Uncertainty Shocks, Financial Frictions and Business Cycle
Asymmetries Across Countries †
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Abstract
This paper explores the interaction of uncertainty shocks and financial frictions in explaining the excess volatility of real variables in emerging countries vis-à-vis advanced countries. I use an open economy DSGE model augmented with the financial accelerator mechanism, nominal rigidities and uncertainty evolving as the time-varying volatility of exogenous shocks. The model is solved using perturbation techniques about a third order approximation to the equilibrium conditions of the model. An uncertainty shock in the model triggers a precautionary response among agents and generates the simultaneous decline in GDP, investment and consumption in this open economy environment. Financial frictions interact with uncertainty to generate the amplified responses in emerging countries along with producing a strong countercyclical response in trade balances. Using this feature of the model I estimate key behavioral parameters that guide differences in business cycle characteristics across advanced and emerging countries using a sample of 8 countries (U.S., U.K., Canada, France, Mexico, Chile, Argentina and South Korea). The results from estimation suggest that borrowing costs for non-financial debt in emerging countries are 270-288 basis points higher compared to advanced countries. While heightened uncertainty is common for both groups of countries in recessions, differences in financial development captured through financial frictions is key towards generating the amplified responses in emerging countries.

JEL Classification Codes: C32, E32, F41, E37, F44, G15
Keywords: Uncertainty Shocks, Financial Frictions, Emerging Countries, Recessions, Business Cycles.

†I am grateful to Fabio Milani and Eric Swanson for their extensive guidance and research advice. I am thankful to Gary Richardson, Andrew Foerster and Antonio Rodriguez-Lopez. I want to thank the participants of 4th Annual Conference of the The Society for Economic Measurement and CAFRAL conference on Financial system and Macroeconomy in Emerging Economies organized by the Reserve Bank of India for their feedback and comments.
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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. Policymakers in various speeches have suggested heightened economic uncertainty as the chief impediment to the global recovery. The other important feature that has garnered special attention in macro models following the Great Recession is the role of financial frictions. Prior to the financial crisis the vast majority of the literature assumed frictionless financial markets. The goal of my paper is threefold. First to highlight the importance of the interaction between financial frictions and aggregate uncertainty in generating recessionary episodes across different countries (advanced and emerging). Second, to underscore the importance of fragile financial systems in amplifying a crisis in emerging countries. Third to estimate key parameters that guide the differences in response across countries.

Specifically, this paper aims to reconcile the differences in the response of real variables to uncertainty shocks across advanced and emerging countries within the framework of a small open economy model. I unify the two approaches that traditionally describe the causes of excess volatility in emerging countries – differences in fundamental features versus differences in exogenous processes - by examining the interaction of financial frictions and uncertainty shocks. While contributing to the literature examining business cycle differences across advanced and emerging countries, this paper also extends the analysis of uncertainty shocks to an open economy framework.

These two strands of literature – the role of uncertainty shocks in explaining business cycle fluctuations and the causes of excess volatility in emerging countries - are characterized by certain stylized facts and modelling conventions. I describe each of these and how I bring together these different ideas within the framework of this analysis.

The impact of uncertainty on the macroeconomy has been explored in earlier works by Bernanke (1983) and Dixit and Pindyck (1994). However, the aftermath of the Great Recession has rekindled the interest in exploring the role of economic uncertainty in generating business cycle fluctuations with a seminal contribution by Bloom (2009). This strand of literature suggests three main stylized facts that characterize the impact of uncertainty on the macroeconomy.

\(^1\)Christine Lagarde 2012, Richard W. Fisher 2013
\(^2\)DSGE models in the Conduct of Policy: Use as intended, edited by Refet S. Gurkaynak and Cedric Tille
First, an increase in uncertainty triggers a ‘wait and see’ response among agents leading to a simultaneous decline in consumption, investment and output (stylized fact 1). Second, emerging and low-income countries are more vulnerable to uncertain environments (stylized fact 2). Third, the effects of higher uncertainty matter more during downturns in the business cycle (stylized fact 3).

The existing literature has attempted to reconcile the consequences of uncertainty shocks within the framework of micro founded models. However, the emphasis has largely been focused towards generating the first stylized fact within the framework of closed economy models calibrated to match characteristics of developed countries such as the United States (Basu and Bundick 2017). In the context of international macroeconomics, Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez and Uribe (2011) examine the role of interest rate uncertainty within the framework of a one sector real business cycle model with the analysis being focused exclusively on emerging countries.

The literature examining the excess volatility of real variables in emerging countries has evolved along two complementary approaches. On the one hand the work of Aguiar and Gopinath (2007) emphasizes the differences in exogenous processes as the guiding factor in the observed excess volatility. The authors 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. The other approach emphasizes that while underlying exogenous processes driving business cycles are similar across countries, differences in fundamentals such as weaker institutions, political instability, and unstable policy amplify the effect of a shock and drive the observed asymmetry between the two sets of countries.

Among these different channels, financial frictions have garnered special interest. Neumeyer and Perri (2005) highlight the dependence of country specific characteristics on borrowing costs within a theoretical framework and subsequently use Argentina as a representative emerging country to generate the observed excess volatility within this model. Uribe and Yue (2006) underscore that the feedback from emerging country fundamentals to country spreads significantly exacerbate business cycle fluctuations. Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez and Uribe (2011) build upon the results from Uribe and Yue (2006) and explore the
uncertainty about interest rates through a stochastic volatility representation for Argentina, Brazil, Ecuador and Venezuela.

The interaction of financial frictions and uncertainty shocks has been investigated to a certain extent within closed economy models and empirical studies. Bonciani and Roye (2016), for instance explore uncertainty shocks in a closed-economy general equilibrium model with a banking sector and sticky prices. Swallow and Cespedes (2013) examine the impact of uncertainty shocks within an SVAR framework for advanced and emerging countries. One of the findings from Swallow and Cespedes (2013) paper suggest that, after controlling for credit market imperfections such as supply of loans there is a significant reduction in the amplification of investment for some emerging countries. In the context of international macroeconomics and business cycle asymmetries across advanced and emerging countries, however, the role of uncertainty shocks has been investigated to lesser extent.

The novel contribution of this paper is to combine these two approaches in an open economy model and isolate the role of financial frictions and exogenous shocks to uncertainty in driving the amplified responses of real variables in emerging countries. I build the theoretical framework on the empirical findings from Chatterjee (2017) where I document the differences in the response of macroeconomic variables to uncertainty shocks across advanced and emerging countries during downturns in business cycles. The findings from Chatterjee (2017) suggest that uncertainty shocks on average generate an amplified response in emerging countries vis-à-vis advanced countries in recessions. Furthermore, along the lines of Aguiar and Gopinath (2007), the results advocate a strong countercyclical response in trade balances to uncertainty shocks as an important distinguishing feature in the response of real variables to uncertainty shocks across these two groups of countries. In addition to this asymmetry the findings underscore the countercyclical nature of uncertainty such that uncertainty shocks are more important during business cycle downturns and that the linear model consistently underestimates the impact of uncertainty shocks across countries. These findings are summarized in following figure.
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.

In the theoretical specification of my model, following Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez and Uribe (2011), uncertainty stems from the time-varying volatility of exogenous processes (preferences and aggregate productivity). Financial frictions are 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 presented in this paper takes a serious approach in preserving the different aspects of an open economy model in specifying the dynamics of trade balances and allowing for different degrees of exchange rate pass-through which is an important empirical distinction between advanced and emerging countries.

To make uncertainty or shocks to the second moment relevant for the dynamics of the
model, I solve the model using perturbation methods, in particular, a third order Taylor Series expansion as suggested in Andreasen, Fernandez-Villaverde and Rubio-Ramirez (2016). This deviation from a log-linearized solution also allows for the nonlinear interaction of uncertainty and macroeconomic variables that is emphasized in the empirical findings from Chatterjee (2017). Furthermore, a higher order solution allows me to outline the welfare costs of financial frictions and uncertainty shocks and together with the dynamics enables me to quantify the role of financial fragility in exacerbating the loss in real activity during periods of heightened economic uncertainty.

I use a small open economy model with nominal rigidities in prices and foreign currency denominated debt along with the financial accelerator mechanism. The former ensures a precautionary response on the part of firms that is key towards generating a simultaneous decline in investment, consumption and output in response to an uncertainty shock (stylized fact 1 characterizing the impact of uncertainty shocks). The financial accelerator mechanism in conjunction with foreign currency denominated debt is pivotal in generating the amplified response in emerging countries (stylized fact 2 – emerging countries are more vulnerable to uncertainty shocks) along with reproducing stronger countercyclical behavior in trade balances. Finally, I estimate parameters governing the differences in financial market imperfections and uncertainty shocks across countries in recessions to shed light on structural differences that exacerbate the impact of uncertainty in recessions across countries (stylized fact 3 – the impact of uncertainty shocks is countercyclical in nature). 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 Jorda (2005).

The main results that 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 GDP. Second, I find that by varying the strength of the financial accelerator mechanism, the model can generate the amplified responses of real variables (consumption, investment and GDP) with strongly countercyclical trade balances that is characteristic of business cycles in emerging countries.
My findings therefore emphasize the interaction of uncertainty shocks and financial frictions in generating business cycle asymmetries between advanced and emerging countries. Third, the results of the estimation suggest that differences in the extent of financial development captured through financial frictions are key towards generating the differences in business cycle characteristics for these two groups of countries. I first estimate the model for the U.K and Mexico – as representatives of advanced-open and emerging-open countries and subsequently generalize the findings by estimating the parameters by averaging across a sample of 4 advanced and 4 emerging countries (U.S., U.K., Canada, France, Mexico, Chile, Argentina and South Korea).

The results from estimation suggest that borrowing costs for non-financial debt in emerging countries are 270-288 basis points higher compared to advanced countries in recessions. While heightened uncertainty is common for both groups of countries in recessions, differences in financial development captured through financial frictions is key towards generating the amplified responses in emerging countries. From a policy perspective, the results suggest that investing in better integrated financial markets and robust financial infrastructure can reduce the volatility underlying key macro variables in times of high macroeconomic uncertainty for 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. First, an upward surge in uncertainty triggers a simultaneous decline in consumption, investment and GDP in a small open economy model. Second, financial frictions and uncertainty shocks interact to generate the asymmetric effect of uncertainty shocks across model calibrations corresponding to representative advanced and emerging countries respectively. In section 4, I match impulse responses generated from the model with impulse responses to uncertainty shocks calculated using a combination of parameter estimates from the recessionary regime of Smooth Transition Vector Auto Regression model and generalized impulse response functions to estimate the parameters of interest guiding the asymmetry in the behavior of macroeconomic variables across the two types of countries in recessions. In section 5, I compare the stochastic and non-stochastic steady states of the model to quantify the loss in real activity attributed to the interaction of financial frictions and uncertainty.
2 Model Specification

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

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

here, $H_t$ denotes the level of habits. $L_t$ 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. Presence

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3Habit 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 me match the hump shaped response of consumption to an uncertainty shock.
of external habits will allow for differences in risk aversion (across model specifications for advanced and emerging countries) for a given value of $\rho$. $\beta \in (0, 1)$ is the discount factor and $z_t$ is the shock to preferences. The intertemporal shock ($z_t$) governs how consumers weigh current utility relative to future utility.

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 as follows:

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

such that

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

where $\eta_1$ is the elasticity of substitution between domestic and foreign goods, $\gamma_1$ is the share of imports in the consumption basket and $\epsilon$ is the elasticity of substitution across goods within each category.

The budget constraint faced by the household is given by:

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

where, 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:

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

such that

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

$W_t^*$ 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\(^4\). Households can invest in domestic bonds: $b_t$ and foreign bonds: $F_t^*$ subject to portfolio holding costs $\Gamma_t$. The costs to holding foreign and domestic assets are modeled following Elekdag, Justiniano and Tchakarov

\(^4\)Home currency price of one unit of foreign currency
(2006) and given by:

\[ \Gamma_t = \frac{\phi_B}{2} \left( \frac{b_t}{P_t} \right)^2 + \frac{\phi_F}{2} \left( \frac{X_t F_t^*}{P_t} \right)^2 \]

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. Given, the set-up described above the intra-temporal optimization condition of the households can be described as follows:

\[ \frac{L_t^\psi}{(C_t - hC_{t-1})^{-\rho}} = \frac{P_{H,t} W_t^r}{P_t} \]  \( \text{(2)} \)

The Euler equation and the modified uncovered interest parity condition following the optimal choice for asset holdings imply:

\[ \left[ 1 + \frac{\phi_B b_t}{P_t} \right] = \beta E_t \left[ \frac{z_{t+1}}{z_t} \left( \frac{c_{t+1} - hC_t}{C_t - hC_{t-1}} \right)^{-\rho} \left( \frac{R_t}{\pi_{t+1}} \right) \right] \]  \( \text{(3)} \)

\[ \frac{\phi_B b_t}{P_t} - \frac{\phi_F F_t^* X_t}{P_t} = \beta E_t \left[ \frac{z_{t+1}}{z_t} \left( \frac{c_{t+1} - hC_t}{C_t - hC_{t-1}} \right)^{-\rho} \left( \frac{R_t}{\pi_{t+1}} - \frac{R_t^* X_{t+1}}{\pi_{t+1}} \right) \right] \]  \( \text{(4)} \)

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:

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

(5)

Here, \( \eta \) is the elasticity of substitution between imports and domestically produced goods in the foreign country. \( \gamma_2 \) is the share of imports in the consumption basket of the foreign sector. The parameter \( \rho' \) 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 \( \eta \) percent, whereas \( \rho' \in (0, 1) \) scales down this effect with the change in demand being given by \( \rho' \eta \) percent.\(^5\) Furthermore, the foreign economy 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 Entrepreneurs

In this paper, I differentiate between advanced and emerging countries in terms of the cost of credit they face in global credit markets. I empirically validate this assumption by examining the country-level credit ratings assigned by Standard and Poor across a sample of 82 countries comprising 32 advanced economies and 50 emerging countries. I use credit ratings as a proxy for the country-specific spread over the risk-free rate (\( R_t^* \) in this model). As figure 1 demonstrates 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.

\(^5\)Given that I approximate the foreign sector as rest of the world, \( \rho' \in (0, 1) \) enables me to slow down the responsiveness of exports to changes in domestic prices.
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. This observed difference in financing debt can also be attributed in part to country-specific fundamental characteristics such as differences in the degree of financial integration and intermediation across advanced and emerging countries as demonstrated by the financial development index in figure 2. The financial development index is constructed by combining indices measuring financial depth (size and liquidity of markets), access to financial markets (ability of individuals and companies to access financial services), and efficiency of financial markets (ability of institutions to provide financial services at low cost and with sustainable revenues, and the level of activity of capital markets).

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Almeida, Cunha, Ferreira and Restrepo (2014) address this link and demonstrate that the sovereign rating is the relevant ceiling for ratings on corporate debt.
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 1) 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 $\theta$. 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 indexed by net-worth $N_t$, chooses capital stock $(K^N_t)$ to be used for production in period $t$ and labor $(L^N_t)$ to be combined with capital from previous period $(K^N_t)$ 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 $\alpha$ denotes the share of capital and $a_t$ is the level of aggregate productivity that is common to all entrepreneurs such that

$$Y^N_{H,t} = a_t(K^N_t)^\alpha(L^N_t)^{1-\alpha} \tag{6}$$

The optimal choice of labor $(L^N_t)$ given $K^N_t$ and $a_t$ is:

$$\arg \max_{L^N_t} P_{W,t}a_t(K^N_t)^\alpha(L^N_t)^{1-\alpha} - P_{H,t}W_tL^N_t$$

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

$$a_t\frac{P_{W,t}}{P_{H,t}}((1-\alpha)\frac{K^N_t}{L^N_t})^\alpha = W_t^r$$

$W_t^r = \frac{W_t}{P_{H,t}}$ 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 $\varphi_t = \frac{P_{W,t}}{P_{H,t}}$:

$$\varphi_t(1-\alpha)a_t\left(\frac{K^N_t}{L^N_t}\right)^\alpha = W_t^r \tag{7}$$

Given constant returns to scale in production of wholesale goods and perfectly competitive labor market, $\frac{K^N_t}{L^N_t} = \frac{K^N_t}{L^N_t}$. 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 in period $t$ is the expected gross revenue net of labor
costs normalized by the current market value of capital. 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:

\[
E_t R_{t+1}^{K,N} = \frac{R_{W,t} a_t K_t^{1-\alpha} L_t^{\alpha} - W_t^N L_t^N + (1 - \delta)Q_t K_t^N}{Q_t-1}
\]

\[
E_t R_{t+1}^{K,N} = \frac{\alpha\varphi_t}{S^H_t a_t} \left( \frac{K_t}{L_t} \right)^{\alpha-1} + (1 - \delta)Q_t
\]

\[
E_t R_{t+1}^{K} = \frac{mpk_t + (1 - \delta)Q_t}{Q_{t-1}}
\]

(8)

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 as depicted in figure 2. 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 1. 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

\[
\Psi(t) = k_t^\nu
\]

(9)

to be an increasing function of leverage \(k_t = \frac{Q_t K_t}{Q_t}\), and \(\nu\) is the elasticity of borrowing costs with respect to leverage. The difference between countries is captured in this model through different values of \(\nu\) - such that weaker degree of financial integration (higher monitoring costs) for emerging countries implies \(\nu^{\text{Emerging}} > \nu^{\text{Advanced}}\).\(^7\) The optimal choice of capital is obtained

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\(^7\)Ordonnez 2010 provides empirical evidence to suggest that monitoring costs or bankruptcy costs are much higher in emerging countries vis-à-vis advanced countries.
by maximizing the ex ante value of entrepreneurial capital $V^N,e_t$

$$\arg \max_{\{K_t^N\}} V^N,e_t = E_t \left[ R^K_t Q_t K^N_t - R^K_t (k^N_t)^\nu X_{t+1} D^N_{t+1} \right]$$

subject to

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

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

$$E_t R^K_t = R^K_t (k^N_t)^\nu E_t \frac{q_{t+1}}{q_t} \text{ where } q_t = \frac{X_t}{P_t}$$

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 10, $k^N_t$ can be solved to be independent of entrepreneur specific characteristics. Therefore $k^N_t = k_t \forall N$. The marginal financing condition can therefore be expressed in terms of aggregate variables:

$$E_t R^K_{t+1} = R^K_t (k^N_t)^\nu E_t \frac{q_{t+1}}{q_t}$$

The ex post value of entrepreneurial capital evolves as:

$$V^N_t = R^K_t Q_t K^N_t - R^K_t k^{-\nu}_t q_t D^N_{t-1}$$

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

$$V_t = \int_N V^N_t f_N dN = \int_N \left[ R^K_t Q_t K^N_t - R^K_t k^{-\nu}_t q_t D^N_{t-1} \right] f_N dN - \int_N R^K_t Q_t K^N_t f_N dN - R^K_t k^{-\nu}_t q_t \int_N K^N_t f_N dN - \int_N N^N_t f_N dN \right]$$

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

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

(12)

where, $E$ is an exogenous constant that ensures that new-born entrepreneurs are endowed with net-worth to start production. 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 Cespedes, Chang and Velasco (2004).

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

$$I_t = \left[(1 - \gamma_1)\frac{1}{\eta_2} I^{\eta_2-1}_{H,t} + \frac{1}{\eta_1} I^{\eta_1-1}_{H,t}\right]^\frac{\eta_2}{\eta_2-1}$$

with:

$$I^e_{H,t} = \left[\int_0^1 I^e_{H,t}(i)^{\frac{1}{\eta_2}} di\right]^{\frac{\eta_2}{\eta_2-1}}, I^e_{F,t} = \left[\int_0^1 I^e_{F,t}(i)^{\frac{1}{\eta_1}} di\right]^{\frac{\eta_1}{\eta_1-1}}$$

This can be endogenized as managerial wages to entrepreneurs as used in Christiano, Motto and Rostagno (2015) 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 $\theta$ that is consistent for a given value of leverage.
where $\eta_2$ is the elasticity of substitution between domestic and foreign goods, $\gamma_1$ is the share of imports in aggregate investment and $\epsilon$ 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:

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

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 $P_{F,t}$:

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

where,

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

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:

$$\max_{\{I_t\}} E_t \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{t+1}}{\lambda_t} \left[Q_t K_{t+1} - (1 - \delta) Q_t K_t - \frac{P_t^I}{P_t} I_t\right]$$

subject to:

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

such that $S\left(\frac{I_t}{I_{t-1}}\right) = \frac{\tau}{2} \left(\frac{I_t}{I_{t-1}} - 1\right)^2$ (13)

This leads to the following optimality condition:

$$Q_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - S'\left(\frac{I_t}{I_{t-1}}\right) \frac{I_t}{I_{t-1}}\right] + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} Q_{t+1} \left[S'\left(\frac{I_{t+1}}{I_t}\right) \left(\frac{I_{t+1}}{I_t}\right)^2\right] = \frac{P_t^I}{P_t}$$ (14)

where $\lambda_t = (C_t - hC_{t-1})^{-\rho}$
2.5 Retailers and the role for nominal rigidities

In the original framework proposed in Bernanke, Gertler and Gilchrist (1999), the role of retailers is primarily to introduce nominal rigidities in the model so as to analyze the scope of policy intervention by the central bank. In the present paper, nominal rigidities play an important role in generating the simultaneous decline in real variables that is characteristic of an uncertainty shock and is well documented in the empirical literature analyzing uncertainty shocks. Furthermore, Basu and Bundick (2017) show that nominal rigidities are essential to guarantee this co-movement in a closed economy model. Additionally, introducing retailers for imported goods in addition to domestic goods provides flexibility to analyze the responses of macroeconomic variables under different degrees of exchange rate pass through (Monacelli (2005)).

2.5.1 Retailers - Domestic Goods

Following Gertler, Gilchrist, 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:

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

The assumption CES preferences for households, capital producers and rest of the world implies that retailer $j$ faces an isoelastic demand given by: $\left( \frac{P_{H,t}(j)}{P_{H,t}} \right)^{\frac{\epsilon}{\epsilon-1}} Y_{H,t}$. Price stickiness is introduced à la Calvo with fraction $(1 - \kappa_H)$ of domestic retailers being able to reset price in each period.

The real marginal cost relevant for retailers of goods produced at home is $\frac{P_{W,t}}{P_{H,t}}$. The optimal
rest price $\hat{P}_{H,t}$ is given as follows:

$$
\hat{P}_{H,t} = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta \kappa_H)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{H,t+s}^{e} \frac{P_{W,t+s}}{P_{H,t+s}} Y_{H,t+s}}{E_t \sum_{s=0}^{\infty} (\beta \kappa_H)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{H,t+s}^{1-\epsilon} Y_{H,t+s}}
$$

where $\Pi_{H,t+s} = \frac{P_{H,t+s}}{P_{H,t}}$ with the GDP deflator evolving as:

$$
P_{H,t}^{1-\epsilon} = \kappa_H P_{H,t-1}^{1-\epsilon} + (1 - \kappa_H) \hat{P}_{H,t}^{1-\epsilon}
$$

(15)

### 2.5.2 Retailers - Imported Goods

For the case of imported goods, I assume incomplete pass through following Monacelli (2005). Retailers of imported goods purchase imports at 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 à la Calvo with fraction $1 - \kappa_F$ of retailers being able to optimally reset the price in each period. The relevant real marginal cost for retailers of imported goods is therefore $\frac{X_t P_{F,t}}{P_{F,t}}$ 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. Similar to retailers of domestic goods, retailers of imported goods purchase wholesale imported goods, differentiate them slightly and sell the final consumption aggregate of imported goods to households, and capital producers. 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

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

CES preferences in households, capital producers and rest of the world implies that retailer j faces an isoelastic demand given by: $\left(\frac{P_{F,t}(j)}{P_{F,t}}\right)^{-\epsilon} Y_{F,t}$. The optimal rest price $\hat{P}_{F,t}$ is given as follows:

$$
\hat{P}_{F,t} = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta \kappa_F)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{F,t+s}^{e} \frac{X_t P_{F,t+s}}{P_{F,t+s}} Y_{F,t+s}}{E_t \sum_{s=0}^{\infty} (\beta \kappa_F)^s \frac{\Lambda_{t+s}}{\Lambda_t} \Pi_{F,t+s}^{1-\epsilon} Y_{F,t+s}}
$$
\[ \Pi_{F,t+s} = \frac{P_{F,t+s}}{P_{F,t}} \]

with the import price index evolving as:

\[ P_{F,t}^{1-\epsilon} = \kappa_F P_{F,t-1}^{1-\epsilon} + (1 - \kappa_F) \dot{P}_{F,t}^{1-\epsilon} \]  

(16)

The parameter \( \kappa_F \) controls the degree of exchange rate pass-through in imports in this model - with values of \( \kappa_F \) closer to 0 denoting a scenario that is closer to PCP (producer currency pricing) and values of \( \kappa_F \) closer to 1 denoting a scenario that is closer to LCP (local currency pricing).

### 2.6 Monetary Policy

In this model, household utility is defined in terms of habit adjusted consumption. The central bank conduct monetary policy taking into account this feature and follows a modified Taylor rule that responds to CPI inflation \( (\pi_t) \), output gap \( \left( \frac{Y_{H,t}}{Y_H} \right) \) as well as output growth. This specification of the Taylor rule is similar to what was adopted in Smets and Wouters (2007).

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

(17)

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:

\[
Y_{H,t} = \frac{P_t}{P_{H,t}} (C_t + I_t) + C_{H,t} - \frac{P_{F,t}}{P_{H,t}} Y_{F,t} + C^e_t + K_H + \frac{P_{F,t}}{P_{H,t}} K_F
\]

(18)

Finally, the model is closed by imposing a market clearing condition for domestic bonds. That is, \( b_t = \bar{b} \).

### 2.8 Exogenous Processes

The empirical literature examining the effect of uncertainty shocks on macroeconomic variables typically incorporates a proxy for aggregate uncertainty such that it captures upward
surges in uncertainty across different sectors of the economy. Likewise, uncertainty is introduced in the model to reflect this empirical feature.

The model setup described so far, accommodates two sources of exogenous disturbances – shock to household preferences \((z_t)\) entering through the utility function of the representative household, capturing demand side fluctuations, and shocks to the aggregate productivity process \((a_t)\) entering through the Cobb-Douglas production function, capturing supply side fluctuations. The first moment or the level of aggregate productivity evolves as an AR(1) process given by:

\[
a_t = (1 - \rho_a)\overline{a} + \rho_a a_{t-1} + \sigma_t^a u_t^a
\]  

Likewise, \(z_t\) evolves as

\[
z_t = (1 - \rho_z)\overline{z} + \rho_z a_{t-1} + \sigma_t^z u_t^z
\]

A shock to \(u_t^a\) would correspond to a shock to the first moment or a shock to the level of aggregate productivity while a shock to \(u_t^z\) would correspond to a shock to the first moment or a shock to the level of the household discount factor \(\beta\). Given that uncertainty arises in the model from the time varying volatility of the exogenous disturbances, the key variables of interest are \(\sigma_t^a\) and \(\sigma_t^z\) respectively. \(\sigma_t^a\) governs the standard deviation of the aggregate productivity process while \(\sigma_t^z\) governs the standard deviation of the discount factor associated with household preferences respectively. I construct \(\sigma_t^a\) and \(\sigma_t^z\) to evolve as follows:

\[
\sigma_t^a = (1 - \rho_{\sigma_a})\sigma_t^a + \rho_{\sigma_a} \sigma_{t-1}^a + \eta_a \sigma_t^a u_t^C
\]

\[
\sigma_t^z = (1 - \rho_{\sigma_z})\sigma_t^z + \rho_{\sigma_z} \sigma_{t-1}^z + \eta_z \sigma_t^z u_t^C
\]

The definitions of \(\sigma_t^a\) and \(\sigma_t^z\) are constructed such that shocks to the standard deviations of \(z_t\) and \(a_t\) follow a correlated structure.\(^{10}\) The presence of this common component implies that a shock to \(u_t^C\) will imply a simultaneous increase in uncertainty about demand as well as the

\(^{10}\)The shocks can be constructed such that the specification allows for productivity specific and demand specific uncertainty along with the common component by augmenting equations 20 and 21 as follows:

\[
\sigma_t^a = (1 - \rho_{\sigma_a})\sigma_t^a + \rho_{\sigma_a} \sigma_{t-1}^a + \eta_a \sigma_t^a u_t^C + \eta_C \sigma_t^C u_t^C
\]

\[
\sigma_t^z = (1 - \rho_{\sigma_z})\sigma_t^z + \rho_{\sigma_z} \sigma_{t-1}^z + \eta_z \sigma_t^z u_t^C + \eta_C \sigma_t^C u_t^C
\]

The results are unchanged if I focus on shock-specific uncertainties i.e. shocks to \(u_t^a\) and \(u_t^z\) respectively.
technology. Therefore, the definition is aligned to the notion of aggregate uncertainty which typically manifests as uncertainty in all sectors of the economy.\(^{11}\)

The important point of distinction between a shock to the first moment \((u_{a t}^a, u_{z t}^z)\) and a shock to the second moment \((u_{C t}^C)\) 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.

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

For the rest of the paper uncertainty shocks within the scope of this model will refer to a 1 standard deviation shock to \(u_{C t}^C\) - which has been constructed to represent the theoretical counterpart of aggregate macroeconomic uncertainty. \(u_{C t}^C, u_{a t}^a\) and \(u_{z t}^z\) are iid processes distributed normally with mean 0 and standard deviation of 1 respectively. The parameters \(\sigma^a(\sigma^z)\), and \(\eta_a(\eta_z)\) control the degree of mean volatility and stochastic volatility in aggregate productivity (preferences): with a high \(\sigma^a(\sigma^z)\) implying a high mean volatility of aggregate productivity (preferences) and a high \(\eta_a(\eta_z)\) implying a high degree of stochastic volatility in aggregate productivity (preferences). Finally, equations 1-22 describe the equilibrium conditions of the model. I next describe the nonlinear solution technique employed to solve the model.

\(^{11}\)Following Basu and Bundick (2017), the shock processes are specified in levels to prevent the volatility of \(\sigma_t^a\) and \(\sigma_t^z\) from impacting the average values of \(a_t\) and \(z_t\) through a Jensen’s inequality effect.
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. While a first order approximation effectively captures risk aversion, it fails to capture the channels through which precautionary behavior manifests itself in theoretical models. Therefore, following the intuition put forth in Leland (1968), Sandmo (1970) and Kimball (1990) a precautionary savings response is motivated by the convexity of the marginal utility function. For firms, the precautionary pricing channel becomes relevant when their decisions explicitly incorporate the changes in the standard deviation of exogenous processes that govern final demand. To incorporate these dimensions in the solution of the model, it is important to deviate from a first order approximation.

A second order solution is not sufficient to generate dynamic effects to an uncertainty shock since the coefficients on the linear and quadratic terms for the state vector for a second-order expansion of the decision rule are independent of the volatility of the exogenous shocks (Schmidt-Grohè and Uribe 2004). Therefore, if I consider a second order solution, uncertainty will impact the steady state of the model however, will not impact the dynamics.

To ensure that uncertainty or properties of second moments impact the dynamics of the model, I need to consider at least a third order approximation. To achieve this, I use perturbation techniques suggested in Andreasen, Fernandez-Villaverde and Rubio-Ramirez (2016). The solution technique uses pruning to generate closed form solutions for impulse responses, as well as the first and second moments for the endogenous variables.

Furthermore, using a third order solution provides me the flexibility to compare the non-stochastic steady state and the stochastic steady state of the model to isolate how fundamental differences such as fragile financial markets can influence the dynamics of the model. The impulse responses uses this stochastic steady state as an input and is computed as the difference between the conditional (conditioning on the uncertainty shock being different from zero) and unconditional expected values (stochastic steady state of the model).

The research questions that I seek to answer through this paper are threefold. First, 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, fragile financial markets in emerging countries captured
in the model through higher values of $\nu$ -elasticity of borrowing costs with respect to leverage in conjunction with foreign currency denominated debt generates the amplified response in emerging countries vis-à-vis advanced countries. Third, use the qualitative features of the model to estimate key parameters that differentiate the response to uncertainty shocks across advanced and emerging countries.

The calibration exercise describe the in next section, aims to have a model parameterization that enables me to demonstrate the qualitative features of the model and shedding light on how an uncertainty shock transmits in the model. After establishing these features, I proceed to the estimation in section 4.

### 2.10 Model Calibration

**Calibrating external finance premium across countries:** In order to emphasize the interaction of borrowing costs and aggregate macroeconomic uncertainty in generating the excess volatility in emerging countries vis-à-vis advanced countries, I calibrate the representative models for advanced and emerging countries to differ only on the dimension that governs the spread over the international risk free rate. This is captured by the parameter $\nu$ in the model. I calibrate the parameters such that the leverage is same however the parameter $\nu$ is different. The model is then able to capture the differences in the transmission of an uncertainty shock that is entirely attributed to the cost of credit for calibrations representing advanced and emerging countries respectively. The steady states of the model calibrated for the same level of leverage but different $\nu$ reflects how higher borrowing costs translates into lower values of GDP, consumption and investment. I present these details when I discuss the welfare implications in section 5. Table 1 defines the calibrations for representative advanced and emerging countries.

The given values of leverage and $\nu$ imply borrowing costs of 4.76% and 7.68% per quarter for

<table>
<thead>
<tr>
<th>Model type</th>
<th>Leverage (k)</th>
<th>Elasticity of borrowing costs wrt leverage ($\nu$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representative Advanced Country</td>
<td>2.5</td>
<td>0.04</td>
</tr>
<tr>
<td>Representative Emerging Country</td>
<td>2.5</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Table 1: Calibrating $\nu$

the representative emerging and advanced country respectively.

**Calibration strategy for exogenous processes:** The volatility of stock market return is a
commonly used empirical proxy for measuring aggregate macroeconomic uncertainty. I use this to calibrate the mean volatility of productivity (preferences) across $-\sigma(\sigma^z)$ model calibrations. The average volatility of stock market returns between 1993Q1 – 2014Q4 is 0.112 for Mexico (representative emerging country) and 0.076 for the United Kingdom (representative advanced country). In order to isolate the role of borrowing costs and demonstrate the effectiveness of the model in capturing the asymmetric effect of uncertainty shocks across representative advanced and emerging countries, I fix the mean volatilities to 0.112 across calibrations (details in table 2) for advanced and emerging countries. However, in section 4 when I estimate the recession specific estimates of borrowing costs, I allow this parameter to vary across countries. The parameter $\eta_C$ which capture the extent of stochastic volatility is calibrated such that a one standard deviation shock in the model corresponds to a 1% increase in the standard deviation of productivity (and preferences). The AR(1) coefficients are calibrated such that shocks to uncertainty are moderately persistent in the model - this is reflecting the empirical feature that upward surges of uncertainty are relatively short lived. Like the average level of uncertainty, I estimate the parameters governing the persistence of the shocks in section 4.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Calibrated Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma^a$</td>
<td>Mean Volatility</td>
<td>0.112</td>
</tr>
<tr>
<td>$\eta_C$</td>
<td>Stochastic Volatility</td>
<td>0.00112</td>
</tr>
<tr>
<td>$\rho_a$</td>
<td>Persistence: $\sigma_t^a$</td>
<td>0.83</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>Persistence: $\sigma_t^z$</td>
<td>0.85</td>
</tr>
<tr>
<td>$\rho_\sigma$</td>
<td>Persistence: $a_t$</td>
<td>0.75</td>
</tr>
<tr>
<td>$\rho_\tau$</td>
<td>Persistence: $z_t$</td>
<td>0.85</td>
</tr>
<tr>
<td>$\tau = \tau$</td>
<td>Mean: Level</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: Calibrating uncertainty shocks

The remaining behavioral parameters have been calibrated as follows:

**Households:** I fix the discount factor $\beta$ to 0.997, 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. For the first set of results where I compare the strength of the model in generating business cycle asymmetries for calibrations corresponding to representative advanced and emerging countries I set $h = 0.5$. However, in section 4, I estimate the value of this parameter. The calibrated values for $h$ and $\rho$ imply an intertemporal elasticity of substitution of 0.25.$^{12}$ The Frisch elasticity of substitution is obtained as $\frac{1}{\psi} = 0.5$ by setting

---

$^{12}$The formula for the intertemporal elasticity of substitution being given as $\frac{1}{\psi = \frac{1}{\rho} \frac{1}{1-h}}$. 

---
The elasticity of substitution between exports and imports for consumption - \( \eta_1 \) is set to 0.89 (following Gertler, Gilchrist and Natalucci (2007)). \( \eta \) - 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. Portfolio holding costs for domestic (\( \phi_B \)) and foreign assets (\( \phi_F \)) are set to 0.0009 and 0.009 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 (\( \nu \)), the other parameters that characterize the choices of the entrepreneurs are - \( \alpha \) - share of capital in the production function and \( \theta \) - the exit rate of entrepreneurs. I fix \( \alpha \) to 0.5 (following Gertler, Gilchrist and Natalucci (2007)). I set \( \theta \) 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 \( \nu \) I calibrate \( \theta \) to 0.915 for the representative advanced country as well.

**Retailers:** In addition to leverage and the elasticity of borrowing costs with respect to leverage, the other parameter that is important in driving the results is the extent of nominal rigidities. I calibrate \( \kappa_H = 0.75 \) - implying an average duration of \( \frac{1}{1-\kappa_H} = 4 \) quarters for prices set by domestic retailers. The parameter \( \kappa_F \) governs the extent of price stickiness for firms selling imported goods. This parameter can also capture the extent of exchange rate pass through given the model specification. Higher values of \( \kappa_F \) imply a lower extent of exchange rate pass through. I calibrate \( \kappa_F = 0.25 \) to demonstrate the initial set of results however, in section 4, I estimate this parameter. The elasticity of substitution across goods within a category (domestically produced and imports) is set to 8 such that in steady state firms experience a mark-up of \( \approx 15\% \).

**Capital Producers:** The key parameters of interest for capital producers comprise the elasticity of substitution between domestic goods and imports for investment goods - \( \eta_2 \), the depreciation rate of capital- \( \delta \) and investment adjustment costs \( S''(\cdot) \). For simplicity I set \( \eta_2 = \)

---

\(^{13}\)Decreasing the elasticity of labor supply amplifies the impact of uncertainty shocks.

\(^{14}\)Decreasing the elasticity of substitution between exports and imports for the foreign sector amplifies the impact of uncertainty shocks.
\( \eta_1 = 0.89 \) - the elasticity of substitution between domestic goods and imports for consumption.\(^{15}\)

\( \delta \) is calibrated to 0.05. \( S''(\cdot) \) is calibrated to 6.

**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 \( \chi_\Delta y = 0.22 \)

Table 3: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Calibrated Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho/(1-h) )</td>
<td>Intertemporal Elasticity of substitution (after adjusting for habits)</td>
<td>0.25</td>
</tr>
<tr>
<td>( h )</td>
<td>Habit</td>
<td>0.5</td>
</tr>
<tr>
<td>( \psi )</td>
<td>Frisch elasticity of labor supply</td>
<td>2</td>
</tr>
<tr>
<td>( \eta_1 )</td>
<td>Elasticity of substitution between home and foreign goods for consumption</td>
<td>0.89</td>
</tr>
<tr>
<td>( \phi_B, \phi_F )</td>
<td>Portfolio Holding Costs</td>
<td>Gertler, Gilchrist and Natalucci (2007)</td>
</tr>
<tr>
<td>( \beta )</td>
<td>Discount Factor</td>
<td>0.997</td>
</tr>
<tr>
<td>( \gamma_1 )</td>
<td>Share of home goods in aggregate consumption</td>
<td>0.55</td>
</tr>
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<table>
<thead>
<tr>
<th>Parameters</th>
<th>Definition</th>
<th>Calibrated Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \eta )</td>
<td>Elasticity of substitution between home and foreign goods for foreign country</td>
<td>Gertler, Gilchrist and Natalucci (2007)</td>
</tr>
<tr>
<td>( \gamma_2 )</td>
<td>Share of goods produced at home -exports for rest of the world</td>
<td>0.0187</td>
</tr>
<tr>
<td>( C^* )</td>
<td>Aggregate consumption for rest of the world</td>
<td>200</td>
</tr>
<tr>
<td>( P_F^* )</td>
<td>CPI for Rest of the world</td>
<td>1</td>
</tr>
<tr>
<td>( R^* )</td>
<td>Gross foreign Interest Rate (quarterly)</td>
<td>1.0099 (1.04% Annualized after quarterly compounding)</td>
</tr>
<tr>
<td>( 1 - \rho' )</td>
<td>Persistence of export demand from rest of the world</td>
<td>0.75</td>
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<td>( \alpha )</td>
<td>Share of capital in production process</td>
<td>0.5, Gertler, Gilchrist and Natalucci (2007)</td>
</tr>
<tr>
<td>( \theta )</td>
<td>Exit rate of entrepreneurs</td>
<td>0.915, Fernandez and Gulan (2015) estimate 0.9</td>
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<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Calibrated Value</th>
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<td>Elasticity of substitution between home and foreign goods for investment</td>
<td>0.89</td>
</tr>
<tr>
<td>( \delta )</td>
<td>Depreciation rate</td>
<td>0.05</td>
</tr>
<tr>
<td>( S'' )</td>
<td>Elasticity of investment adjustment costs</td>
<td>6 Smets and Wouters (2007) use 5.74</td>
</tr>
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<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Calibrated Value</th>
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<tbody>
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<td>( \epsilon )</td>
<td>Elasticity of substitution across varieties for domestically produced goods</td>
<td>8</td>
</tr>
<tr>
<td>( \epsilon_1 )</td>
<td>Elasticity of substitution across varieties for foreign goods</td>
<td>8</td>
</tr>
<tr>
<td>( \kappa_H )</td>
<td>Calvo price stickiness for retailers of domestic goods</td>
<td>0.75 Gertler, Gilchrist and Natalucci (2007)</td>
</tr>
<tr>
<td>( \kappa_F )</td>
<td>Calvo price stickiness for retailers of imported goods</td>
<td>0.25</td>
</tr>
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</table>

<table>
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<th>Monetary Policy: Taylor Rule Coefficients</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi_y )</td>
<td>Output deviation from steady state</td>
</tr>
<tr>
<td>( \chi_\Delta y )</td>
<td>Output growth</td>
</tr>
<tr>
<td>( \chi_\pi )</td>
<td>CPI inflation</td>
</tr>
</tbody>
</table>

\(^{15}\)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.
Finally, while solving the model I assume that $C_t^f$ is set equal to zero. This is aligned to the assumption in Bernanke, Gertler and Gilchrist (1999) which fixes the share of entrepreneurial consumption to 0.01. This simplification does not alter the dynamics of the model.

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 $u_t^C$. The correlated structure between the standard deviations of aggregate productivity ($a_t$) and the exogenous component of the discount factor ($z_t$) will imply that a shock to $u_t^C$ will translate into an increase in uncertainty about productivity as well intertemporal discounting by households. Given that the solution is computed using a third order approximation of the equilibrium conditions, this increase in uncertainty about productivity and the discount factor will simultaneously trigger a precautionary response among households and firms. Thus, even though, an uncertainty shock will have no first order properties, through the third order precautionary channel, it will generate a first order change in real activity.

For the scope of demonstrating the transmission mechanism I focus on a one standard deviation shock to $u_t^C$. The model calibration is such that a one standard deviation shock to this common component leads to 1% increase in the volatility of preferences and aggregate productivity respectively.

An increase in uncertainty in the model - implies a mean preserving spread for aggregate productivity ($a_t$) and the exogenous component of the discount factor ($z_t$). 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.

Given, that a bad outcome for productivity is more now likely firms engage in precautionary pricing behavior to hedge against risks of reduced profitability in the future by increasing their mark-up over marginal cost (similar to the approach in Born and Pfeifer 2017). This consequently leads to an inward shift of the labor demand curve. The increased mark-up translates to an increase in the price of domestic goods triggering a decrease in consumption and investment demand along with an increase in the marginal utility of wealth.
The decrease in consumption demand is amplified as households respond to uncertainty about future preferences by engaging in precautionary savings behavior – reducing consumption demand and increasing labor supply. This leads to an outward shift of the labor supply curve. In equilibrium, wages and hours both decline on impact. The dynamics of labor demand relies crucially on nominal rigidities for retailers of domestic goods and emphasizes the mechanism suggested in Basu and Bundick (2017). Figure 4 illustrates these dynamics.

![Mark Up](image1)

![Marginal Utility of Wealth](image2)

![Labor](image3)

![Real Wages](image4)

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

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 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:

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

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)

![Price of Capital](image1)

![Rate of Return on Capital](image2)

![Leverage](image3)

![mpkt](image4)

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

The main differentiating feature in responses is brought about by the equilibrium condition

31
that defines the marginal financing condition. Recall,

\[ E_t v_t^K = R_t^* \left[ \frac{Q_tK_t}{N_t} \right]^\nu \frac{q_{t+1}}{q_t} \]

When the value of \( \nu \) is large enough, the decrease in capital demand triggered by the decrease in investment is not sufficient towards restoring equilibrium by countering the 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 \( \nu \) 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:

\[
C_{H,t}^* = \left[ \gamma_2 \left( \frac{P_{H,t}^*}{P_{F,t}^*} \right)^{-\eta} C_t^* \right]^{\rho} C_{H,t}^{1-\rho} \\
= \left[ \gamma_2 \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} C_t^* \right]^{\rho} C_{H,t}^{1-\rho} \\
= \left[ \gamma_2 \left( q_t \frac{P_t}{P_{H,t}} \right)^{\eta} C_t^* \right]^{\rho} C_{H,t}^{1-\rho} \\
\text{with } q_t = \frac{X_t}{P_t} \text{ and } P_{F,t}^* = 1
\]

Therefore as long as the increase in \( q_t \) exceeds the decline in \( \frac{P_{H,t}}{P_t} \), 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. For the calibration corresponding to a representative advanced country, this depreciation of the real exchange rate is absent. Consequently, the calibration does not generate this countercyclical response in trade balances. The model calibrations differing only with respect to this one parameter $\nu$ is not only able to generate the asymmetric response in real variables to uncertainty shocks, with larger values of $\nu$ leading to an amplified decline. 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.

![Figure 6: Solid line: Advanced Country, Dashed line: Emerging Country. Divergence 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](image)

Finally, given that the decline in consumption and investment demand exceed the increase in net-exports, overall GDP declines. The model specification can 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.

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.

![Graphs showing investment, consumption, and GDP responses over time for advanced and emerging countries.](image)

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 in the model economy. Now that I have successfully reproduced these qualitative features, I proceed to estimating the key parameters guiding the differences in response across advanced and emerging countries.
4 Estimating the role of financial frictions across countries in recessions

The results so far underscore the interaction of uncertainty shocks and financial frictions in generating business cycle asymmetries across advanced and emerging countries. Empirical evidence\textsuperscript{16} on the impact of uncertainty shocks on real variables suggest that the effects of macroeconomic uncertainty are largely countercyclical. That is, upward surges in macroeconomic uncertainty matter more during downturns in business cycles.

To test this interaction between financial frictions and uncertainty shocks in recessions I use a modified version of the VAR-based impulse response function matching estimator. I estimate the role of financial frictions and uncertainty shocks in recessions by using a two-step procedure in a limited information environment. First, I estimate a Smooth Transition Vector Auto Regression Model (STVAR) to obtain recession specific coefficients and a recession specific measure of an uncertainty shock. Next, I use this recession specific shock to compute generalized impulse responses using the technique of local projections as outlined in Jorda (2005).

4.1 Calculating recession specific impulse responses

Using a combination of the STVAR model and the technique of local projection mapping from Jorda (2005), I first estimate the behavioral parameters for the U.K and Mexico to compare the differences in parameters pivotal for the asymmetric transmission of uncertainty between advanced and emerging countries. The reason for this choice is the availability of substantial data with sufficient recessionary episodes\textsuperscript{17}. This allows me to estimate a more detailed specification for these countries.

The choice of the U.K and Mexico as representative advanced and emerging countries is also justified as both countries exhibit a comparable degree of openness to trade,\textsuperscript{18} both countries follow similar monetary policy (with emphasis on inflation targeting) and this allows me compare the impact of uncertainty after conditioning for the role of policy and degree of openness. For these two countries, the model is estimated using a specification with

\[ Y_t = [U_t, I_t, C_t, TB_t, \Pi_t, r_t]' \]

where \( U \) is the country specific proxy for ‘aggregate macroeconomic

\textsuperscript{16}Jurado et al 2015), Bloom (2015), Caggiano, Castelbuovo, and Grosheny (2014)
\textsuperscript{17}I discuss data limitations and constraints in detail in Chatterjee 2017
\textsuperscript{18}≈ 52% for the U.K between 1979 Q1 and 2014 Q2 and for Mexico between 1993 Q1 and 2014Q2
uncertainty’, \( I \) is the growth rate of investment, \( C \) is the growth rate of consumption, \( TB \) is the first difference of net exports expressed as a percentage of GDP, \( \Pi \) is the inflation and \( r \) is the policy rate. To generalize the findings from the estimation exercise, I extend the sample of advanced countries to the U.S., France, Canada, and emerging to South Korea, Chile and Argentina. I estimate the STVAR with fewer variables - \( Y_t = [U_t, I_t, C_t, TB_t]^{**} \)\(^{19} \) to overcome the data constraints for this expanded sample, compute the average impulse responses to uncertainty across the 4 advanced and 4 emerging countries, and subsequently estimate the key behavioral parameters that characterize the differences in the impact of uncertainty for these two country groups on average.

I now describe the STVAR model in detail. The STVAR model distinguishes between a recessionary regime and a ‘catch all’ non-recessionary regime. The model also, incorporates the ability to allow for country specific differences in guiding the smoothness of transition across regimes. The detailed model specification is given below:

\[
Y_t = F(z_{t-1})B_R(L)Y_t + (1 - F(z_{t-1}))B_{NR}(L)Y_t + \epsilon_t \tag{23}
\]

\[
\epsilon_t \sim N(0, \Omega_t) \tag{24}
\]

\[
\Omega_t = F(z_{t-1})\Omega_R + (1 - F(z_{t-1}))\Omega_{NR} \tag{25}
\]

\[
F(z_t) = \frac{\exp(-\gamma z_t)}{1 + \exp(-\gamma z_t)} \text{ and } \gamma > 0 \tag{26}
\]

\[
E(z_t) = 0 \text{ and } Var(z_t) = 1 \tag{27}
\]

\( Y_t = [U_t, I_t, C_t, TB_t, \Pi_t, r_t]' \) or \( Y_t = [U_t, I_t, C_t, TB_t]' \) depending on the choice of country and data availability. I quantify uncertainty 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. Volatility of stock

\(^{19}\)For the U.S. the model is estimated using \( Y_t = [U_t, I_t, C_t, TB_t, \Pi_t, r_t]' \)
market returns is standard measure of macro-financial uncertainty, however, Bloom (2014) demonstrates that measures such as the VIX, standard deviation of stock market returns are correlated with other measures of macroeconomic uncertainty and can be used to represent aggregate macroeconomic uncertainty as well.

The remaining endogenous variables included in the system are 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 - $\Pi_t$ (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 - section 3 of the appendix.

As described in the model specification, the STVAR framework allows for a two-way propagation mechanism for shocks to uncertainty. The regime specific VAR coefficients defined by $\{B_R, B_{NR}\}$ allow for dynamic propagation of shocks and the regime specific variance covariance matrices $\{\Omega_R, \Omega_{NR}\}$ allow for contemporaneous propagation of uncertainty shocks. $\{B_R, \Omega_R\}$, therefore, describes the behavior of the economy deep in recessions and likewise, $\{B_{NR}, \Omega_{NR}\}$ describes the behavior of the economy during ‘catch all’ non-recessionary phases.

The parameter $\gamma > 0$ governs the smoothness of transition from recessionary to the non-recessionary regime. As $\gamma \to \infty$ the transition becomes very abrupt between the regimes, whereas setting $\gamma = 0$ reverts the system to the linear VAR specification. I set $\gamma = 1.75$ for the U.K and $\gamma = 2.5$ for Mexico to capture the differences in volatilities exhibited by key macro variables across the two countries. Table 1 in the appendix lists the parametrization of $\gamma$ for the entire sample. The variable $z_t$ governs the transition from one regime to the other. The goal is to capture the differences in business cycles across countries by appropriately calibrating $\gamma$ and choosing the state transition variable such that the system spends sufficient time in recessions. In the current set up $F(z)$ is given by the logistic function. It defines the likelihood of being in any particular state, with $F(z) \approx 1$ implying the recessionary regime and $F(z) \approx 0$ implying the expansionary regime. The logistic function is used for assigning regime specific probabilities by using the smoothness parameter ($\gamma$) and the state transition variable ($z_t$) as inputs.
Following Auerbach and Gorodnichenko (2012) the transition function enters the VAR specification (equation 23) with a lag of one period to avoid contemporaneous effects of policy variables in defining the state of the economy. The state transition variable is not included in the system of endogenous variables, thus, eliminating interaction and feedback effects between the state transition variable and the dynamics of the macroeconomic variables included in the system. The choice of the transition function is very important as this is the driving force that induces non-linearities in endogenous variables at turning points in the business cycle. While there are multiple ways to capture regime switches in the business cycle, following Auerbach and Gorodnichenko (2012) (and what was adopted in Caggiano, Castelnuovo and Groshenny 2014), I have defined \( z_t \) to be the standardized 7 quarter moving average of the growth rate of real GDP. Therefore, \( z_t > 0 \) implies that the growth trajectory of real GDP is above average and vice versa.

Using the recession specific variance-covariance matrix \( \Omega_R \), and Cholesky identification, I construct the uncertainty shock that is subsequently used to compute the generalized impulse responses. This non-parametric method of calculating impulse responses, benefits the estimation in two ways. The STVAR model does not include \( z_t \) or the state transition variable in the model specification and in process eliminates feedback arising from an uncertainty shock to the definition of a recession. The impulse responses obtained using a combination of recession specific coefficients \( B_R \) and recession specific shock \( \Omega_R \) ignores the possibility of regime changes during the propagation. The use of GIRFs allows me to bypass this assumption of conditional linearity in calculating impulse responses and accommodate for the possibility of regime switches during the transmission process. Second, this allows a one for one comparison between the theoretical and empirical impulse responses. However, as a robustness check, I also estimate the parameters using the conditionally linear recession specific impulse responses to find qualitatively similar estimates across both measures.

### 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 attempt to match the responses of consumption and investment. 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 in itself, 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. As highlighted earlier, I incorporate the possibility of regime switches during the propagation by calculating the generalized impulse responses using the recession specific shock identified from the STVAR model using the same variables that are used as inputs for estimating the STVAR model.

Finally, a comment on the ordering of variables - the impulse responses to a 1% shock to uncertainty have been constructed with uncertainty ordered as the first variable in the STVAR. This means that the one step ahead forecast error in ‘country specific uncertainty’ is attributed in entirety to uncertainty shocks. This ordering matches the formulation in the theoretical model described in section 3, where uncertainty is interpreted as the time varying volatility of the process governing the evolution of aggregate productivity and preferences. 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 Budick (2017) demonstrate that the theoretical counterpart of the VIX in their model is relatively unresponsive to non-uncertainty shocks.

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 extensively in other papers such as Christiano, Eichenbaum and Evans (2005) and Christiano, Eichenbaum and Trambandt (2015).

Let, $\gamma$ denote impulse responses generated from the DSGE model such that,

$$\gamma = g(\hat{\phi}, \tilde{\phi}, h)$$

Let $n$ denote the total number of parameters in the model and $\hat{\phi} = [\hat{\phi}_1, ..., \hat{\phi}_n]$ denote the
subset \( n_1 < n \) parameters that I estimate using the IRFME procedure. \( \bar{\phi} = [\bar{\phi}_{n_1+1}, \ldots, \bar{\phi}_n] \) 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 impul ed responses. \( \hat{\gamma} \) therefore corresponds to the estimate of \( \gamma \). The IRFME of \( \hat{\phi}_i = \hat{\phi}_i(\bar{\phi}, h) \) \( \forall i \in 1, \ldots, n_1 \) such that:

\[
\begin{pmatrix}
\hat{\phi}_1(\bar{\phi}, h) \\
\hat{\phi}_2(\bar{\phi}, h) \\
\vdots \\
\hat{\phi}_{n_1}(\bar{\phi}, h)
\end{pmatrix} = \arg\min_{\hat{\phi}_1(\bar{\phi}, h), \ldots, \hat{\phi}_{n_1}(\bar{\phi}, h)} [\hat{\gamma} - g(\hat{\phi}, \bar{\phi}, h)]' \Omega_T(h) [\hat{\gamma} - g(\hat{\phi}, \bar{\phi}, h)]
\]

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 - \( \nu \), the average level of uncertainty in the economy \( \bar{\sigma}_a \) and \( \bar{\sigma}_z \), the persistence of second-moment shocks to productivity (and preferences) \( \rho_{\sigma_a} \) (and \( \rho_{\sigma_z} \)), the degree of exchange rate pass-through \( \kappa_F \), the persistence of external habits - \( h \) and the elasticity of labor supply \( \psi \). While estimating the parameters, I hold the leverage fixed across countries to 2.5 so that the parameter \( \nu \) can entirely capture country specific differences in borrowing costs. Finally, I set \( \Omega_T = I \) such that both consumption and investment are assigned equal importance during the optimization routine.

### 4.3 Results of the IRFME procedure

The results suggest substantial differences in borrowing costs faced by these two countries at a quarterly level with Mexico facing interest rates that are 288 basis points higher in comparison to the United Kingdom. The average level of uncertainty is higher for both countries for shocks that originate in recessions with the U.K recording higher average uncertainty (about 8.5%). These results suggest financial fragility is more important in comparison to the exogenous shock in generating the excess volatility of real variables in a representative emerging country like Mexico. An important thing to note is that while the qualitative features of the transmission mechanism are governed exclusively by \( \nu \), the quantitative features are governed
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mexico</th>
<th>United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\nu$ - Elasticity of borrowing costs wrt leverage</td>
<td>0.0713</td>
<td>0.0418</td>
</tr>
<tr>
<td>$\sigma_z = \sigma_{z}$ - Average uncertainty</td>
<td>0.2456</td>
<td>0.2685</td>
</tr>
<tr>
<td>$\rho_{z}$ - Persistence of second-moment shock - preference</td>
<td>0.949</td>
<td>0.9078</td>
</tr>
<tr>
<td>$\rho_{z}$ - Persistence of second-moment shock - productivity</td>
<td>0.8622</td>
<td>0.854</td>
</tr>
<tr>
<td>$h$ - Persistence of external habits</td>
<td>0.4701</td>
<td>0.5031</td>
</tr>
<tr>
<td>$\kappa_F$ - Degree of exchange rate pass through - extent of nominal rigidities in imports</td>
<td>0.2481</td>
<td>0.4996</td>
</tr>
<tr>
<td>$\psi$ - Frisch elasticity of labor supply</td>
<td>2.0121</td>
<td>3.0026</td>
</tr>
<tr>
<td>Est. $R_{t+1}^K$</td>
<td>1.0781</td>
<td>1.0493</td>
</tr>
</tbody>
</table>

Table 4: Estimating behavioral parameters guiding the differences in the transmission of uncertainty shocks for Mexico and the United Kingdom

by the interaction of $\nu$ as well as the higher level of uncertainty. The persistence parameters of second moment shocks suggest that an uncertainty shock that originates during a recession lasts longer in an emerging country like Mexico. The higher degree of price stickiness in imports in the United Kingdom are aligned to findings from Gopinath (2012) which suggests advanced countries are closer to a ‘local currency pricing (LCP)’ model for imports. While estimates for $\kappa_F$ in Mexico suggests evidence leaning towards a ‘producer currency pricing (PCP)’ in imports. In figures 8 and 9, I compare the empirical IRFs with those generated from the model and calculated using parameters reported in table 4.

Figure 8: Comparing impulse responses to a 1% uncertainty shock generated from the STVAR model (solid line) and theoretical model (dashed line) for Mexico
To generalize the findings from the estimation, I expand the sample of advanced countries to include the U.S., France and Canada along with the U.K. and the sample of emerging countries to include Chile, Argentina and South Korea along with Mexico. Using a combination of the STVAR model and the GIRFs I construct country specific impulse responses to a 1% uncertainty shock and then average across these two 4-country groups to construct the average effect of uncertainty shocks across advanced and emerging countries. The estimation technique is exactly the same as described earlier.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average Emerging Markets</th>
<th>Average Advanced Economies</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \nu ) - Elasticity of borrowing costs wrt leverage</td>
<td>0.0687</td>
<td>0.0408</td>
</tr>
<tr>
<td>( \sigma_\pi = \sigma_z ) - Average uncertainty</td>
<td>0.3</td>
<td>0.2891</td>
</tr>
<tr>
<td>( \rho_\sigma_z ) - Persistence of second-moment shock - preference</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>( \rho_\sigma_a ) - Persistence of second-moment shock - productivity</td>
<td>0.824</td>
<td>0.8199</td>
</tr>
<tr>
<td>h - Persistence of external habits</td>
<td>0.4374</td>
<td>0.5031</td>
</tr>
<tr>
<td>( \kappa_F ) - Extent of nominal rigidities in imports</td>
<td>0.2427</td>
<td>0.5002</td>
</tr>
<tr>
<td>( \psi ) - Inverse of Frisch elasticity of labor supply</td>
<td>5.007</td>
<td>4.0039</td>
</tr>
<tr>
<td>Est. ( R_{t+1}^K )</td>
<td>1.0756</td>
<td>1.0484</td>
</tr>
</tbody>
</table>

Table 5: Estimating behavioral parameters guiding the differences in the transmission of uncertainty shocks for representative advanced and emerging countries

As before, differences in the parameter governing the elasticity of borrowing costs wrt leverage leads to borrowing costs that significantly higher in emerging countries with the difference amounting to 270 basis points. The average level of uncertainty is relatively as before is comparable across the country groups with emerging countries on average recording higher un-
certainty. The findings with the broader group of countries reinforce the initial result whereby the interaction of financial frictions with elevated uncertainty is crucial towards generating the stylized facts within the theoretical model. These findings are summarized in figures 10, 11 and table 5.

In the next section, I discuss the welfare costs of higher financial frictions and why this interaction of financial frictions and uncertainty is crucial towards generating the excess volatility in merging countries.

Figure 10: Comparing impulse responses to a 1% uncertainty shock generated from the STVAR model (solid line) and theoretical model (dashed line) for emerging countries - averaged across Mexico, Chile, Argentina and South Korea

Figure 11: Comparing impulse responses to a 1% uncertainty shock generated from the STVAR model (solid line) and theoretical model (dashed line) for the advanced economies - averaged across the U.K., the U.S., France and Canada
5 Welfare implications of uncertainty and financial frictions - which hurts more?

The transmission mechanism and results from the estimation shed light on the efficacy of the set-up in providing a structural interpretation of the differences that characterize the interaction of uncertainty shocks and financial frictions across advanced and emerging countries. While these findings suggest this channel as a key factor in driving the excess volatility of real variables in emerging countries, the set-up can also be used to understand the welfare implications.

Given that the model is solved using a third order approximation, the framework allows me to compare the steady states with and without uncertainty to understand the magnitude of distortions introduced by financial frictions and uncertainty respectively. In table 6, I outline the non-stochastic and stochastic steady states for calibrations corresponding to representative advanced (k=2.5 and ν = 0.04) and emerging countries (k=2.5 and ν = 0.07) and calibrating average uncertainty to 0.112 respectively. The stochastic steady state can be interpreted to be the ergodic mean of the system. It has been calculated by simulating the model 10,000 times using k=2.5 and ν = 0.04 for advanced and k=2.5 and ν = 0.07 for emerging countries, average uncertainty 0.112 and subsequently selecting positive shocks to \( u_t^C \),\(^{21}\) to compute the average value across these simulations.

Table 6: Comparing the steady state values for different values of the elasticity of borrowing costs with respect to leverage (ν) and leverage k. The %\( \Delta y/x \) indicate the % change real activity between scenarios y and x. The results highlight the importance of the interaction between uncertainty and financial frictions in generating lower steady state output for representative emerging countries in comparison to advanced countries.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Non-Stochastic Steady State</th>
<th>Stochastic Steady State - Ergodic Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>k=2.5 &amp; ν = 0.04</td>
<td>k=2.5 &amp; ν = 0.04</td>
</tr>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>GDP</td>
<td>5.21</td>
<td>4.32</td>
</tr>
<tr>
<td></td>
<td>(%( \Delta b/a )= -17%)</td>
<td>(%( \Delta c/a )= -31%)</td>
</tr>
<tr>
<td>Investment</td>
<td>1.36</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>(%( \Delta b/a )= -31%)</td>
<td>(%( \Delta c/a )= -40%)</td>
</tr>
<tr>
<td>Consumption</td>
<td>3.26</td>
<td>3.08</td>
</tr>
<tr>
<td></td>
<td>(%( \Delta b/a )= -5%)</td>
<td>(%( \Delta c/a )= 2%)</td>
</tr>
</tbody>
</table>

\(^{21}\)This is because the shock processes are specified in levels to prevent the volatility of \( \sigma_t^y \) and \( \sigma_t^z \) from impacting the average values of \( a_t \) and \( z_t \) through a Jensen’s inequality effect.
can generate a lower level of real activity for the calibration corresponding to the emerging country. I compare these outcomes as $\%\Delta_{b/a}, \%\Delta_{d/c}$ in table 6 to outline which of the two distortions hurt agents more in this model economy. When I consider differences in borrowing costs only (and compare the non-stochastic steady states of the model - $\%\Delta_{b/a}$) I find that output, consumption, and investment are about 17, 5, 31% lower in emerging countries. This result is not surprising since financial market imperfections operate through the investment decisions in this model. However, once I consider the role of uncertainty and carry out a similar comparison for the stochastic steady states ($\%\Delta_{d/c}$), I find that GDP, consumption and investment are 45, 24 and 78% lower in the representative emerging country vis-à-vis-advanced country. This highlights the joint importance of uncertainty and financial frictions.

The model is simple yet provides a relevant way to quantify the interaction of financial fragility and macroeconomic uncertainty using both dynamics as well as welfare considerations. This result is particularly relevant for policy implications as the welfare losses under uncertainty are disproportionately larger for countries with weaker financial markets. This is captured when I compare the reduction in real activity across the non-stochastic and stochastic steady states across representative countries ($\%\Delta_{c/a}$ - advanced countries and $\%\Delta_{d/b}$ for emerging countries respectively). Of particular relevance is the behavior of consumption. While it remains relatively unchanged across the different steady states for the representative advanced country, steady state consumption declines by 18% after conditioning on uncertainty for the representative emerging country. The decrease in investment is even more sharp – 40% versus 81% for advanced and emerging countries respectively.

The analysis of course assumes that differences in the extents of financial market development across countries is being captured exclusively through the parameter controlling the elasticity of borrowing costs to leverage. Nonetheless the results underscore the importance of incorporating both fundamental features as well as characteristics of exogenous processes in understanding the differences in real activity across advanced and emerging countries and losses in real activity attributed to these channels.
6 Concluding remarks

An uncertainty shock in my open economy model with financial frictions and nominal rigidities does not impact first order properties of the model, however, 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. This paper contributes to the existing literature by explicitly addressing the interaction between macroeconomic uncertainty and financial frictions and quantifies the loss of real activity attributed to the two separate channels.

Although this paper does not directly address the causes of financial fragility, it takes the differences in weaker financial institutions and infrastructure as a given and captures it through the higher borrowing cost faced by emerging countries in international capital markets - the results shed light on the heightened vulnerability of emerging countries to increases in aggregate uncertainty. The model succeeds in matching the empirical features characterizing the transmission of uncertainty in open economy models. From a policy perspective the framework is particularly useful to assess changes in real activity attributed to these different channels, either due to elevated uncertainty or elevated borrowing costs or some combination of the two. The results suggest that investing in better integrated financial markets and robust financial infrastructure can reduce the volatility underlying key macro variables in times of high macroeconomic uncertainty for emerging countries.
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Appendix

1 Pinning down E as a function of model parameters and the steady state leverage

Given, leverage $k$, and capital $K$ (from previous section) I can pin down the steady state level of net-worth $N$. The steady state value of entrepreneurial capital $V_t$ is given by:

\[
V = [r^K - \Psi(k) R^*]K + \Psi(k) R^* N
\]

\[
V = [r^K - k^\nu R^*]K + k^\nu R^* N
\]

\[
V = [k^\nu R^* - k^\nu R^*]K + k^\nu R^* N
\]

\[
V = k^\nu R^* N = r^K N
\]

Using the equation that characterizes the evolution of net worth after accounting for fraction $(1 - \theta)$ of exiting entrepreneurs:

\[
N = \theta V + (1 - \theta)E
\]

\[
N = \theta r^K N + (1 - \theta)E
\]

\[
(1 - \theta r^K)N = (1 - \theta)E
\]

\[
D = \frac{(1 - \theta r^K)N}{(1 - \theta)}
\]

Thus, given $N, \theta, r^K$ I can pin down the value of $E$ that is consistent with a steady state leverage of $k$. I want to point out that:

\[
\frac{\partial D}{\partial \theta} = -\frac{N(1 + r^K)}{(1 - \theta)^2} \implies \frac{\partial D}{\partial \theta} < 0
\]

\[
\frac{\partial D}{\partial \nu} = -\frac{\theta N}{(1 - \theta)} + \frac{1 - \theta r^K}{1 - \theta} k \frac{\partial K}{\partial \nu} \frac{\partial K}{\partial \nu} < 0 \implies \frac{\partial D}{\partial \nu} < 0
\]

Thus for larger values of $\nu$ as $r^K$ increases, $D$ decreases and may become negative. Therefore, the calibration of $\theta$ takes into account this dynamic and ensures that $D > 0$
2 Reporting the values of $\gamma$ - the parameter the governs the smoothness of transition between regimes across countries

<table>
<thead>
<tr>
<th>Country</th>
<th>$\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>1.6</td>
</tr>
<tr>
<td>UK</td>
<td>1.75</td>
</tr>
<tr>
<td>Canada</td>
<td>2.25</td>
</tr>
<tr>
<td>France</td>
<td>2</td>
</tr>
<tr>
<td>South Korea</td>
<td>1.75</td>
</tr>
<tr>
<td>Mexico</td>
<td>2.5</td>
</tr>
<tr>
<td>Chile</td>
<td>2.75</td>
</tr>
<tr>
<td>Argentina</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1: Choice of $\gamma$ for the sample of countries chosen in the analysis. Higher values of $\gamma$ correspond to more abrupt transitions between the recessionary and the non-recessionary regimes. $\gamma$ has been chosen to match the incidence of actual recessionary episodes in the sample chosen for each country.
3 Data Description

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

Table 2: Defining Uncertainty
<table>
<thead>
<tr>
<th>Country</th>
<th>GDP Total</th>
<th>Gross Fixed Capital Formation</th>
<th>Private Consumption Expenditure</th>
<th>GDP Deflator</th>
<th>Exports of Goods and Services</th>
<th>Imports of Goods and Services</th>
<th>Interest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. (1986Q1 – 2014Q2)</td>
<td>OECD</td>
<td>Main Economic Indicators</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>Effective Federal Funds Rate - FRED</td>
</tr>
<tr>
<td>U.K. (1979Q1 – 2014Q3)</td>
<td>OECD</td>
<td>Main Economic Indicators</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>3-Month or 90-day Rates and Yields: Treasury Securities for the U.K. - FRED</td>
</tr>
<tr>
<td>Canada (1990Q1 – 2014Q4)</td>
<td>OECD</td>
<td>Main Economic Indicators</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>Not Used</td>
</tr>
<tr>
<td>France (1991Q1 – 2014Q4)</td>
<td>OECD</td>
<td>Main Economic Indicators</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>Not Used</td>
</tr>
<tr>
<td>South Korea (1975Q1 – 2014Q3)</td>
<td>OECD</td>
<td>Main Economic Indicators</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>Not Used</td>
</tr>
<tr>
<td>Mexico (1993Q1 – 2014Q2)</td>
<td>OECD</td>
<td>Main Economic Indicators</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>3-Month or 90-day Rates and Yields: Treasury Securities for Mexico - FRED</td>
</tr>
<tr>
<td>Chile (1993Q1 – 2014Q2)</td>
<td>OECD</td>
<td>Main Economic Indicators</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>OECD</td>
<td>Not Used</td>
</tr>
</tbody>
</table>

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