in the rate of return on capital and finally the value of entrepreneurial net worth. Erosion of net worth increases borrowing costs and thereby triggers a decline in capital, investment demand. Furthermore, when financial frictions are large and debt is denominated in foreign currency, the fall in capital does not completely offset the increase in borrowing costs and triggers a depreciation of real exchange rate and subsequently induces a countercyclical change in the current account. When these effects are combined, an uncertainty shock in the model can generate the first stylized fact (simultaneous decline in consumption, investment and output).

Second, on varying the strength of the financial accelerator mechanism, the model can generate amplified responses of the real variables (consumption, investment and GDP) with strongly countercyclical trade balances that is characteristic of business cycles in emerging countries. Higher cost of credit in emerging countries translates into a sharper decline in real activity and larger depreciation of the real exchange rate. This amplified depreciation further erodes entrepreneurial net worth and reinforces the financial accelerator mechanism to generate excess volatility in the model for emerging countries. My findings therefore emphasize the interaction of uncertainty shocks and financial frictions in generating business cycle asymmetries between advanced and emerging countries. The novelty of the model lies in its ability to simultaneously generate the decline in real activity and the stronger depreciation of the real exchange rate in emerging countries for uncertainty shock.

Third, I estimate the nonlinear model by matching the responses of consumption and investment for advanced and emerging countries separately generated from a nonlinear VAR with the impulse responses from the DSGE model. On estimating the model, I find that differences in the extent of financial frictions are key towards generating the differences in business cycle characteristics for these two groups of countries in recessions. Results from the estimation suggest that borrowing costs for non-financial debt in emerging countries are 592 basis points (annualized) higher compared to advanced countries in recessions. While heightened uncertainty is common for both groups of countries in recessions, differences in financial conditions captured through financial frictions is key towards generating the amplified responses in emerging countries.

The countercyclicality in my paper is driven by the endogenously determined real exchange rate and not the accounting identity stemming from the budget constraint of households. To validate the results from the estimation I carry out an out-of-sample exercise. I compare the impulse response of the real exchange in the data with what I obtain from the model using the estimated parameters. The model with the estimated parameters for advanced and emerging countries can generate comparable dynamics for the real exchange rate across countries in recessions. To emphasize the role of financial frictions, I shut this channel off and demonstrate that even with elevated levels of uncertainty, and preserving standard features of an open-economy model, changes in the country-specific component of borrowing costs are critical towards understanding the heterogeneity in response across advanced and emerging countries.

In addition to quantifying the contribution financial frictions and uncertainty shocks in generating the excess volatility in emerging countries I examine the scope for policy intervention by introducing a countercyclical subsidy on borrowing costs faced by entrepreneurs. I show that the decline in activity triggered due to a precautionary response driven change in leverage can be dampened by the presence of such a subsidy.

Related Literature. This paper is broadly related to three major strands of literature. The first group of studies - Bloom (2009), Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2018) motivates the role of shocks to the second moment as a driver of business cycles. These papers however examine the 'wait and see' response of uncertainty shocks triggered by non-convex adjustment costs in closed economy models with frictionless financial markets. Basu and Bundick (2017) examine the strength of precautionary motives in the transmission of uncertainty shocks and highlights the role of nominal rigidities in generating the simultaneous decline consumption investment and output. However, this analysis is carried out in a closed-economy environment without financial frictions and calibrated to match features of the US economy.

In the context of open-economy models, Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011) examine the effects of risk shocks to the interest rate on Argentina, Venezuela, Brazil and Ecuador in a one-good open RBC model. The authors show that changes in the second moment of borrowing costs can generate decline in real activity. This framework however is one good RBC model without any role for the real-exchange rate or nominal rigidities.[3] My paper incorporates uncertainty shocks in a two good open economy model where the dynamics of trade balances is critical towards the transmission of uncertainty shocks. The real exchange rate is solved endogenously by considering the changes in net-exports as well as the financial frictions in the model. These features can simultaneously generate the recessionary effects of an uncertainty shock as well as the countercyclical response in net-exports.[4]

[3] In the re-calibrated version of this model Born and Pfeifer (2014) show that the contribution of interest rate risk shocks to business cycle volatility increases. However, after the recalibration it does worse at matching the countercyclical feature in net-exports.

[4] While the response of real exchange rate to uncertainty shocks has not been examined in the context of generating business cycle asymmetries in earlier studies, in a related analysis, Bhattarai, Chatterjee, and Park (2019) find that changes in global uncertainty leads to a depreciation of the nominal exchange

The second group of studies that is related to my paper examine the causes of excess volatility in emerging countries. On the one hand, Aguiar and Gopinath (2007) show that shocks to the trend of the productivity process is the main driver of business cycle fluctuations in emerging countries as opposed to advanced countries which, are characterized by shocks to productivity that are stable about the trend. On the other hand, Neumeyer and Perri (2005) and Uribe and Yue (2006) address the excess volatility stemming from differences in fundamental features - with emphasis on the financial frictions. These studies however examine the properties of shocks to the first moment. My paper contributes to the shocks versus fundamentals debate by comparing the relative strengths of uncertainty shocks, financial frictions and the nonlinear interaction between the two.[5]

The paper is also related to the rich strand of work that examines the impact of financial frictions on the business cycle. The implementation of the financial accelerator closely follows Gertler, Gilchrist, and Natalucci (2007) which builds from the findings in Bernanke, Gertler, and Gilchrist (1999). The novel contribution of this paper lies in using the nonlinear interaction between financial frictions and uncertainty shocks to explain the heterogeneity in the response of macro variables to changes in uncertainty across advanced and emerging countries.

The paper is organized as follows. I describe the model set-up in detail in section 2. In section 3, I demonstrate the ability of the model to replicate the first two stylized facts about uncertainty shocks. In section 4, I carry out the estimation. Section 5 examines the robustness of the results using out-sample checks as well as within model checks. Section 6 discusses the role for policy intervention. Finally, section 7 concludes.

2 Model Specification

This is a model in discrete time where agents live infinitely. There are five agents in this model economy - households, entrepreneurs, producers of capital goods, retailers

rate for a sample of 15 emerging countries.

[5]García-Cicco, Pancrazi, and Uribe (2010) compare the strength of the financial frictions channel versus the shocks to trend channel, they focus exclusively on Mexican and Argentine data at annual frequency in a RBC framework with financial frictions appearing as disturbance to the country risk premium. Akinci (2017) studies a variant of the financial accelerator in matching business cycle moments for emerging countries by comparing the relative importance of different types of shocks in a linear framework for Argentina.

and central bank. Households consume, supply labor and save in foreign and domestic assets. Entrepreneurs borrow from global credit markets and use a combination of net worth and foreign currency denominated debt to raise capital required for the production of wholesale goods. Capital producers purchase undepreciated capital at the end of each period from entrepreneurs, combine them with investment to meet the final capital demand from entrepreneurs. Retailers of domestically produced goods operate within a monopolistically competitive environment. They purchase wholesale goods from entrepreneurs, costlessly differentiate them and sell the final composite good to households (for consumption), capital producers (for investment) and rest of the world (as exports). Retailers of imported goods also operate within a monopolistically competitive environment and purchase wholesale goods from rest of the world to costlessly differentiate and sell the final imported good to households (for consumption) and capital producers (for investment). Prices are sticky. The central bank conducts monetary policy according to a Taylor rule. I assume that the main difference between advanced and emerging countries lies in the cost of credit faced in international capital markets and is specified in the characterization of the entrepreneurial sector. The behavior of each type of agent is described in detail as follows:

2.1 Households

Households maximize:

$$U_t = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{(C_t - H_t)^{1-\rho}}{1-\rho} - \frac{L_t^{1+\psi}}{1+\psi} \right)$$

subject to:

$$P_t C_t + P_t \Gamma_t + B_t + X_t F_t^* = P_{H,t} W_t^r L_t + R_{t-1} B_{t-1} + R_{t-1}^* X_t F_{t-1}^* + \Pi_t$$

$$\Gamma_t = \frac{\phi_B}{2} \left(\frac{B_t}{P_t} \right)^2 + \frac{\phi_F^*}{2} \left(\frac{X_t F_t^*}{P_t} \right)^2$$

and

$$C_t = \left[(1-\gamma_1)^{\frac{1}{\eta_1}} C_{H,t}^{\frac{\eta_1 - 1}{\eta_1}} + \gamma_1^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta_1 - 1}{\eta_1}} \right]^{\frac{\eta_1}{\eta_1 - 1}}$$

Here, H_t denotes the level of habits.[6] L_t denotes hours worked. I assume that habits are external and evolve as function of aggregate consumption in the past, that is, $H_t = hC_{t-1}$. C_t is the consumption aggregate across domestic goods $C_{H,t}$ and foreign goods $C_{F,t}$. $\frac{1}{\rho}$ is the intertemporal elasticity of substitution for habit-adjusted consumption across periods. Π_t denotes residual profits from retailers and capital producers. $\beta \in (0,1)$ is the discount factor. There is a unit continuum of differentiated domestic goods and a unit continuum of differentiated foreign goods such that the aggregate consumption basket is defined by a CES aggregator and

$$C_{H,t} = \left[\int_0^1 C_{H,t}(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}, \; C_{F,t} = \left[\int_0^1 C_{F,t}(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}.$$

Here η_1 is the elasticity of substitution between domestic and foreign goods, γ_1 is the share of imports in the consumption basket and ϵ is the elasticity of substitution across goods within each category. The aggregate price index P_t is a CES combination of the price index for domestically produced goods $P_{H,t}$ and the import price index $P_{F,t}$ such that:

$$P_t = \left[(1-\gamma_1) P_{H,t}^{1-\eta_1} + \gamma_1 P_{F,t}^{1-\eta_1} \right]^{\frac{1}{1-\eta_1}} \text{ and}$$

$$P_{H,t} = \left[\int_0^1 P_{H,t}(i)^{1-\epsilon} di \right]^{1-\epsilon}, \; P_{F,t} = \left[\int_0^1 P_{F,t}(i)^{1-\epsilon} di \right]^{1-\epsilon}$$

W_t^r is the real wage measured in terms of $P_{H,t}$ that households obtain from supplying labor for production of wholesale goods. R_t is the gross nominal rate of interest at home and R_t^* is the gross nominal rate of interest abroad. X_t is the nominal exchange rate[7]. Households can invest in domestic bonds: B_t and foreign bonds: F_t^* subject to portfolio holding costs Γ_t. The costs to holding foreign and domestic assets are modeled following Elekdag, Justiniano, and Tchakarov (2006). Quadratic costs characterizing portfolio holdings induce stationarity in consumption and stocks of bond holdings. Households choose $\{C_t, B_t, F_t^*, L_t\}$ subject to the budget constraint and the portfolio holding costs.

[6]Habit formation in preferences enables the estimation of model parameters. Presence of habits in the utility of the representative household incorporates the dependence of current consumption on past consumption - this makes the specification closer to the empirical setup in the Smooth Transition Vector Auto Regression Model as well as inducing persistence in aggregate consumption. This helps matching the hump-shaped response of consumption to an uncertainty shock.

[7]Home currency price of one unit of foreign currency.

Lastly, the optimal allocation of expenditure across home and foreign goods imply the following demand functions for goods produced at home and the foreign country respectively:

$$C_{H,t} = (1-\gamma_1)\left(\frac{P_t}{P_{H,t}}\right)^{\eta_1} C_t$$

$$C_{F,t} = \gamma_1\left(\frac{P_t}{P_{F,t}}\right)^{\eta_1} C_t$$

2.2 Foreign Sector

Aggregate demand (C_t^*), aggregate price index ($P_{F,t}^*$) and interest rate (R_t^*) for the foreign economy (here approximated as rest of the world) are assumed to be constant and treated as parameters in the model. Following Monacelli (2005) and Gertler, Gilchrist, and Natalucci (2007), I assume that the Law of One Price holds at the wholesale level for foreign transactions. Price of exports for the home country (imports for rest of the world) evolves as follows:

$$P_{H,t}^* = \frac{P_{H,t}}{X_t}$$

and the demand for exports is given as:

$$C_{H,t}^* = \left[\gamma_2\left(\frac{P_{H,t}^*}{P_{F,t}^*}\right)^{-\eta} C_t^*\right]^{\rho'} {C_{H,t}^*}^{1-\rho'}$$

Here, η is the elasticity of substitution between imports and domestically produced goods in the foreign country, γ_2 is the share of imports in the consumption basket of the foreign sector. The parameter ρ' helps govern the responsiveness of export demand to changes in domestic prices $P_{H,t}$ and X_t by scaling the price elasticity of export demand. $\rho' = 1$ implies that a one percent change in relative prices leads to a change in export demand by η percent, whereas $\rho' \in (0,1)$ scales down this effect with the change in demand being given by $\rho'\eta$ percent. Furthermore, the foreign sector is modeled as a large economy such that imports from the home country constitute a negligible portion of the consumption basket and $P_t^* \approx P_{F,t}^*$. That is, the CPI in the foreign country is equal to the price of domestically produced goods in the foreign country. I further set $P_{F,t}^* = 1$ while solving the model. This implies that the real exchange rate is defined as follows:

$$q_t = \frac{X_t P^*_{F,t}}{P_t} = \frac{X_t}{P_t}$$

2.3 Financial frictions and behavior of entrepreneurs

What is the fundamental characteristic that differentiates advanced and emerging countries?: In this paper, I differentiate between advanced and emerging countries in terms of the cost of credit they face in global credit markets. I introduce differences in the cost of credit across these two groups of countries by incorporating a role for financial frictions in the model specification. Financial frictions are specified such that they reflect the empirical differences in borrowing costs across advanced and emerging countries.

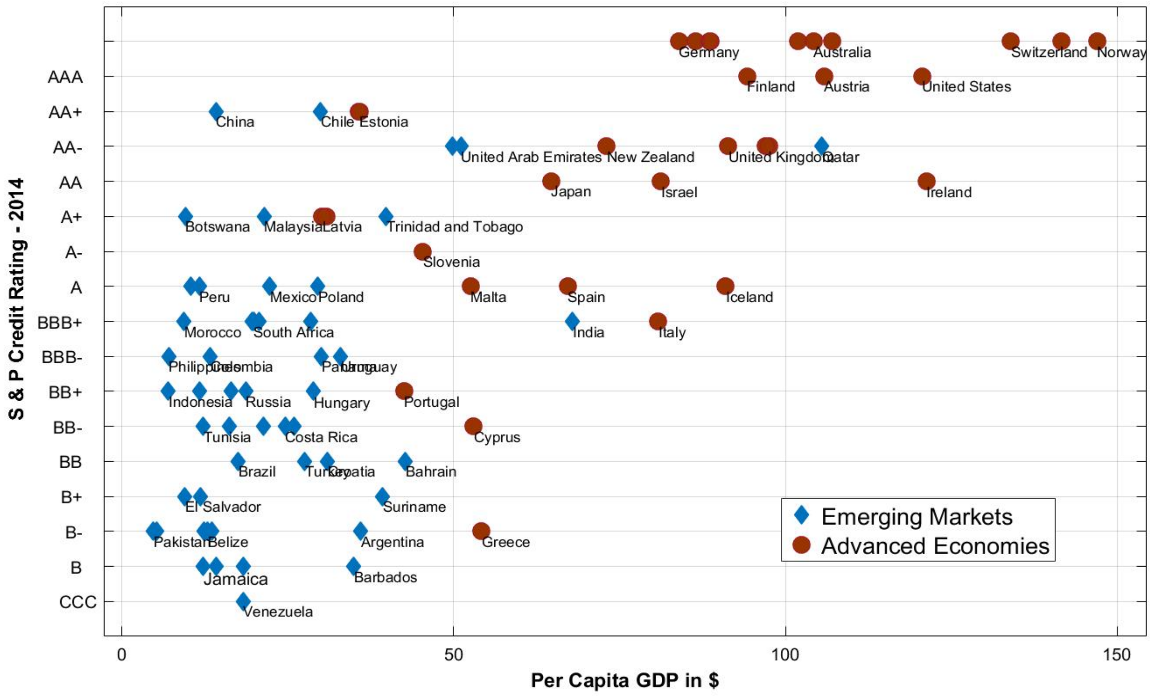

Figure 2: Plotting per capita GDP in dollars (x-axis) and country specific credit ratings assigned by Standard and Poor's for 82 countries - 32 advanced economies and 50 emerging markets (y-axis). Source: International Monetary Fund.

In figure 2, I illustrate the empirical difference in borrowing costs across countries by plotting the sovereign credit ratings as a proxy for corporate borrowing costs. As demonstrated in figure 2, emerging countries on average receive a rating between BB+ and BBB, in comparison to advanced countries which receive an average rating between

A+ and AA. While country specific ratings often account for the differences in the interest rate for sovereign debt across advanced and emerging countries, there is a very strong co-movement between corporate and sovereign credit ratings.[8]

In order to capture this asymmetry, I model borrowing costs faced by entrepreneurs to evolve as a function of a global component and a country-specific component. The global component corresponds to the international risk free rate and is constant across countries. The country specific component is defined to be an increasing function of leverage. I model the higher borrowing cost faced by emerging countries in international capital markets (as indicated in figure 2) by making borrowing costs more responsive to leverage for emerging countries. In order to capture this asymmetry in the responsiveness of borrowing costs to leverage I use the financial accelerator mechanism outlined in Gertler, Gilchrist, and Natalucci (2007) which generalizes the costly state verification approach adopted in Bernanke, Gertler, and Gilchrist (1999) to a small open economy DSGE model.

Entrepreneurs in this set up are risk neutral and produce wholesale goods by combining the capital that they own with labor services which they hire from households. Capital required for production is sourced using a combination of net worth (N_t) and foreign currency denominated debt (D_t). Debt contracts are defined for one period. To ensure that entrepreneurs continue to finance capital requirements using a combination of net worth and foreign debt, I assume that entrepreneurs have a finite life with each surviving the next period with probability θ. Consequently, the expected lifetime of an entrepreneur is given by $\frac{1}{1-\theta}$. Additionally, the population of entrepreneurs is stationary and exiting entrepreneurs are replaced by new ones. Each exiting entrepreneur endows the new entrepreneurs with a constant endowment E to ensure that new entrepreneurs have funds to start production.

Finally, capital acquired in period t becomes effective for production in period *t+1*. Entrepreneurs in this framework can thus be interpreted to represent agents conducting non-financial borrowing. A key assumption that will guide the dynamics in this model is the role of foreign currency denominated debt. In each period t, each entrepreneur

[8] Almeida, Cunha, Ferreira, and Restrepo (2014) address this link and demonstrate that the sovereign rating is the relevant ceiling for ratings on corporate debt. Şenay Ağca and Celasun (2012) find that the corporate sector faces higher borrowing costs when the external debt of the public sector is higher. This link between corporate and sovereign debt is further strengthened when the country has weak creditor rights and past sovereign default episodes.

indexed by net worth N_t^N, chooses capital stock (K_{t+1}^N) to be used for production in period *t+1* and labor (L_t^N) to be combined with capital from previous period (K_t^N) and used for production of wholesale goods. I start by describing the optimal choice of labor. Each entrepreneur produces wholesale goods using a Cobb-Douglas production function where α denotes the share of capital and a_t is the level of aggregate productivity that is common to all entrepreneurs such that

$$Y_{H,t}^N = a_t (K_t^N)^\alpha (L_t^N)^{1-\alpha}$$

The optimal choice of labor (L_t^N) given K_t^N and a_t is:

$$\underset{\{L_t^N\}}{\arg\max}\ P_{W,t} a_t (K_t^N)^\alpha (L_t^N)^{1-\alpha} - P_{H,t} W_t L_t^N$$

$P_{W,t}$ denotes the price of wholesale goods. The first order condition with respect to L_t^N implies:

$$a_t \frac{P_{W,t}}{P_{H,t}} (1-\alpha) \left(\frac{K_t^N}{L_t^N} \right)^\alpha = W_t^r$$

$W_t^r = \frac{W_t}{P_{H,t}}$ is the real wage expressed in terms of the domestically produced good. Rewriting in real terms, by using the domestic price index ($P_{H,t}$) such that $\varphi_t = \frac{P_{W,t}}{P_{H,t}}$:

$$\varphi_t (1-\alpha) a_t \left(\frac{K_t^N}{L_t^N} \right)^\alpha = W_t^r$$

Given constant returns to scale in production of wholesale goods and perfectly competitive labor market, $\frac{K_t}{L_t} = \frac{K_t^N}{L_t^N}$ $\forall N$. The optimal capital-labor ratio is therefore independent of entrepreneur specific net worth.

I next proceed to describe the capital acquisition decision. The demand for entrepreneurial capital depends on the expected return on capital and the expected marginal financing cost. The expected marginal return on capital ($E_t R_{t+1}^{K,N}$) in period t is the expected gross revenue net of labor costs normalized by the current market value of capital (Q_t). The expected gross revenue is the sum of the expected revenue from selling wholesale goods and sale of undepreciated capital. This can be summarized as:

$$E_t R^{K,N}_{t+1} = E_t \frac{\frac{P_{W,t+1}}{P_{H,t+1}} a_{t+1} {K^N_{t+1}}^{\alpha} {L^N_{t+1}}^{1-\alpha} - W^r_{t+1} L^N_{t+1} + (1-\delta) Q_{t+1} K^N_t}{Q_t K^N_t}$$

$$E_t R^{K,N}_{t+1} = E_t \frac{\frac{\alpha \varphi_{t+1}}{S_{H,t+1}} a_{t+1} \left(\frac{K_{t+1}}{L_{t+1}}\right)^{\alpha-1} + (1-\delta) Q_{t+1}}{Q_t}$$

$$E_t R^{K}_{t+1} = E_t \frac{\frac{mpk_{t+1}}{S_{H,t+1}} + (1-\delta) Q_{t+1}}{Q_t}$$

I next describe conditions that summarize the marginal financial conditions. I restrict my attention to one period financial contracts that offer lenders a payoff independent of aggregate risk. I consider a form of the contract that is a reduced form representation of the standard debt contract with costly bankruptcy as used in Gertler, Gilchrist, and Natalucci (2007). The contract incorporates the possibility of default and subsequently assumes a premium in case of default. The value of the premium will depend on the country specific fundamental characteristics such as quality of financial intermediation, extent of financial integration and access to financial markets. This is analogous to monitoring costs in Bernanke, Gertler, and Gilchrist (1999). I assume that this premium (which is a function of country fundamentals) varies inversely with the status of development of a country and captures the asymmetry in borrowing costs demonstrated in figure 2. The debt contract is summarized by the amount foreign currency denominated loans D_t and interest rate $R^*_t \Psi(t)$. Here R^*_t is the international risk free rate and $\Psi(t)$ is the country specific component. I model

$$\Psi(t) = k_t^{\nu}$$

to be an increasing function of leverage $k_t = \frac{Q_t K_t}{N_t}$, and ν is the elasticity of borrowing costs with respect to leverage. The difference between countries is captured in this model through different values of ν - such that weaker degree of financial integration (higher monitoring costs) for emerging countries implies $\nu^{Emerging} > \nu^{Advanced}$.[9] The optimal choice of capital is obtained by maximizing the ex ante value of entrepreneurial capital

[9] Ordoñez (2013) provides empirical evidence to suggest that monitoring costs or bankruptcy costs are much higher in emerging countries vis-*à*-vis advanced countries

$V_t^{N,e}$

$$\arg\max_{\{K_{t+1}^N\}} V_t^{N,e} = E_t\left[R_{t+1}^K Q_t K_{t+1}^N - R_t^*(k_t^N)^\nu \frac{X_{t+1}}{P_{t+1}} D_t^N\right]$$

subject to

$$Q_t K_{t+1}^N = N_t^N + \frac{X_t D_t^N}{P_t}$$

The first-order conditions of this problem, imply the following marginal financing condition:

$$E_t R_{t+1}^K = R_t^*(k_t^N)^\nu E_t \frac{q_{t+1}}{q_t} \text{ where } q_t = \frac{X_t}{P_t}$$

The marginal financing condition captures the external finance premium that arises in equilibrium. This can be related to the financing premium that arises in Bernanke, Gertler, and Gilchrist (1999) to cover bankruptcy costs. The equilibrium condition also implies that all entrepreneurs choose the same leverage since from equation describing the marginal financing condition, k_t^N can be solved to be independent of entrepreneur specific characteristics. Therefore $k_t^N = k_t \; \forall N$. The marginal financing condition can therefore be expressed in terms of aggregate variables:

$$E_t R_{t+1}^K = R_t^*(k_t)^\nu E_t \frac{q_{t+1}}{q_t}$$

The ex post value of entrepreneurial capital evolves as:

$$V_t^N = R_t^K Q_{t-1} K_t^N - R_{t-1}^* {k_{t-1}}^\nu q_t D_{t-1}^N$$

Integrating of over the mass of entrepreneurs, I obtain the aggregate value of entrepreneurial capital:

$$V_t = \int_N V_t^N f_N dN = \int_N \left[R_t^K Q_{t-1} K_t^N - R_{t-1}^* {k_{t-1}}^\nu q_t D_{t-1}^N\right] f_N dN =$$

$$\left[R_t^K Q_{t-1} \int_N K_t^N f_N dN - R_{t-1}^* {k_{t-1}}^\nu \frac{q_t}{q_{t-1}} (Q_{t-1} \int_N K_t^N f_N dN - \int_N N_{t-1}^N f_N dN)\right] =$$

$$\left[R_t^K Q_{t-1} K_t - R_{t-1}^* {k_{t-1}}^\nu \frac{q_t}{q_{t-1}} (Q_{t-1} K_t - N_{t-1})\right],$$

where aggregate net worth $N_t = \int_N N_t^N f_N dN$, and aggregate capital stock $K_t = \int_N K_t^N f_N dN$. Finally, given that in each period fraction θ of entrepreneurs survive, aggregate net worth at the end of each period evolves as:

$$N_t = \theta V_t + (1-\theta)E$$

where, E is an exogenous constant that ensures that new-born entrepreneurs are endowed with net worth to start production.[10] An important consideration that I want to highlight at this point is the balance sheet effect of the real exchange rate. The assumption of foreign currency debt implies that depreciation of the real exchange rate will dampen the value of entrepreneurial capital, decrease the net worth and subsequently increase leverage both through the marginal financing condition as well as through V_t. Thus, depreciation of the exchange rate in period t will imply an increase in the external financing premium in period $t+1$. This effect of exchange rate on the balance sheet of entrepreneurs is similar to the approach adopted in Céspedes, Chang, and Velasco (2004).

Finally, exiting entrepreneurs consume $C_t^e = (V_t - E)$ after transferring E to the surviving entrepreneurs. Consumption is allocated between home goods and imports such that $C_{H,t}^e = (1-\gamma_1)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta_1} C_t^e$ and $C_{F,t}^e = \gamma_1\left(\frac{P_{F,t}}{P_t}\right)^{-\eta_1} C_t^e$, respectively.

2.4 Capital Producers

Capital producers operate in a perfectly competitive environment, purchase undepreciated capital from entrepreneurs and combine them with new investment goods to construct new capital that is available for production in the next period. Capital producers use both domestic and foreign goods for investment such that aggregate investment evolves as follows:

$$I_t = \left[(1-\gamma_1)^{\frac{1}{\eta_2}} I_{H,t}^{\frac{\eta_2-1}{\eta_2}} + \gamma_1^{\frac{1}{\eta_2}} I_{F,t}^{\frac{\eta_2-1}{\eta_2}}\right]^{\frac{\eta_2}{\eta_2-1}}$$

[10]This can be endogenized as managerial wages to entrepreneurs as used in Christiano, Motto, and Rostagno (2014) which builds off Bernanke, Gertler, and Gilchrist (1999). However for the scope of this analysis this variable does not play any role. Thus to simplify the model, I assume that E is constant. This parameter helps pin down the value of transfers along with the exit rate θ that is consistent for a given value of leverage.

with:

$$I_{H,t}=\Big[\int_0^1 I_{H,t}(i)^{\frac{\epsilon-1}{\epsilon}}di\Big]^{\frac{\epsilon}{\epsilon-1}},\ I_{F,t}=\Big[\int_0^1 I_{F,t}(i)^{\frac{\epsilon-1}{\epsilon}}di\Big]^{\frac{\epsilon}{\epsilon-1}}$$

where η_2 is the elasticity of substitution between domestic and foreign goods, γ_1 is the share of imports in aggregate investment and ϵ is the elasticity of substitution across goods within each category. The optimal allocation of expenditure across home and foreign goods imply the following demand functions for goods produced at home and the foreign country respectively:

$$I_{H,t}=(1-\gamma_1)\Big(\frac{P_t}{P_{H,t}}\Big)^{\eta_2}I_t,\ I_{F,t}=\gamma_1\Big(\frac{P_t}{P_{F,t}}\Big)^{\eta_2}I_t$$

The price index for investment is described as a CES combination of the price index for domestically produced goods - $P_{H,t}$ and the import price index $P_{F,t}$:

$$P_t^I=\Big[(1-\gamma_1)P_{H,t}^{1-\eta_2}+\gamma_1 P_{F,t}^{1-\eta_2}\Big]^{\frac{1}{1-\eta_2}}$$

where,

$$P_{H,t}=\Big[\int_0^1 P_{H,t}(i)^{1-\epsilon}di\Big]^{1-\epsilon},\ P_{F,t}=\Big[\int_0^1 P_{F,t}(i)^{1-\epsilon}di\Big]^{1-\epsilon}$$

Capital production is characterized by adjustment costs following Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007) such that $S(.)=S'(.)=0$ in steady state. Producers of capital goods choose investment I_t as follows:

$$\max_{\{I_t\}} E_t\sum_{t=0}^{\infty}\beta^t\frac{\lambda_{t+1}}{\lambda_t}\Big[Q_tK_{t+1}-(1-\delta)Q_tK_t-\frac{P_t^I}{P_t}I_t\Big]$$

subject to:

$$K_{t+1}=(1-\delta)K_t+\Big[1-S\Big(\frac{I_t}{I_{t-1}}\Big)\Big]I_t$$

$$\text{such that } S\Big(\frac{I_t}{I_{t-1}}\Big)=\frac{\tau}{2}\Big(\frac{I_t}{I_{t-1}}-1\Big)^2$$

$$\text{where } \lambda_t=(C_t-hC_{t-1})^{-\rho}$$

2.5 Nominal rigidities

Nominal rigidities in this framework are important towards generating the simultaneous decline in consumption, investment and output. The intuition relies on the marginal convexity of the profit function. As demonstrated in Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015) and Born and Pfeifer (2017) an increase in the dispersion of future supply creates an upward pressure on the mark-up through channels. First, mark-ups increase endogenously when there is a precautionary-driven contraction in aggregate demand. Second, through a precautionary pricing response by retailers whereby ex ante agents prefer setting higher prices and selling smaller quantities vis-*à*-vis setting a lower price and selling larger quantities. In this framework, I introduce price stickiness following Rotemberg (1982) and DePaoli, Scott, and Weeken (2010).

Retailers - Domestic Goods Following Gertler, Gilchrist, and Natalucci (2007) I assume there is a continuum of monopolistically competitive retailers of measure unity. Each of these retailers purchases wholesale goods at price $P_{W,t}$ from the entrepreneurs, differentiates the products slightly and resells the consolidated aggregate as exports to the rest of the world, to households for consumption and to capital producers for production of investment goods. Retailers also incur a fixed cost of production denoted by K_H. Fixed costs are chosen such that profits are zero in steady state. Let $Y_{H,t}(j)$ be the output produced by retailer j. Final domestic output is a CES composite of individual retail goods and is given as:

$$Y_{H,t} = \left[\int_0^1 Y_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} - K_H$$

The assumption of CES preferences for households, capital producers and rest of the world implies that retailer j faces an isoelastic demand given by: $Y_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H},t}\right)^{-\epsilon} Y_{H,t}$. Given this demand, retailers choose the optimal price. Resetting prices is costly and retailers face quadratic adjustment costs $(AP_j^{p_h})$ in changing the nominal prices of goods with ϕ_{p_h} being the parameter guiding the extent of nominal rigidities. Retailers discount future cash flows using the stochastic discount factor from the households' optimization exercise. Retailers therefore choose prices by maximizing the sum of discounted future cash flows -

$$\max_{\{P_{H,t+s}(j)\}} E_t \sum_{s=0}^{\infty} \beta^j \frac{\lambda_{t+s}}{\lambda_t} \Big[\Big(\frac{P_{H,t+s}(j)}{P_{H,t+s}} \Big) Y_{H,t+s}(j) - \varphi_t Y_{H,t+s}(j) - AP^{p_h}_{j,t+s} \Big]$$

subject to

$$AP^{p_h}_{j,t} = \frac{\phi_{p_h}}{2} \Big(\frac{P_{H,t}(j)}{P_{H,t-1}(j)} - 1 \Big)^2 Y_{H,t}$$

and

$$Y_{H,t}(j) = \Big(\frac{P_{H,t}(j)}{P_H, t} \Big)^{-\epsilon} Y_{H,t}$$

and

$$\lambda_t = (C_t - hC_{t-1})^{-\rho}$$

2.5.1 Retailers - Imported Goods

Retailers of imported goods purchase imports at the dock such that PCP (producer currency pricing) holds. However, in setting the domestic price of imports the importers solve a dynamic markup problem characterized by nominal rigidities. Similar to the specification for domestic retailers, nominal rigidities are introduced through adjustment costs. A point to address while specifying the dynamics of imports is the currency in which imports are invoiced. Gopinath (2016) finds that overwhelming share of world trade is invoiced in very few currencies, with the dollar the dominant currency. This is a small open economy model and the framework abstracts away from the notion of a dominant currency.[11]

The relevant real marginal cost for retailers of imported goods is therefore $\psi_{f,t} = \frac{X_t P^*_F}{P_{F,t}}$ where $P_{F,t}$ is the price of imported goods at home and $P^*_{F,t}$ is the foreign currency price of the wholesale imported goods and X_t is the nominal exchange rate. Similar to retailers of domestic goods, retailers of imported goods purchase wholesale goods from the rest of the world, differentiate them slightly and sell the final aggregate to households for consumption, and capital producers for investment. Resetting prices is costly and retailers face quadratic adjustment costs ($AP^{p_f}_j$) in changing the nominal prices of goods with ϕ_{p_f}

[11]However, in this small open economy model, I indirectly capture the invoicing effect by allowing prices of imports to be more flexible in comparison to domestic goods. A smaller adjustment cost for retailers of imported goods relative to retailers of domestic goods will mean that any change in the real exchange rate will get reflected faster in the prices of imports that domestic residents pay.

being the parameter guiding the extent of nominal rigidities. Retailers of imported goods also incur fixed cost of production denoted by K_F. Fixed costs are chosen such that profits are zero in steady state. Let $Y_{F,t}(j)$ be the output produced by retailer j. The final imported good is a CES composite of individual retail goods and is given as

$$Y_{F,t} = \left[\int_0^1 Y_{F,t}(j)^{\frac{\epsilon_1 - 1}{\epsilon_1}} dj\right]^{\frac{\epsilon_1}{\epsilon_1 - 1}} - K_F$$

CES preferences in households, capital producers and rest of the world implies that retailer j faces an isoelastic demand given by: $Y_{F,t}(j) = \left(\frac{P_{F,t}(j)}{P_{F,t}}\right)^{-\epsilon} Y_{F,t}$. Like the retailers of domestic goods, retailers of imported goods choose prices by maximizing the sum of discounted future cash flows. The optimization problem is given by -

$$\max_{\{P_{F,t+s}(j)\}} E_t \sum_{s=0}^{\infty} \beta^j \frac{\lambda_{t+s}}{\lambda_t} \left[\left(\frac{P_{F,t+s}(j)}{P_{F,t+s}}\right) Y_{F,t+s}(j) - \psi_{f,t} Y_{F,t+s}(j) - AP_{j,t+s}^{p_f}\right]$$

subject to

$$AP_{j,t}^{p_f} = \frac{\phi_{p_f}}{2}\left(\frac{P_{F,t}(j)}{P_{F,t-1}(j)} - 1\right)^2 Y_{F,t}$$

and

$$Y_{F,t}(j) = \left(\frac{P_{F,t}(j)}{P_F, t}\right)^{-\epsilon} Y_{F,t}$$

$$\lambda_t = (C_t - hC_{t-1})^{-\rho}$$

2.6 Monetary Policy

In this model, household utility is defined in terms of habit adjusted consumption. The central bank conducts monetary policy taking into account this feature and follows a modified Taylor rule that responds to CPI inflation (π_t), output gap ($\frac{Y_{H,t}}{Y_H}$) as well as output growth.

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{(1-\chi)} \left[\left(\frac{Y_{H,t}}{Y_H}\right)^{\chi_y} \left(\frac{\pi_t}{\pi}\right)^{\chi_\pi}\right]^{\chi} \left(\frac{Y_{H,t}}{Y_{H,t-1}}\right)^{\chi_{\Delta y}}$$

Here Y_H is the steady state output and R_t is the gross nominal interest rate and $\pi_t = \frac{P_t}{P_{t-1}}$.

2.7 Market clearing

Market clearing implies the following resource constraint for the model economy:

$$Y_{H,t} = \underbrace{\frac{P_t}{P_{H,t}}(C_t + I_t)}_{Domestic\ Demand} + \underbrace{C^*_{H,t} - \frac{P_{F,t}}{P_{H,t}}Y_{F,t}}_{Net\ Exports} + \underbrace{\frac{P_t}{P_{H,t}}C^e_t}_{Entrepr.\ Consumption} + \underbrace{K_H + \frac{P_{F,t}}{P_{H,t}}K_F}_{Fixed\ Costs}$$

Finally, the model is closed by imposing a market clearing condition for domestic bonds. That is, $B_t = \overline{B}$.

2.8 Exogenous Processes

Uncertainty in this environment stems from the time varying volatility of aggregate productivity and I specify the process for aggregate productivity to evolve as follows:

$$a_t = (1 - \rho_a)\overline{a} + \rho_a a_{t-1} + \sigma^a_t u^a_t$$

A shock to u^a_t would correspond to a shock to the first moment or a shock to the *level* of aggregate productivity. Given that uncertainty arises in the model from the time varying volatility of the exogenous disturbances, the key variable of interest is σ^a_t.

$$\sigma^a_t = (1 - \rho_{\sigma_a})\sigma^{\overline{a}} + \rho_{\sigma^a}\sigma^a_{t-1} + \eta_a u^{\sigma^a}_t$$

The main point of distinction between a shock to the first moment (u^a_t) and a shock to the second moment $(u^{\sigma^a}_t)$ is that for the former, the ergodic distribution of the exogenous process remains unchanged and only the average level of the exogenous process changes. For an uncertainty shock however, the average level remains unchanged. Shocks to the second moment transmit by changing the shape of the distribution and increasing the likelihood of tail events. These differences in transmission can be observed in figure 3. For the rest of the paper uncertainty shocks within the scope of this model will refer to a 1 standard deviation shock to $u^{\sigma^a}_t$. $u^{\sigma^a}_t, u^a_t$ are iid processes distributed normally with mean 0 and standard deviation of 1 respectively. The parameters $\sigma^{\overline{a}}$ and η_a control the degree of mean volatility and the extent of stochastic volatility in aggregate productivity: with a high $\sigma^{\overline{a}}$ implying a high mean volatility of aggregate productivity and a high η_a

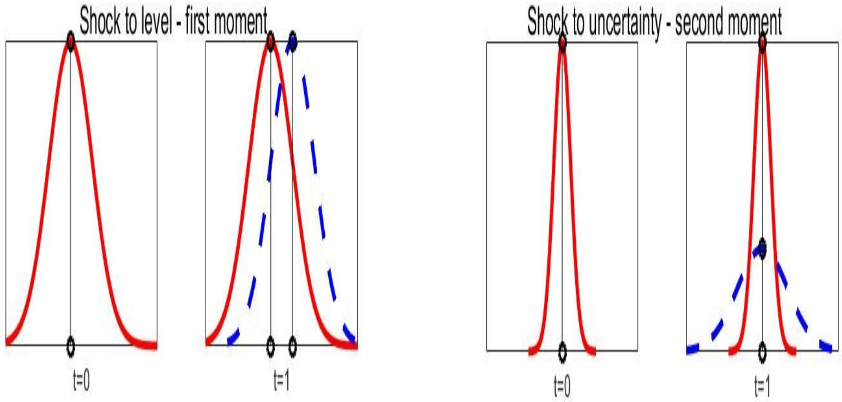

Figure 3: Comparing the effects and transmission of shocks to the first and second moment. A shock to the first moment (u_t^a) does not change the ergodic distribution of the underlying exogenous process. However, shocks to the second moment ($u_t^{\sigma^a}$), alter the distribution of the process under consideration and make extreme events more likely than before.

implying a high degree of stochastic volatility in aggregate productivity. I summarize the nonlinear equilibrium conditions characterizing the model solution in section 1 of the appendix. I next describe the nonlinear solution technique employed to solve the model.

2.9 Model Solution using numerical techniques

The goal of this paper is to explore the interaction of uncertainty shocks and financial frictions in generating business cycle asymmetries across countries. Changes in the second moment lead to a precautionary response among agents in this model economy. The strength of this mechanism relies on the marginal convexity of the utility function as well as the convexity of the marginal revenue function for firms (Sandmo (1970), Kimball (1990), Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015)). A first order approximation will fail to capture these interactions as by construction it rules out these channels of transmission. A second order solution will impact the expected values but not influence the dynamics as higher order terms do not independently enter the solution (Schmitt-Grohé and Uribe (2004)). To effectively quantify the effects of uncertainty shocks, I need to consider at least a third-order solution. This is computationally demanding for a model with multiple state variables. To overcome the hurdles imposed by computational challenges, I use the solution technique suggested in Andreasen, Fernández-Villaverde, and Rubio-Ramírez (2018). The method uses perturbation methods to solve a model using a third-order approximation. In conjunction with this, the method uses pruning to prevent explosive solutions.

2.10 Calibration

The research questions that I seek to answer through this paper are threefold. First, can the standard new Keynesian DSGE model augmented with financial frictions and uncertainty shocks can generate the stylized facts that characterize the response of uncertainty across advanced and emerging countries alike? Second, can fragile financial markets in emerging countries captured in the model through higher values of ν - elasticity of borrowing costs with respect to leverage in conjunction with foreign currency denominated debt generate the amplified response in emerging countries vis-*à*-vis advanced countries? Third, can the qualitative features of the model be used to estimate key parameters that differentiate the response to uncertainty shocks across advanced and emerging countries?

To answer the first two questions, I discuss the transmission of uncertainty highlighting the nonlinear interaction between financial frictions and shocks to the second moment. When I discuss the transmission of uncertainty in section 3, the only channel through which I want to differentiate between advanced and emerging countries is the elasticity of borrowing costs with respect to leverage (ν).

I fix the steady state (non-stochastic) level of leverage to 2.25 and set $\nu^{Emerging} > \nu^{Advanced}$.[12] For the purpose of demonstrating the model properties I set

[12] This is a nonlinear model, and the solution is sensitive to the steady state value of leverage. For given value of ν a higher steady state value of leverage will amplify the responses of variables to uncertainty shocks. Therefore, to purely capture the effects of ν I fix the steady state leverage k_t and differentiate across countries through ν.

Table 1: Calibration

Parameter	Definition	Calibrated Value
	Households - see details of calibration	
$\frac{1}{\rho/(1-h)}$	Intertemporal Elasticity of substituition (after adjusting for habits)	0.25
h	Habit	0.5
ψ	Frisch elasticity of labor supply	1 - Choi and Cook (2004)
η_1, η_2	Elasticity of substitution between home and foreign goods for consumption/investment	0.87
ϕ_B , ϕ_F^*	Portfolio Holding Costs - domestic and foreign Assets	0.0005 0.005 - Born and Pfeifer (2014)
β	Discount Factor	0.98 - Aguiar and Gopinath (2007)
$1-\gamma_1$	Share of home goods in aggregate consumption/investment	0.55
	Foreign Sector - see details of calibration	
η	Elasticity of substitution between home and foreign goods for foreign country	1 - Gertler, Gilchrist, and Natalucci (2007)
γ_2	Share of goods produced at home -exports for rest of the world	0.0187
C^*	Aggregate consumption for rest of the world	200
P_F^*	CPI for Rest of the world	1
R^*	Gross foreign Interest Rate (quarterly)	1.01% (1.04% Annualized after quarterly compounding) - Choi and Cook (2004)
$1-\rho'$	Persistence of export demand from rest of the world	0.75 - Gertler, Gilchrist, and Natalucci (2007)
	Entrepreneurs - see details of calibration	
α	Share of capital in production process	0.5 - Gertler, Gilchrist, and Natalucci (2007)
θ	Exit rate of entrepreneurs	0.915 - Fernandez and Gulan (2015)
η_2	Elasticity of substitution between home and foreign goods for investment	0.89 - Gertler, Gilchrist, and Natalucci (2007)
δ	Depreciation rate	0.05 - Aguiar and Gopinath (2007)
S''	Elasticity of investment adjustment costs	6 - Smets and Wouters (2007) use 5.74
	Retailers - see details of calibration	
ϵ	Elasticity of substitution across varieties for domestically produced goods	21 - Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015)
ϵ_1	Elasticity of substitution across varieties for foreign goods	21 - Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015)
ϕ_{ph}	Rotemberg price adjustment cost for retailers of domestic goods	237.48 - Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015)
ϕ_{pf}	Rotemberg price adjustment cost for retailers of imported goods	150
	Monetary Policy - see details of calibration	
χ_y	Output deviation from steady state	0.08
$\chi_{\Delta y}$	Output growth	0.22 - Smets and Wouters (2007), Hofmann and Bogdanova (2012), Best (2013)
χ_π	CPI inflation	1.5 - Smets and Wouters (2007), Hofmann and Bogdanova (2012), Best (2013)

$\nu^{Emerging} = 0.085, \nu^{Advanced} = 0.065$, $\sigma^{\overline{a},Emerging} = \sigma^{\overline{a},Advanced} = 0.01$, $\eta_a^{Emerging} = \eta_a^{Advanced} = 0.0001$ and $\rho_{\sigma_a}^{Emerging} = \rho_{\sigma_a}^{Advanced} = 0.85$ respectively. Here, $\sigma^{\overline{a}}$ denotes the average level of uncertainty, η_a denotes the extent of stochastic volatility and ρ_{σ_a} denotes the AR(1) coefficient in the process describing the evolution of uncertainty. I discuss the calibration of the remaining parameters in detail in section 2 of the appendix.

Once I establish the success of the model in qualitatively generating the stylized facts, I answer the third question by estimating $\nu, \sigma^{\overline{a}}, \eta_a, \rho_{\sigma_a}$ in recessions for advanced and emerging countries separately and check if model is quantitatively relevant.

3 Transmission Mechanism of an Uncertainty Shock

Uncertainty shocks in a stochastic volatility environment arise from shocks to the standard deviation of exogenous processes. In this model, uncertainty shocks are therefore captured by shocks to $u_t^{\sigma^a}$. Given that the solution is computed using a third-order approximation of the equilibrium conditions, this increase in uncertainty about productivity will trigger a precautionary response among households and firms. Thus, even though, an uncertainty shock will have no first-order effects, through the third-order precautionary channel, it will generate a first-order change in real activity. An increase in uncertainty in the model implies a mean preserving spread for aggregate productivity (a_t). This change in the shape of the distribution of the exogenous processes implies that tail events are more likely than before. This is key towards generating a precautionary response among agents in the model economy.

Following an uncertainty shock in the model, households engage in precautionary savings by supplying more labor and consuming less. This precautionary motive is captured by the changes in the marginal utility. This triggers a fall in aggregate demand. In a model with nominal rigidities, the decline in aggregate demand generates an increase in the mark-up. This upward pressure on the mark-up is further amplified as retailers respond to uncertainty about future supply by engaging in precautionary pricing (Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez (2015)). When these two channels are combined an uncertainty shock in the model generates an increase in mark-up.

The increase in mark-up causes the labor demand curve to shift inwards. While the precautionary savings motive by households pushes the labor supply curve outwards. In equilibrium, wages and hours both decline on impact. The dynamics of labor demand in the presence of nominal rigidities emphasizes the mechanism suggested in Basu and Bundick (2017). Figure 4 illustrates these dynamics.

The reduction in investment demand triggered by the increase in mark-up leads to a decline in the price of capital. Given that both the level of capital stock and the level of aggregate productivity remains unchanged, the fall in employment triggers a decline in the marginal productivity of capital. This in conjunction with the decline in the price

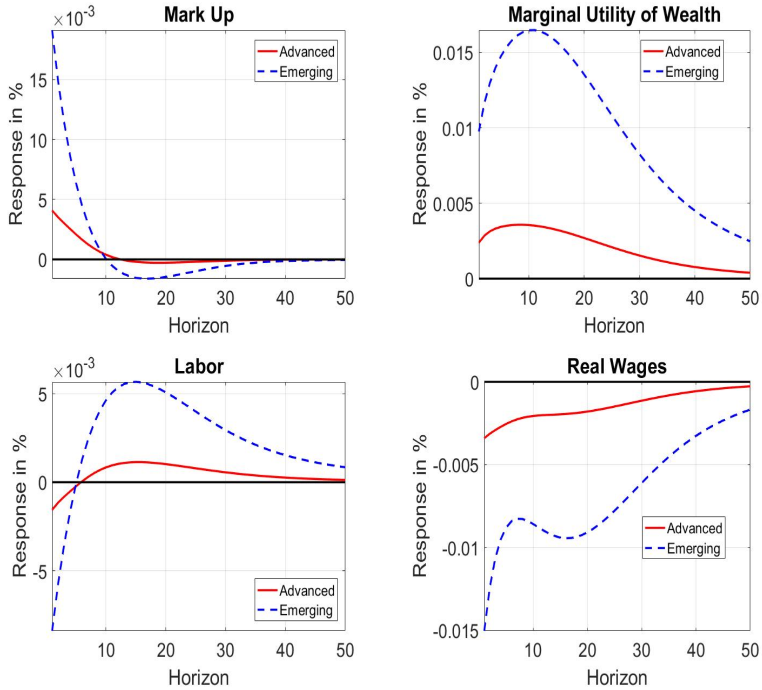

Figure 4: Solid line: Advanced Country, Dashed line: Emerging Country. Upward pricing by firms and precautionary savings by households with nominal rigidities leads to a decrease in wages and hours supplied.

of capital causes the real rate of return on capital to fall. This decline in the rate of return on capital erodes entrepreneurial net worth and causes leverage to increase. This is can be seen by examining the expression for the entrepreneurial value of capital (V_t), net worth (N_t) and leverage (k_t) respectively:

$$V_t = \left[R_t^K Q_t K_t - R^* {k_{t-1}}^{\nu} \frac{q_t}{q_{t-1}} (k_t - 1) N_t \right], \; k_t = \frac{Q_t K_t}{N_t}, \; N_t = \theta V_t + (1-\theta) E$$

These dynamics are qualitatively similar across the two calibrations of the model with the calibration corresponding to emerging countries exhibiting an amplified response. (Refer to figures 4 and 5) The main differentiating feature in responses is brought about by the equilibrium condition that defines the marginal financing condition. Recall,

$$E_t r_{t+1}^K = R_t^* \left[\frac{Q_t K_t}{N_t} \right]^{\nu} E_t \frac{q_{t+1}}{q_t}$$

When the value of ν is large enough, the decrease in capital demand triggered by the decrease in investment is not sufficient towards restoring equilibrium by countering the

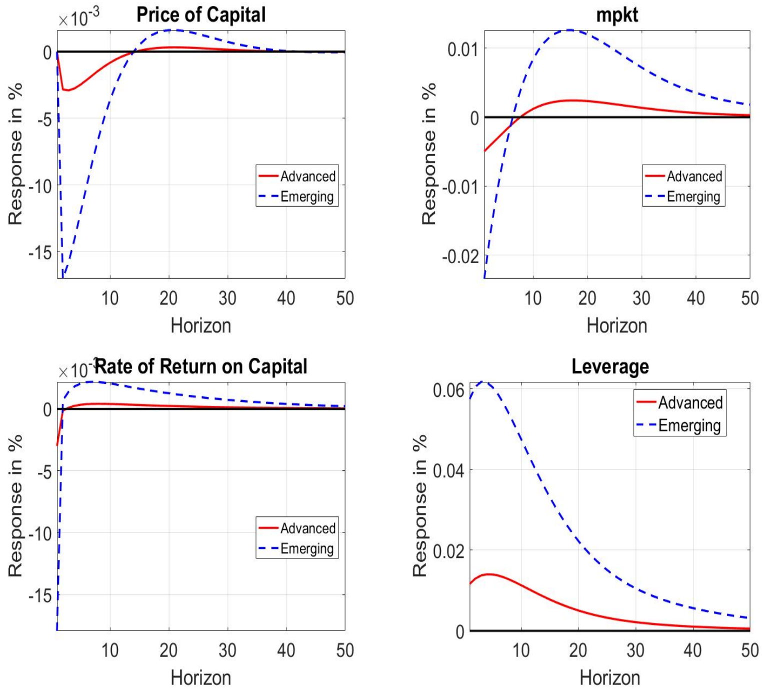

Figure 5: Solid line: Advanced Country, Dashed line: Emerging Country. Decline in capital prices and the marginal productivity of capital (*mpkt*) reduces the rate of return on capital and erodes entrepreneurial value of capital along with increase in leverage.

effect of an increase in leverage. This initial increase in leverage is brought about by the decrease in the value of entrepreneurial capital. Therefore, to restore equilibrium, the currency depreciates and q_t increases. The depreciation of domestic currency further erodes the value of entrepreneurial capital and increases leverage. Thus, for $\nu^{Emerging} > \nu^{Advanced}$, the initial amplification in leverage induced by a higher value of ν is further amplified due to the depreciation of the exchange rate. Higher elasticity of borrowing costs with respect to leverage in conjunction with foreign currency denominated debt are key channels that generate the amplified responses in leverage, exchange rate and investment for the calibration corresponding to that of a representative emerging country.

In addition to reinforcing the financial accelerator mechanism, if the depreciation in the real exchange rate offsets the increase in the price of domestic goods ($P_{H,t}$) relative to the CPI (P_t), it triggers an increase in the demand for exports from rest of the world.

This is can be seen from the following equation governing export demand:

$$C^*_{H,t} = [\gamma_2\Big(\frac{P^*_{H,t}}{P^*_{F,t}}\Big)^{-\eta} C^*_t]^{\rho_\star} {C^*_{H,t}}^{1-\rho_\star}$$

$$= [\gamma_2\Big(\frac{P_{H,t}/P_t}{X_t P^*_{F,t}/P_t}\Big)^{-\eta} C^*_t]^{\rho\prime} {C^*_{H,t}}^{1-\rho\prime}$$

$$= [\gamma_2\Big(q_t\frac{P_t}{P_{H,t}}\Big)^{\eta} C^*_t]^{\rho_\star} {C^*_{H,t}}^{1-\rho\prime}$$

$$\text{with } q_t = \frac{X_t}{P_t} \text{ and } P^*_{F,t} = 1$$

Therefore as long as the increase in q_t exceeds the decline in $\frac{P_t}{P_{H,t}}$, demand for exports increases in response to an upward surge in aggregate uncertainty. These dynamics are demonstrated in figure 6. While on the one hand a weaker domestic currency propels export demand, on the other hand, it amplifies the decline in import demand. Thus, in conjunction, the two can generate an increase in net-exports such that a higher value of ν is associated with a stronger countercyclical response in trade balances.

The model calibrations differing only with respect to this one parameter ν is able to successfully generate the asymmetric response in real variables to the same uncertainty shock, with larger values of ν leading to an amplified decline. Furthermore, it is also able to generate the strong countercyclicality in trade balances that is the key distinguishing feature between business cycles in advanced and emerging countries. Finally,

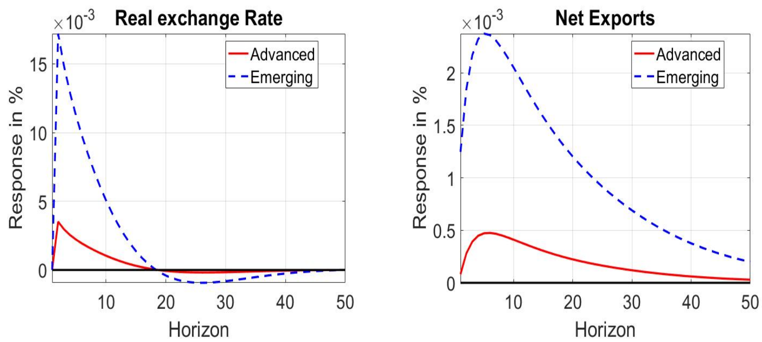

Figure 6: Solid line: Advanced Country, Dashed line: Emerging Country. Differences in the response of the real exchange rate across calibrations for advanced and emerging countries is induced by differences in higher borrowing costs in emerging countries.

given that the decline in consumption and investment demand exceed the increase in net-exports, overall GDP declines. The model specification can therefore successfully generate the simultaneous decline in consumption, investment, and GDP along with a strong countercyclical response by trade balances for the model calibration corresponding to an emerging country. Furthermore, the model can produce the asymmetry in the responses of real variables to an uncertainty shock across model calibrations for advanced and emerging countries. The dynamics of GDP, investment and consumption can be seen in figure 7. Finally, as a secondary feature, the model is also able to generate the decline in labor supply in response to an uncertainty shock.

The main takeaway from the transmission mechanism is: even though an increase in uncertainty might not lead to a negative outcome ex post, precautionary actions by agents can generate decline in real activity that is of first order importance. Furthermore, for countries that are financially fragile this precautionary response is amplified - generating deeper and a more persistent decline in real activity along with a strong countercyclical response in trade balances.

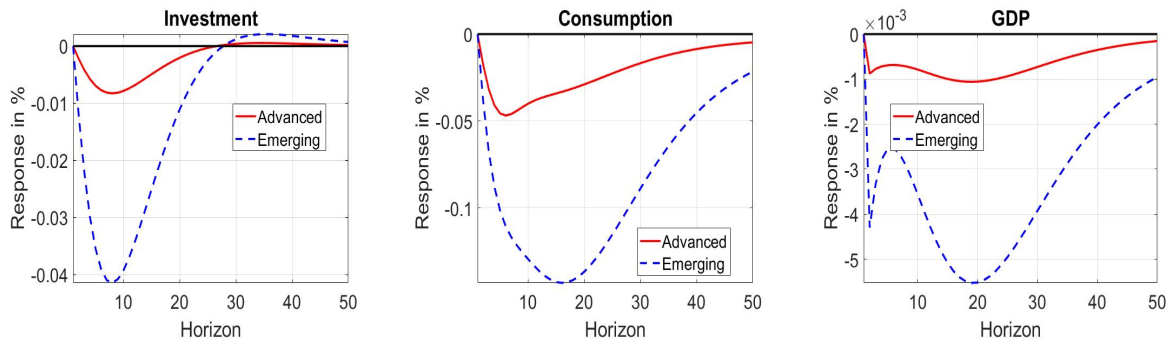

Figure 7: Solid line: Advanced Country, Dashed line: Emerging Country. Simultaneous decline in investment, consumption and GDP in response to an uncertainty shock.

The goal of the calibration exercise was to demonstrate that the model can generate the features that characterize the impact of uncertainty. Now that I have successfully reproduced these qualitative features, I proceed to estimating key parameters guiding the differences in response across advanced and emerging countries.

4 Estimating the role of financial frictions across countries in recessions

The environment with nonlinear interaction between financial frictions and uncertainty shocks together with foreign currency denominated debt can successfully match the qualitative features that characterize the impact of uncertainty across advanced and emerging countries. I use these model properties to quantify the relative importance of shocks versus frictions in the transmission of uncertainty for the two groups of countries. To reconcile the model predictions with the quantitative features of the data, I estimate this nonlinear model using the impulse response function matching estimator. While estimating the model, I will focus on recessions. The reason for focusing on recessions is to consider the countercyclical nature of uncertainty (stylized fact 3).[13]

4.1 Calculating empirical impulse responses

To estimate the nonlinear model, I carry out the following steps. In the first step, I estimate the Smooth Transition Vector Auto Regression Model (STVAR) following Auerbach and Gorodnichenko (2012). The STVAR framework allows me to obtain the recession specific estimate of an uncertainty shock. Second, I calculate impulse responses using the method of local projections following Jordà (2005) by using the recession specific estimate of uncertainty shock in step 1. Finally, in the third step I estimate the parameters of interest by minimizing the distance between the impulse responses calculated in step 2 and the theoretical impulse responses that I obtain from the DSGE model described earlier. I describe the equations that characterize the specification for the STVAR model.

$$Y_t = F(z_{t-1})B_R(L)Y_t + (1 - F(z_{t-1}))B_{NR}(L)Y_t + \epsilon_t \tag{1}$$

$$\epsilon_t \sim N(0, \Omega_t) \tag{2}$$

$$\Omega_t = F(z_{t-1})\Omega_R + (1 - F(z_{t-1}))\Omega_{NR} \tag{3}$$

$$F(z_t) = \frac{exp(-\gamma z_t)}{1 + exp(-\gamma z_t)} \text{ and } \gamma > 0 \tag{4}$$

[13]The effects of uncertainty in non-recessionary phases of the business cycle is negligible. A linear VAR with no regime differentiation will capture a dampened effect of uncertainty as it represents the average effects across recessions and non-recessions (see Chatterjee (2018)). Results for non-recessionary phases can be provided on request.

$$E(z_t) = 0 \text{ and } Var(z_t) = 1 \quad (5)$$

Here, Y_t denotes the vector of endogenous variables and $Y_t = [U_t, I_t, C_t, TB_t, \Pi_t, r_t]'$ or $Y_t = [U_t, I_t, C_t, TB_t]'$ depending on the choice of country and data availability. I quantify uncertainty U_t by using the volatility of stock market returns. I have constructed the quarterly measure of country specific uncertainty by averaging the monthly standard deviation of stock market returns calculated using daily data. Investment I_t (gross fixed capital formation), consumption - C_t (private consumption expenditure), trade balances - TB_t (net exports of goods and services expressed as a percent of GDP), inflation - Π_t (quarter on quarter change in the GDP deflator) and interest rate r_t (policy rate or closest available proxy). Investment and consumption are in log first differences. For trade balances the first difference in the ratio of net exports to GDP has been taken. I use data that has been seasonally adjusted. Data sources and variable definitions have been provided in detail in tables 2 and 3 in section 3 of the appendix. $\{B_R,\ B_{NR}\}$ are the regime specific VAR coefficients and $\{\Omega_R,\ \Omega_{NR}\}$ the regime specific estimates of shocks to this system. [14]

The state transition variable is z_t. Following Auerbach and Gorodnichenko (2012), I define z_t to be the 7 quarter moving average of the real GDP growth rate.[15] The parameter γ takes positive values and governs the smoothness of transition across regimes. As $\gamma \to \infty$ the transition becomes very abrupt between the regimes, whereas setting $\gamma = 0$ reverts the system to the linear VAR specification. By calibrating γ to match the incidence of recessions across countries, I can capture the abruptness in business cycles across advanced and emerging countries. For example, I calibrate $\gamma = 1.75$ for the U.K and $\gamma = 2.5$ for Mexico to account for the fact that for UK 15% of the observed sample (1979 Q1 - 2014 Q3) and for Mexico, 27% in the observed sample (1993 Q1 - 2014 Q2) corresponds to recessionary episodes. Table 4 in section 3 of the appendix lists the parametrization of γ for the entire sample. $F(z_t)$ - the probability of being in the recessionary regime - is calculated using the logistic function with z_t and γ as

[14] R indicates recession-specific estimates, and NR indicates the estimates from the non-recessionary regime.

[15] At time t, z_t is defined using the average of the real GDP growth rate between t-6,t-5,t-4,...,t-1,t.

inputs. As evident from equation 1, the STVAR framework allows for a weighted average representation of the economy. When $F(z_t) \approx 1$, the system generates the dynamics of the economy deep in a recession, and when $F(z_t) \approx 0$, the system generates the dynamics of expansions.

Finally, the STVAR model has been estimated separately for each country, obtain the recession-specific shock to uncertainty from the recession-specific estimate of the variance-covariance matrix Ω_R. I identify the system using the method of Cholesky decomposition with uncertainty ordered as the first variable. The ordering in the empirical specification matches the theoretical set-up whereby shocks to uncertainty are exogenous.[16] Local projections have been computed following Jordà (2005) using the identified shock from the recessionary-regime and obtain the empirical impulse responses for each country. I calculate the impulse responses for the representative advanced country by averaging across the U.S., U.K, France, Canada and for the representative emerging country by averaging across Mexico, South Korea, Chile and Argentina.[17] I use these averaged empirical impulse responses in the final step where I minimize the distance between what is observed in the data and what is found from the theory to estimate the behavioral parameters guiding the transmission of uncertainty for the representative advanced and emerging country groups.

A point to note here is that the DSGE model does not have separate regimes. The method of local projections incorporates regime differences only through the shock and not the structural coefficients like the STVAR model. By estimating the theoretical model using the local projections for recessions, I am therefore recovering the recession-specific estimates of the shock and the financial frictions parameter. The same could be done for an uncertainty shock during non-recessionary episodes, however, since the effects are negligible in non-recessionary phases, I focus on the recession specific shock.[18]

[16]The approach is similar to what has been adopted in Basu and Bundick (2017) where an upward surge in uncertainty is causally prior to the responses of macroeconomic variables. Furthermore, Basu and Bundick (2017) demonstrate that the theoretical counterpart of the VIX in their model is relatively unresponsive to non-uncertainty shocks.

[17]The choice of countries in the estimation is restricted by the availability of data. A crucial ingredient to this regime differentiated view of business cycles is the availability of data points that correspond to recessions. For this the time series must be long enough with sufficient data points corresponding to recessionary episodes.

[18]The use of local projections allows the possibility of recovery during the propagation of shock. So, the system may start in a recession specific shock but recover as the effect of the uncertainty shock tapers

4.2 Impulse Response Function Matching Estimator (IRFME)

The impact of an uncertainty shock on macroeconomic variables is typically characterized by the simultaneous decline in consumption, investment and GDP. Therefore, while estimating the role of financial frictions in generating business cycle asymmetries across countries, I match the responses of consumption and investment.[19] I later validate my results by comparing the predictions of the model for the real exchange rate using the estimated parameters and what I empirically observe.

I proceed to defining the Impulse Response Function Matching Estimator (IRFME) following Hall, Inoue, Nason, and Rossi (2012) that helps isolate the role of key behavioral parameters that guide the differences in transmission across countries. This technique has been used in other papers such as Christiano, Eichenbaum, and Evans (2005) and Christiano, Eichenbaum, and Trabandt (2015). Let, γ denote impulse responses generated from the DSGE model such that,

$$\Gamma = g(\hat{\phi}, \overline{\phi}, h)$$

Let n denote the total number of parameters in the model and $\hat{\phi} = [\hat{\phi}_1, .., \hat{\phi}_{n_1}]$ denote the subset $n_1 < n$ parameters that I estimate using the IRFME procedure. $\overline{\phi} = [\overline{\phi}_{n_1+1}, .., \overline{\phi}_n]$ denotes the set of calibrated parameters in the model. Let $\hat{\Gamma}$ denote the impulse responses to a 1% uncertainty shock constructed by identifying the shock corresponding to the recessionary regime of the STVAR model and implemented using the generalized impulsed responses. $\hat{\Gamma}$ therefore corresponds to the estimate of Γ. The IRFME - $\hat{\phi}_i$= $\hat{\phi}_i(\overline{\phi}, h)$ $\forall i \in$

away.

[19]I exclude GDP from the STVAR since, the seven quarter moving average of real GDP growth rate is used as an input in defining the regime specific probabilities. Including, real GDP as a variable in the STVAR specification while estimation, would imply that the regime changes maybe induced by changes in uncertainty. While this is an interesting question, the main point of focus in this section is to isolate the impact of upward surges in uncertainty during recessionary episodes and quantify the strength of the financial frictions channel in generating the heterogeneous response to uncertainty shocks across countries.

$1, .., n_1$ such that:

$$\begin{pmatrix} \hat{\phi}_1(\overline{\phi}, 1:h) \\ \hat{\phi}_2(\overline{\phi}, 1:h) \\ ... \\ \hat{\phi}_{n_1}(\overline{\phi}, 1:h) \end{pmatrix} = \underset{\hat{\phi}_1(\overline{\phi},1:h),..,\hat{\phi}_{n_1}(\overline{\phi},1:h)}{\arg\min} [\hat{\Gamma} - g(\hat{\phi}, \overline{\phi}, 1:h)]'\hat{\Omega}[\hat{\Gamma} - g(\hat{\phi}, \overline{\phi}, 1:h)]$$

The goal of the estimation procedure is to emphasize the differences in key behavioral parameters that guide the differences in the response of macro variables to uncertainty shocks across countries. The main ingredients that characterize this difference are the elasticity of borrowing costs with respect to leverage - ν , the average level of uncertainty in the economy $\overline{\sigma_a}$, the persistence of second-moment shocks to productivity ρ_{σ_a} and the extent of stochastic volatility, η_a. While estimating the parameters, I hold the leverage fixed across countries to 2.25 so that the parameter ν can entirely capture country specific differences in borrowing costs. Finally, I set $\hat{\Omega}_T = \mathbf{I}_{2h\times 2h}$ such that both consumption and investment are assigned equal importance during the optimization routine.

4.3 Results of the IRFME procedure

Table 2: Estimates from IRFME procedure

Parameter	Average - Emerging Markets	Average - Advanced Economies
ν - Elasticity of borrowing costs wrt leverage	0.0765	0.0625
$\overline{\sigma}^a$ - Average uncertainty	0.05644	0.05397
ρ_{σ_a} - Persistence of second-moment shock - Productivity	0.8180	0.8559
η^a - Stochastic Volatility	0.0031	0.0015
Est. R^K_{t+1}	1.074624	1.06249

There are two things that stand out in the results of estimation process. One, in recessions, the level of uncertainty is comaparable across advanced and emerging countries. Second, this difference in financial frictions and its interaction with uncertainty is crucial towards explaining the heterogeneity in the response of macro variables to an uncertainty shock. The results from the estimation therefore suggest that while average levels of uncertainty are higher in recessions consistently across advanced and emerging countries, this difference in financial frictions and its interaction with uncertainty is crucial towards explaining the heterogeneity in the response of macro variables to an uncertainty shock.

I illustrate this point in the figure 8 below. To outline the importance of financial frictions I carry out the following exercise. I first plot the impulse response of investment as implied by the estimated parameters for the group of advanced economies (column 3 of table 2). Next, I keep the level of financial frictions constant, but change the level of uncertainty. That is, I plot the impulse response of investment using the estimated financial friction for the advanced country group and estimated value of uncertainty for the emerging country group (see crossed line-pink: Counterfactual/Model, figure 8). As seen from figure 8, the difference in the level of uncertainty is not enough to explain the amplified response that is observed for the emerging country group. Finally, I plot the impulse response that is obtained by plugging in the estimated values for the emerging country group (column 2 of table 2). As seen, the nonlinear interaction of higher financial frictions and higher uncertainty is crucial towards generating the observed amplification in the data.

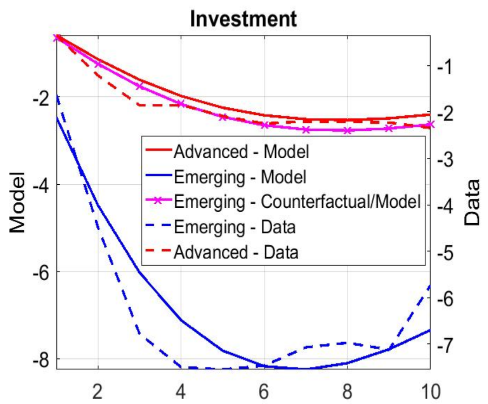

Figure 8: Solid line-red : Advanced Country/Model, Dashed line-red : Advanced Country/Data, Solid line-blue: Emerging Country/Model, Dashed line-blue: Emerging Country/Data. Crossed solid line - Pink: Emerging Country/Counterfactual, X-Axis: Horizon, Y-Axis: Response in %

The estimated values of ν across the two groups of countries implies that in recessions, emerging countries face an annualized premium of 592 basis points in comparison to advanced countries. The findings support my initial hypothesis, whereby I set-up the model environment such that the key difference between advanced and emerging countries show up in the financial frictions that these countries face. The estimates suggest relative importance of financial frictions. I compare the data and model implied impulse responses using the estimated parameters from table 2 in figures 9 and 10.

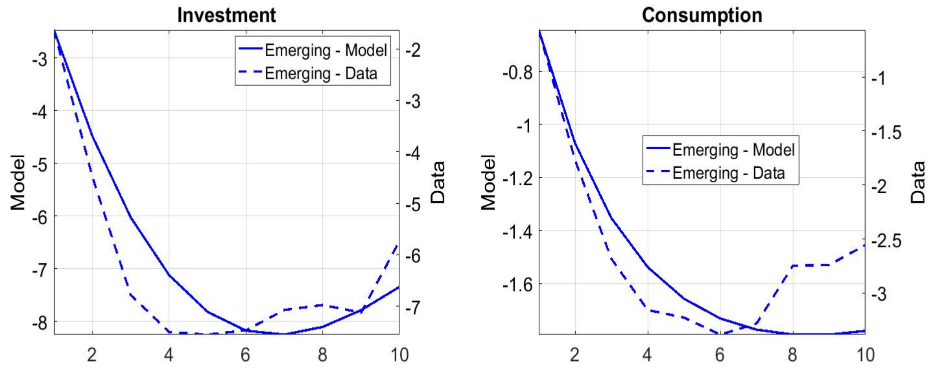

Figure 9: Solid line-blue: Emerging Country/Model, Dashed line-blue: Emerging Country/Data. X-Axis: Horizon, Y-Axis: Response in %

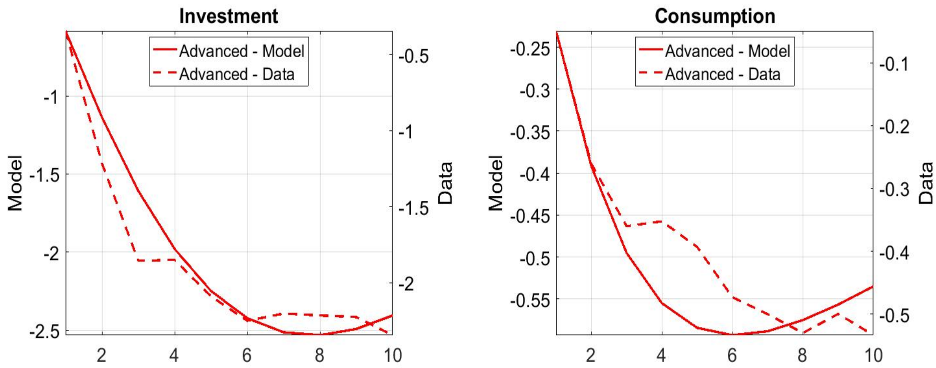

Figure 10: Solid line-red : Advanced Country/Model, Dashed line-red : Advanced Country/Data. X-Axis: Horizon, Y-Axis: Response in %

5 Discussion

The results from the estimation highlight the importance of the nonlinear interaction between uncertainty shocks, financial frictions and the behavioral parameters of the model. This evidence of higher financial frictions in emerging countries, its interactions with uncertainty and real exchange rate can be validated using out-of-sample checks as well as checks within the model.

5.1 Validating the predictions of the model

Emprical response of the real-exchange rate When I estimate the model, I match the impulse responses for consumption and investment from an empirical specification that constructs recession-specific impulse responses from a model consisting of uncertainty, consumption, investment and net-exports. One of the distinguishing features of this model is that it specifies an explicit role for the real-exchange rate. The stronger countercyclical response of trade balances for emerging countries is generated by the larger depreciation in real exchange rate stemming from amplified distortions in borrowing costs from the marginal financing condition. While this is a robust feature of the model, it is useful to examine the empirical response of the real exchange rate considering what is predicted by the model. To check this feature in the data, I calculate the generalized impulse response of the real exchange rate to an uncertainty shock for the two groups of countries and compare it with the model predictions using the estimated parameters from in table 2.[20] As seen from figure 11, this amplified depreciation of the real exchange

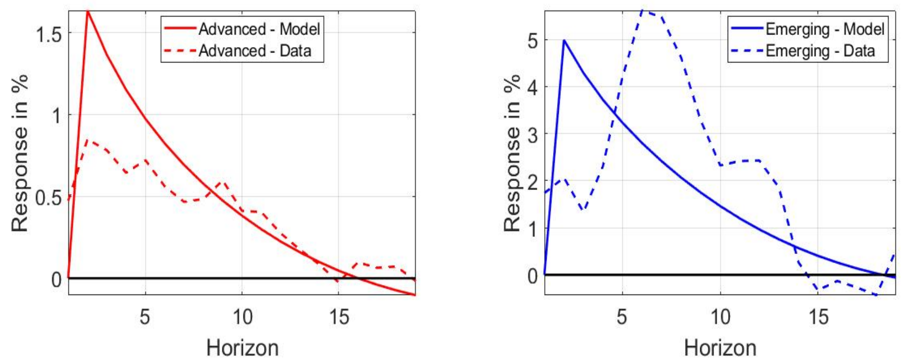

Figure 11: Comparing the responses of the real exchange rate - Model (solid line) and GIRFs (dashed line). X-Axis: Horizon, Y-Axis: Response in %

rate is indeed a consistent empirical feature. If anything, the empirical response exceeds what I find from the estimated theoretical model. For emerging countries, the model with the estimated parameters, imply a peak depreciation of $\approx 5\%$ while in the data the peak response is $\approx 6\%$. For advanced countries, the model predicts a peak response of $\approx 1.5\%$

[20] One point to note here is the availability of the data for the real-effective exchange rate. The broad effective real exchange rate is available since 1994. So, for countries (US, UK, Canada, France and South Korea) where the data in the estimation starts before this date, the narrow effective exchange rate has been used. In the model, the definition of the real exchange rate is consistent with the broad measure.

while the data predicts a peak response of $\approx 0.75\%$. If we had used a one-good framework, the model would have entirely missed out on the dynamics of the real-exchange rate, and the balance sheet channel for transmission of an uncertainty shock.

Linking the theoretical definition of uncertainty to the emprical counterpart Another point I wish to address here is the link between the theoretical and the empirical counterparts of uncertainty. In the data, uncertainty has been measured using the volatility of stock market returns across countries. In the model uncertainty stems from the time-varying volatility of aggregate productivity. This a common convention in the literature where the volatility of stock market return or the VIX is used as a proxy to capture aggregate uncertainty (see Bloom (2009)). The specification in my model, likewise, assumes that the volatility of stock market returns captures changes in uncertainty underlying aggregate productivity. Since there is no stock market return (or the VIX) in the model, I check the validity of this assumption by comparing the impulse responses of the volatility of the one-period ahead expected rate of return on capital across the groups of two countries.

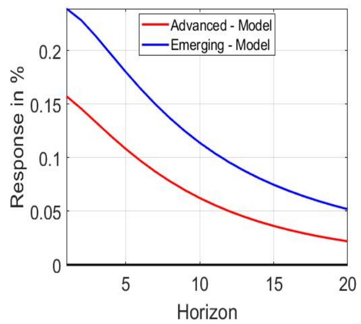

Figure 12: Comparing the responses of the volatility of one-period ahead expected rate of return on capital - Model. X-Axis: Horizon, Y-Axis: Response in %

Using the estimated parameters, I find that the model predicts a larger response in the volatility of the one-period ahead expected rate of return on capital for emerging countries (figure 12). Changes in uncertainty about aggregate productivity triggers a change in the volatility of the one-period ahead expected rate of return on capital for both groups of countries, and this change purely captures the impact of the changes in higher order moments on the marginal financing condition. A change in uncertainty about productivity can therefore generate this type of VIX-like distortion for the marginal financing condition. The model-definition and the empirical definitions of uncertainty can in this way interpreted to be comparable.

5.2 Role of different frictions

In this part, I discuss the importance of the respective channels in the transmission of an uncertainty shock.[21]

The exercise that I conduct is as follows. I examine the transmission of an uncertainty shock under two alternate scenarios. In the first case, I use the estimated values of the parameters that describe the evolution of uncertainty and financial frictions and switch off nominal rigidities by setting price adjustment costs to zero for both domestic and imported goods. I discuss these results in figure 13. An increase in uncertainty on impact in the flexible price model, leads to a precautionary-response induced increase in labor supply and reduction in consumption. However, in the absence of sticky prices, this increased labor supply is absorbed and leads to an increase in net exports, investment and hence GDP on impact. But, a sustained decline in consumption demand leads to a decline in investment and GDP in the periods following the uncertainty shock.

An important point to note here that is even though the qualitative features for investment, consumption and GDP can be generated with flexible prices from the second period onwards, the quantitative fit is extremely poor. Thus even after feeding the estimated values of uncertainty shocks and financial frictions consistent with recessions, the flexible-price model predicts a recession where the amplitude of decline is 0.04% and 0.017% for consumption and investment as opposed to the results from empirical analysis which suggests that when faced with an increase in uncertainty, the amplitudes of decline in consumption and investment are 3.4% and 7.5% respectively.[22]

Next, I switch off the financial frictions channel. In the absence of financial frictions, nominal rigidities for domestic goods and imports are the only remaining distortions such that the framework reverts to a model of a small open economy with incomplete markets

[21] The robustness checks are carried out using the estimated values of parameters from table 2 for emerging countries only. The results are qualitatively similar when evaluated using the estimated parameter values for advanced countries. The intensity of response as before is still linked to the strength of the financial frictions channel.

[22] Amplitude refers to the maximum decline in investment/consumption following an uncertainty shock.

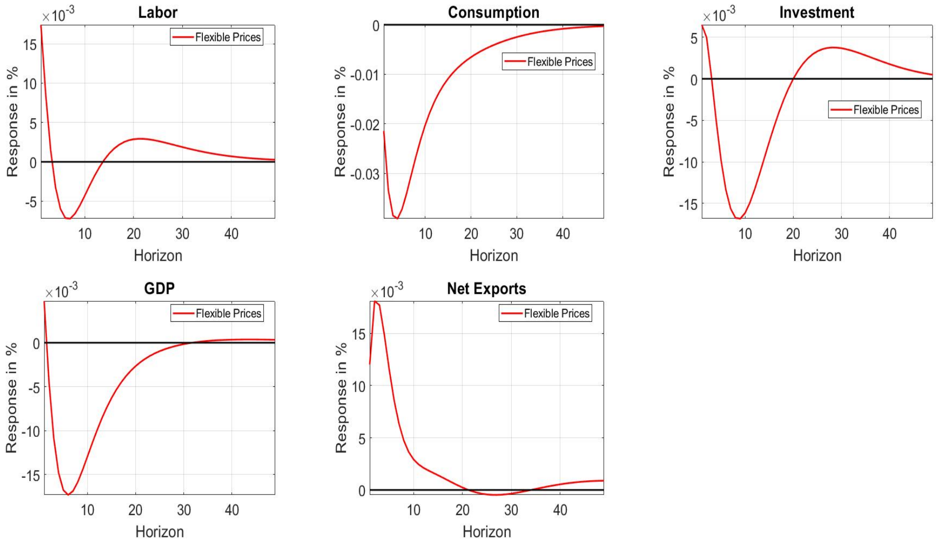

Figure 13: Evaluating the role for different frictions - shutting down the sticky price channel, setting financial frictions and uncertainty to the estimated values from table 2. X-Axis: Horizon, Y-Axis: Response in %

and sticky prices. A key feature in this experiment is that when I set $\nu = 0$, the marginal financing condition now depends on the global risk-free rate and the real exchange rate. In the presence of sticky prices, an uncertainty shock triggers the similar precautionary response from firms and households, but now instead of the financial frictions driving the transmission, the real exchange rate instead becomes the key channel. As seen from figure 14, the real exchange rate depreciates to restore equilibrium - triggering a decline in consumption but increase in net exports, investment and GDP on impact. However, in the periods following the shock, there is a continued decline in consumption, investment and GDP. Like first exercise, the responses are not quantitatively significant.

The key takeaway from this exercise is as follows. While evaluating the role for different frictions, I keep the level of uncertainty to what is implied by the results from the impulse response matching estimation procedure for the recessionary regime (see table 2). However, even with elevated levels of uncertainty and extent of stochastic volatility consistent with recessions in the absence of sticky prices or financial frictions the model is unable to yield quantitatively meaningful predictions. If the model were to be re-calibrated without either friction the implied estimates for the parameters characterizing uncertainty would be several times higher than what is economically or empirically justified.

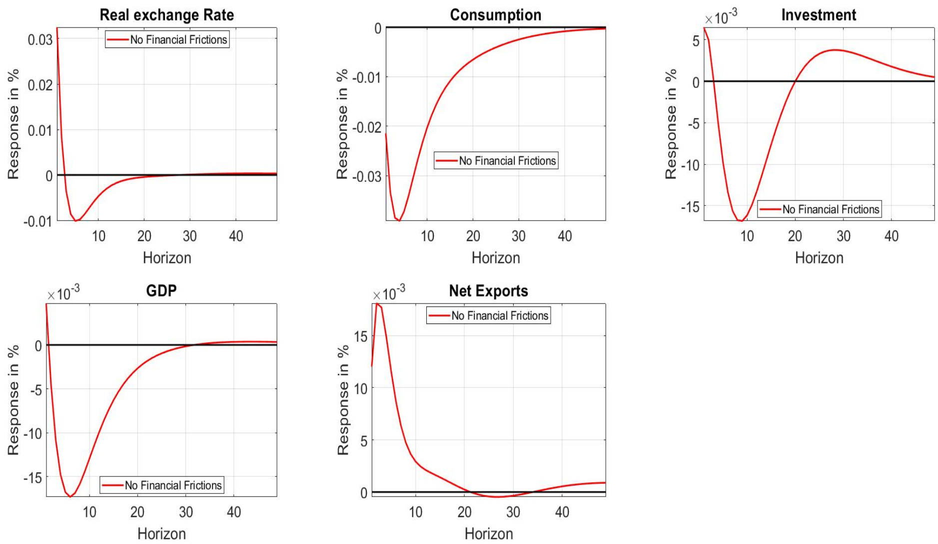

Figure 14: Evaluating the role for different frictions - switching off the financial frictions channel by setting $\nu = 0$, setting uncertainty to the estimated values from table 2 and calibrating price stickiness to values from table 1. In the absence of financial frictions, the model predictions are not quantitatively meaningful. Sticky prices itself are not enough to explain the stylized facts. X-Axis: Horizon, Y-Axis: Response in %

6 Role for policy

An uncertainty shock in this small open economy environment triggers a precautionary response among agents and causes a decline in labor supply, marginal productivity of capital, and subsequently the realized rate of return on capital. This leads to an erosion of net worth and an increase in leverage. Thus, the main channel through which financial frictions and uncertainty shocks interact is the change in leverage from the initial precautionary response. The change in leverage distorts the marginal financing condition which then leads to fall in key macroeconomic variables and a depreciation of the real exchange rate. From a policy perspective, it is interesting to examine possibilities that could potentially mitigate the negative effects of an uncertainty shock by dampening the leverage-induced decline in capital.

One such possibility is to consider countercyclical subsidies that aim at dampening the change in borrowing costs when an uncertainty shock hits the economy (especially during a downturn). I propose a rule which is similar to the policy fraemwork adopted by a financial authority in Carrillo, Mendoza, Nuguer, and Roldan-Pena (2018). The subsidy (tax) $\tau_{s,t}$ evolves as:

$$(1+\tau_{s,t}) = (1+\tau_s)\Big[\frac{E_t r^K_{t+1}}{R^*_t} / \frac{r_k}{R^*_t}\Big]^{a_{r_k}}$$

where r_k denotes the steady state value of the gross rate of return on capital. a_{r_k} is the parameter that governs the intensity with which policymakers respond to deviations of the rate of return on capital from its steady state value. Setting $a_{r_k} = 0$ will revert the economy to the state without any policy response to changes in uncertainty. Setting $a_{r_k} > 0$ will imply that there is a subsidy whenever $\frac{E_t r^K_{t+1}}{R^*_t} > \frac{r_k}{R^*_t}$ and a tax whenever $\frac{E_t r^K_{t+1}}{R^*_t} < \frac{r_k}{R^*_t}$. In steady state with $\frac{E_t r^K_{t+1}}{R^*_t} = \frac{r_k}{R^*_t}, \tau_s = 0$. The subsidy (tax) is introduced such that the expressions for the marginal financing condition and the entrepreneurial value of capital are modified as follows:

$$E_t R^K_{t+1} = \frac{R^*_t (k_t)^{\nu} E_t \frac{q_{t+1}}{q_t}}{(1+\tau_{s,t})}$$

$$V_t = R^K_t Q_t K_t - \frac{R^*_t {k_{t-1}}^{\nu} q_t D_{t-1}}{(1+\tau_{s,t-1})}$$

The subsidies (taxes) are introduced in a balanced-budget way with lump-sum taxes

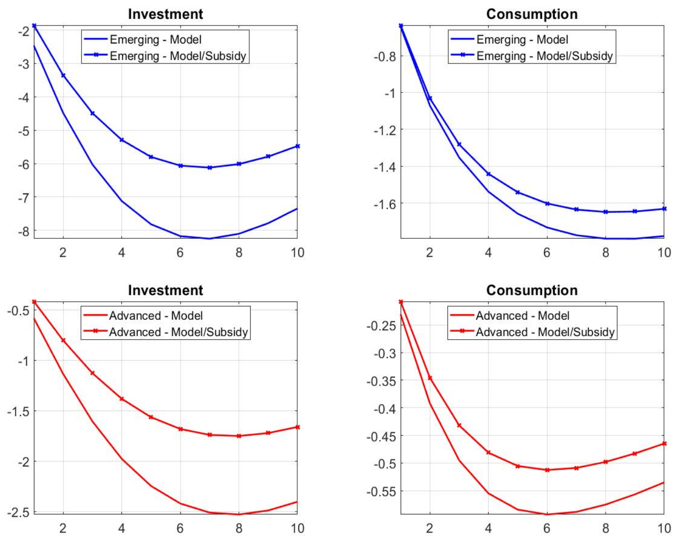

Figure 15: Solid line-red : Advanced Country/Model, Crossed line-red : Advanced Country/Subsidy, Solid line-blue: Emerging Country/Model, Crossed line-blue: Emerging Country/Subsidy. X-Axis: Horizon, Y-Axis: Response in %

(subsidies) being imposed on the household. I set $a_{r_k} = 0.25$, use the estimated values of

$\nu, \overline{\sigma^a}, \rho_{\sigma^a}, \eta^a$ (from table 2) and show that the presence of this countercyclical policy can to a certain extent mitigate the negative effects of an uncertainty shock (see figure 15).

7 Conclusion

An uncertainty shock in my open economy model with financial frictions, foreign currency debt and nominal rigidities manifests itself through precautionary motives of agents in the economy to generate a decline in real activity. Even though ex post, the higher uncertainty might not translate into negative outcomes, precautionary pricing among firms and precautionary saving from households drives GDP, investment and consumption down and triggers a recessionary scenario in the model economy. Financial fragility, reflected in higher borrowing costs, amplifies these responses on the part of agents for an emerging economy and in turn generates the excess volatility that distinguishes these countries from advanced economies. With foreign currency denominated debt and a two-good small open economy environment the model can successfully generate the heightened depreciation of real exchange rate in response to an uncertainty shock in emerging countries. The mechanism I present in the paper is novel. By explicitly addressing the nonlinear interaction between macroeconomic uncertainty and fundamentals, this paper quantifies the loss of real activity attributed to these two separate channels. This in turn helps explain the observed excess volatility in emerging countries. The model is not only successful in qualitatively reconciling the stylized facts but also performs well in matching the quantitative features. I estimate the nonlinear model to find that indeed financial frictions are relatively more important to explain the differential response across advanced and emerging countries.

I present a mechanism that explicitly quantifies the nonlinear interaction between uncertainty shocks and financial frictions and its impact on business cycles across advanced and emerging countries. I subsequently shut down financial frictions and sticky prices to demonstrate the importance of the interaction effects of these two features with elevated levels of uncertainty during recessions in explaining the empirical patterns. I propose the role for a countercyclical subsidy that mitigates the negative effects of an uncertainty shock. While the suggested rule dampens the precautionary response-driven change in leverage in this small open economy environment, it would be interesting to examine the effects of a macroprudential policy in a general equilibrium setting. The other aspect that I do not address but is relevant include the conditions that impact the supply of credit to emerging countries in the face of heightened domestic uncertainty. It would be useful to understand how much of the slowdown in the pace of recovery following a recession or a period of high economic uncertainty is attributed to a disproportionate withdrawal of credit from emerging market economies.

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Appendix

1 Detailed first order conditions of the model

I summarize the complete set of nonlinear equilibrium conditions in the model below. The intra-temporal optimization condition of the households:

$$\frac{L_t^{\psi}}{\left(C_t - hC_{t-1}\right)^{-\rho}} = \frac{P_{H,t}W_t^r}{P_t} \tag{1}$$

The Euler equations for domestic and foreign asset holdings and the modified uncovered interest parity condition following the optimal choice for asset holdings by households:

$$\left[1 + \frac{\phi_B B_t}{P_t}\right] = \beta E_t\left[\left(\frac{C_{t+1} - hC_t}{C_t - hC_{t-1}}\right)^{-\rho} \frac{R_t}{\pi_{t+1}}\right]$$

$$\left[1 + \frac{\phi_{F^*} F_t^* X_t}{P_t}\right] = \beta E_t\left[\left(\frac{C_{t+1} - hC_t}{C_t - hC_{t-1}}\right)^{-\rho} R_t^* \frac{X_{t+1}}{X_t}/\pi_{t+1}\right]$$

Combining the two equations yields the modified UIP condition.

$$\frac{\phi_B B_t}{P_t} - \frac{\phi_{F^*} F_t^* X_t}{P_t} = \beta E_t\left[\left(\frac{C_{t+1} - hC_t}{C_t - hC_{t-1}}\right)^{-\rho} \left(R_t/\pi_{t+1} - R_t^* \frac{X_{t+1}}{X_t}/\pi_{t+1}\right)\right] \tag{2}$$

The budget constraint of the household is given by:

$$P_tC_t + P_t\frac{\phi_B}{2}\left(\frac{B_t}{P_t}\right)^2 + \frac{\phi_F^*}{2}\left(\frac{X_tF_t^*}{P_t}\right)^2 + B_t + X_tF_t^* = P_{H,t}W_t^rL_t + R_{t-1}B_{t-1} + R_{t-1}^*X_tF_{t-1}^* + \Pi_t \tag{3}$$

Residual profits Π_t

$$\Pi_t = P_{H,t}[Y_{H,t} - Y_{H,t}\varphi_t - K_H] + P_{F,t}[Y_{F,t} - Y_{F,t}\psi_{f,t} - K_F] + Q_t[K_t - (1-\delta)K_{t-1} - I_t]$$

Given aggregate productivity (a_t) and the levle of capital (K_t) the optimal choice of labor implies:

$$a_t\frac{P_{W,t}}{P_{H,t}}(1-\alpha)\left(\frac{K_t^N}{L_t^N}\right)^\alpha = W_t^r$$

$W_t^r = \frac{W_t}{P_{H,t}}$ is the real wage expressed in terms of the domestically produced good. Rewriting in real terms, by using the domestic price index ($P_{H,t}$) such that $\varphi_t = \frac{P_{W,t}}{P_{H,t}}$:

$$\varphi_t(1-\alpha)a_t\left(\frac{K_t^N}{L_t^N}\right)^\alpha = W_t^r \tag{4}$$

Optimal choice of capital by entrepreneurs imply:

$$E_tR_{t+1}^K = R_t^*(k_t)^\nu E_t\frac{q_{t+1}}{q_t} \tag{5}$$

Ex post value function:

$$V_t = R_t^KQ_tK_t - R_t^*k_{t-1}{}^\nu q_tD_{t-1} \tag{6}$$

Evolution of net worth:

$$N_t = \theta V_t + (1-\theta)E \tag{7}$$

The optimal choice of investment by producers of capital] given capital demand from entrepreneurs imply

$$Q_t\left[1 - S(\frac{I_t}{I_{t-1}}) - S'(\frac{I_t}{I_{t-1}})\frac{I_t}{I_{t-1}}\right] + \beta E_t\frac{\lambda_{t+1}}{\lambda_t}Q_{t+1}\left[S'(\frac{I_{t+1}}{I_t})(\frac{I_{t+1}}{I_t})^2\right] = \frac{P_t^I}{P_t} \tag{8}$$

The first oder conditions from price setting in the presence of nominal rigidties by retailers of domestic and imported goods:

$$\left[(1-\epsilon) + \epsilon\varphi_t - \phi_{p_h}\frac{P_{H,t}}{P_{H,t-1}}\left(\frac{P_{H,t}}{P_{H,t-1}} - 1\right)\right] + \phi_{p_h}\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{P_{H,t+1}}{P_{H,t}}\left(\frac{P_{H,t+1}}{P_{H,t}} - 1\right)\frac{Y_{H,t+1}}{Y_{H,t}} = 0 \tag{9}$$

$$\left[(1-\epsilon) + \epsilon\psi_{f,t} - \phi_{pf}\frac{P_{F,t}}{P_{F,t-1}}\left(\frac{P_{F,t}}{P_{F,t-1}} - 1\right)\right] + \phi_{pf}\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{P_{F,t+1}}{P_{F,t}}\left(\frac{P_{F,t+1}}{P_{F,t}} - 1\right)\frac{Y_{F,t+1}}{Y_{F,t}} = 0 \tag{10}$$

where $\psi_{f,t} = \frac{X_tP_{F,t}^*}{P_{F,t}}$ is the relevant real marginal cost for retailers of imported goods.

Defining the CPI

$$P_t = \left[(1-\gamma_1)P_{H,t}^{1-\eta_1} + \gamma_1P_{F,t}^{1-\eta_1}\right]^{\frac{1}{1-\eta_1}} \tag{11}$$

The central bank conducts monetary policy following a modified Taylor Rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{(1-\chi)} \left[\left(\frac{Y_{H,t}}{Y_H}\right)^{\chi_y} \left(\frac{\pi_t}{\pi}\right)^{\chi_\pi}\right]^{\chi} \left(\frac{Y_{H,t}}{Y_{H,t-1}}\right)^{\chi_{\Delta y}} \tag{12}$$

Market clearing condition

$$Y_{H,t} = \underbrace{\frac{P_t}{P_{H,t}}(C_t + I_t)}_{Domestic\ Demand} + \underbrace{C^*_{H,t} - \frac{P_{F,t}}{P_{H,t}} Y_{F,t}}_{Net\ Exports} + \underbrace{\frac{P_t}{P_{H,t}} C^e_t}_{Entrepr.\ Consumption} + \underbrace{K_H + \frac{P_{F,t}}{P_{H,t}} K_F}_{Fixed\ Costs} \tag{13}$$

Aggregate demand for imports $Y_{F,t}$ is defined as follows:

$$Y_{F,t} = \gamma \left[\frac{P_{F,t}}{P_t}\right]^{-\eta} \left[C_t + I_t + C^e_t + K_F\right] \tag{14}$$

Aggregate demand for domestic goods $Y_{H,t}$ is defined as follows:

$$Y_{H,t} = (1-\gamma) \left[\frac{P_{H,t}}{P_t}\right]^{-\eta} \left[C_t + I_t + C^e_t + K_H\right] \tag{15}$$

Shocks:

$$a_t = (1-\rho_a)\overline{a} + \rho_a a_{t-1} + \sigma^a_t u^a_t \tag{16}$$

$$\sigma^a_t = (1-\rho_{\sigma_a})\overline{\sigma^a} + \rho_{\sigma^a} \sigma^a_{t-1} + \eta_a u^{\sigma^a}_t \tag{17}$$

2 Model calibration for understanding the transmission of uncertainty in section 3

Parameter	Definition	Calibrated Values
k_t	Leverage - Representative Advanced Country	2.25
k_t	Leverage - Representative Emerging Country	2.25
ν	Elasticity of borrowing costs wrt leverage - Representative Advanced Country	0.065
ν	Elasticity of borrowing costs wrt leverage - Representative Emerging Country	0.085
$\overline{\sigma^a}$	Mean Volatility	0.01
η_a	Stochastic Volatility	0.0001
ρ_{σ^a}	Persistence: σ^a_t	0.85
ρ_a	Persistence: a_t	0.85

Table 1: Fixing parameters characterizing uncertainty shocks

The given values of leverage and ν imply borrowing costs of 6.47% and 8.21% per quarter for the representative emerging and advanced country respectively. The steady state level of aggregate productivity is fixed to 1. The remaining behavioral parameters have been calibrated as follows:(Back to main text).

Households and foreign sector: I fix the discount factor β to 0.98 for emerging countries and 0.997 for advanced countries, the coefficient of risk aversion $\rho = 2$. Household consumption is characterized by external habits with the parameter h governing the extent of indexation to past consumption. I set $h = 0.5$. The calibrated values for h and ρ imply an intertemporal elasticity of substitution of 0.25.[23] The Frisch elasticity of substitution is obtained as $\frac{1}{\psi} = 1$ by

[23]The formula for the intertemporal elasticity of substitution being given as $\frac{1}{\rho/1-h}$.

setting $\psi = 1$.[24] The elasticity of substitution between exports and imports for consumption - η_1 is set to 0.87. [25] η - the elasticity of substitution between exports and imports for the foreign sector is set to 1 allowing for a greater degree of substitutability for rest of the world relative to the small open economy under consideration (Gertler, Gilchrist, and Natalucci (2007),Choi and Cook (2004)). Portfolio holding costs for domestic (ϕ_B) and foreign assets (ϕ_F) are set to 0.0005 and 0.005 respectively. The portfolio holding costs in conjunction with the discount factor, and steady state level of domestic bond holdings pin down the steady state value of the domestic interest rate.

Entrepreneurs: In addition to leverage (k) and elasticity of borrowing costs with respect to leverage (ν), the other parameters that characterize the choices of the entrepreneurs are - α - share of capital in the production function and θ - the exit rate of entrepreneurs. I fix α to 0.5 (following Gertler et al. (2007)). I set θ to 0.915 as estimated by Fernandez and Gulan (2015) for the calibration corresponding to a representative emerging country. To preserve symmetry in all dimension excepting ν I calibrate θ to 0.915 for the representative advanced country as well.

Capital Producers: The key parameters of interest for capital producers comprise the elasticity of substitution between domestic goods and imports for investment goods - η_2, the depreciation rate of capital- δ and investment adjustment costs $S''(.)$. For simplicity I set $\eta_2 = \eta_1 = 0.87$.[26] δ is calibrated to 0.05. $S''(.)$ is calibrated to 6.

Retailers: I introduce nominal rigidities in the model using Rotemberg (1982). The parameter governing the price adjustment cost for retailers of domestic goods - ϕ_{p_h} is set to 237.48 following Fernández-Villaverde et al. (2015). I follow Fernández-Villaverde et al. (2015) and set the elasticity of substitution across goods within a category (domestically produced and imports) to 21 such that in steady state firms face a mark-up of $\approx 5\%$. For retailers of imported goods, I set the price adjustment cost for the retailers of imported goods - ϕ_{p_f} to 150. The lower value indicates that prices of imports are more flexible in domestic currency and allowing for exchange rate pass-through at a faster pace.

Monetary Policy: The parameters of the Taylor rule are set to standard values adopted in the literature with the coefficient on inflation $\chi_\pi = 1.5$, coefficient on output gap with respect to steady state $\chi_y = 0.08$ and coefficient on the growth rate of output $\chi_{\Delta y} = 0.22$ for both groups of countries. Hofmann and Bogdanova (2012) estimate the Taylor rule for 11 advanced economies and 17 emerging market countries using data between 1995 and 2012 to to find that on average the coefficient on inflation is 1.5 for both groups of countries. The main difference lies in the steady state real interest rate. For emerging countries this is estimated to be 6% and for advanced economies it is estimated to 2%. The steady state real interest rate differential is pinned down in the model by using different values of household discount factor β (0.98 for emerging and 0.997 for advanced countries). The sample used in Hofmann and Bogdanova (2012) includes Mexico, Chile, Argentina and South Korea – the countries that are included in my sample. Furthermore, Best (2013) estimates the Taylor rule parameters using a sample between 1995 and 2005 for Mexico to find that the coefficient on inflation is 1.24 and the coefficient on the growth rate of output is 0.38. Given these results, I set the parameters governing the Taylor rule for both groups of countries to be the same. (Back to main text).

3 Data Description

[24]Decreasing the elasticity of labor supply amplifies the impact of uncertainty shocks.

[25]Decreasing the elasticity of substitution between exports and imports for the foreign sector amplifies the impact of uncertainty shocks.

[26]Typically, investment goods exhibit a lower degree of substitution in comparison to consumption goods. Letting the price indices for investment and consumption to display this heterogeneity will amplify the effects of uncertainty shocks.

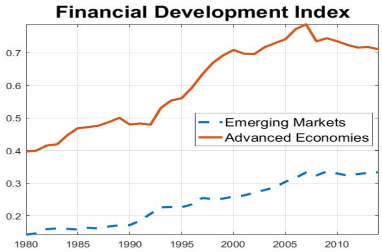

Figure 1: Financial Development Index calculated using the access, depth and efficiency of financial institutions and markets for advanced and emerging countries. Source: International Monetary Fund.

Country	Variable used for defining Uncertainty
U.S. ($1986Q1 - 2014Q2$)	CBOE VIX
U.K. ($1979Q1 - 2014Q3$)	FTSE Composite Index
Canada ($1990Q1 - 2014Q4$)	Composite Index Toronto Stock Exchange
South Korea ($1975Q1 - 2014Q3$)	Korea Stock Exchange - Kospi Composite Index
France ($1991Q1 - 2014Q4$)	Stock Market Index - SBF 250 Index
Mexico ($1993Q1 - 2014Q2$)	Mexican Stock Exchange: Bolsa IPC
Chile ($1993Q1 - 2014Q2$)	Santiago Stock Exchange- IGPA Index
Argentina($1993Q1 - 2014Q2$)	Buenos Aires Stock Exchange - Merval Index

Table 2: Defining Uncertainty

Country	GDP - Total	Gross Fixed Capital Formation	Private Consumption Expenditure	GDP Deflator	Exports of Goods and Services	Imports of Goods and Services	Interest Rate
U.S. ($1986Q1 - 2014Q2$)	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	Effective Federal Funds Rate - FRED
U.K. ($1979Q1 - 2014Q3$)	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	3-Month or 90-day Rates and Yields: Treasury Securities for the U.K. -FRED
Canada ($1990Q1 - 2014Q4$)	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	Not Used
France ($1991Q1 - 2014Q4$)	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	Not Used
South Korea ($1975Q1 - 2014Q3$)	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	Not Used
Mexico ($1993Q1 - 2014Q2$)	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	3-Month or 90-day Rates and Yields: Treasury Securities for Mexico - FRED
Chile ($1993Q1 - 2014Q2$)	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	OECD Main Economic Indicators	Not Used
Argentina ($1993Q1 - 2014Q2$)	IMF, International Financial Statistics (IFS)	IMF, International Financial Statistics (IFS)	IMF, International Financial Statistics (IFS)	IMF, International Financial Statistics (IFS)	IMF, International Financial Statistics (IFS)	IMF, International Financial Statistics (IFS)	Not Used

Table 3: Data Definitions: Variables reported are seasonally adjusted and recorded in local currency units.

Country	US	UK	Canada	France	South Korea	Mexico	Chile	Argentina
γ	1.6	1.75	2.25	2	1.75	2.5	2.75	2

Table 4: Choice of γ for the sample of countries chosen in the analysis. Higher values of γ correspond to more abrupt transitions between the recessionary and the non-recessionary regimes. γ has been chosen to match the incidence of actual recessionary episodes in the sample chosen for each country.