Real Business Cycles in Emerging Economies: the Role of Interest Rates and Exchange Rates

Sihao Chen * HKUST | Kang Shi CUHK | Juanyi Xu HKUST

August 23, 2019

Abstract

In this paper, we document difference in comovement of real exchange rates (RER) with other macroeconomic aggregates between emerging economies and developed small open economies, especially the significant and negative correlation between real interest rate and RER in emerging market economies. Motivated by these observations, we include the RER and real interest rate data in the estimation of a two-sector small open economy RBC model with tradable and non-tradable goods. We find that to explain the RER dynamics and comovement observed in emerging market economies, two features are important. First, imperfect substitution between home and foreign tradable goods are introduced into standard two-sector models to allow for deviation from law of one price in tradable goods. This helps to generate RER volatility relative to output which is consistent with data. Second, the interaction of pecuniary effects of real exchange rate changes and collateral constraint on firms' borrowing helps to explain the negative correlation between RER and real interest rate and countercyclical real interest rates. A model with these features does well in matching business cycle moments in emerging market economies, including those related to RER. Finally, our estimation results also identify country premium shock as the major force in driving RER dynamics and output fluctuations, thus providing another evidence supporting the important role of country premium shock and financial frictions in explaining emerging market business cycle.

JEL classification:

Keywords: Emerging market business cycle, Real interest rate, Real exchange rate;

*Chen: Department of Economics, Hong Kong University of Science and Technology, Email : housechen90@gmail.com; Shi: Department of Economics, The Chinese University of Hong Kong; Email: kangshi@cuhk.edu.hk. Xu: Department of Economics, Hong Kong University of Science and Technology, Email :jennyxu@ust.hk. Xu would like to thank the Hong Kong Research Grants Council (GRF No. 16503017) for financial support

1 Introduction

Understanding real business cycles in emerging market economies remains to be a central issue in international macroeconomics. Currently, there are debates on the major source of aggregate fluctuation in emerging market and the mechanism to generate the puzzling behavior of aggregate moments, such as the excess consumption volatility and strongly counter-cyclical trade balance. Aguair and Gopinath (2007) propose "trend is the cycle" and introduce permanent technology shock to explain the excess consumption volatility puzzle. The other strand of literature (Neumeyer and Perri, 2005; Uribe and Yue, 2006; Garcia-Cicco, Pancrazi and Uribe, 2010) emphasizes the importance of interest rate shock and financial friction to explain the consumption volatility and the counter-cyclical trade balance. [1]

These papers, however, focus on one-sector models and therefore the role of real exchange rates (hereafter, RER) in real business cycles are not discussed or explored. Since most emerging market economies are small open economies subject to external interest rate and relative price shocks, it seems nontrivial to include real exchange rates in the discussion of business cycle. Several interesting questions then arise. First, are real exchange rate dynamics and their comovements with aggregate variables, such as output, consumption, trade balance and real interest rate, different between emerging market economies and developed small open economies? Second, can a standard two-sector model with non-tradable goods explain the RER dynamics and their comovement with macroeconomics aggregates? Finally, can permanent productivity shocks or interest rate shocks help to explain the behavior of RER and aggregate moments related to RER? Do these shocks remain important in explaining the aggregate fluctuations in emerging market economies when the real exchange rates are included in the estimation? These are the questions we intend to answer in this paper.

We first document the real exchange rate behavior and its comovement with

[1] Intuitively, once country spread goes up, interest rate cost to finance working capital is higher and firms reduce production. Households will save more and the reduction of consumption is larger than reduction of output.

macroeconomic variables in emerging market economies to check if there exists difference in RER dynamics and moments between emerging and developed small open economies. On average, RER volatility relative to output and RER persistence in emerging economies are similar to that of developed small open economies. In other words, RER is quite volatile and very persistent. However, the comovement between RER and other macroeconomic aggregates are quite different between emerging economies and developed SOE. First, real exchange rates[2] are positively correlated with consumption and output in the emerging economies, while in developed economies it is counter-cyclical. They are also negatively correlated trade balance to output ratio at business cycle frequency. More importantly, there is significant and negative correlation between real interest rate and real exchange rate in emerging market economies while this correlation is almost zero in developed small open economies. Our findings suggest that like the excess consumption volatility puzzle, RER dynamics and moments differ systematically in emerging market economies and therefore should be considered when investigating emerging market business cycle properties.

Motivated by our empirical finding, we evaluate the performance of a standard two-sector RBC small open economy model with non-tradable goods and homogenous tradable goods. In this benchmark model, the tradable good price is constant and equal to the world tradable good price. So the fluctuation of RER comes from the change of non-tradable goods price. The domestic real interest rate is the sum of international rate and country spread which depends on external debt level. Five shocks are introduced in the Bayesian estimation. Besides the permanent productivity shock and the country premium shock, we also consider the stationary technology shock in both sectors and the preference shock. The unique feature of our estimation is that both real interest rate and real exchange rate data are included in the Bayesian estimation since these data contains information which helps to estimate parameters in the model to explain the RER dynamics and moments, especially the negative correlation between RER and real

[2]We use real effective exchange rate to measure RER. A rise of RER means appreciation of domestic currency.

interest rate.

The estimation results are as follows. The model does well in generating RER persistence, but underestimate the real exchange rate volatility relative to output. It also fails to generate the excess consumption volatility and is unable to generate the countercyclical interest rate. Meanwhile, the model underestimates two negative correlations between real interest rate and macroeconomics variables, real interest rate and trade balance to output ratio, respectively. The reason for the failure of the model in generating excess volatility lies in the fact that the model relies on temporary technology shocks to drive output and consumption fluctuation as well as real exchange rate dynamics, although the permanent shock also accounts for a moderate fraction of output and consumption volatility. When there is a positive technology shock in the non-tradable sector, non-tradable good price decrease and RER will depreciate. Meanwhile, a positive temporary technology shock leads to consumption smoothing, so the increase of output will be higher than that of consumption and investment, implying the trade balance will increase and the real interest rate will decrease. It is therefore not surprising that the negative correlation between real interest rate and RER cannot be fully explained when non-tradable temporary technology shock plays a dominant role in explaining real exchange rate dynamics.

Obviously, to explain this negative correlation, some other shocks which drives the real interest rate and the RER together will be ideal. Most real interest rate fluctuations come from country premium shock, as expected. Will it also drive real exchange rate fluctuation? A positive country premium shock will lead to an increase of domestic interest rate, and a decrease of domestic consumption and investment. This will imply a decrease of non-tradable goods price and a slight RER depreciation. It will also generate the negative correlation between real interest rate and output/consumption. Nevertheless, RER depreciation generated through this channel is too small in magnitude, since it only works through the decrease in demand for non-tradable goods. Is there any other way to generate real exchange rate fluctuations?

In the empirical literature on real exchange rates, the dominant view is that relative prices of tradable goods account for most of the observed high variability of CPI based real exchange rates. Engel (1999) shows that almost all of the variance in the bilateral real exchange rates between the US and a number of OECD countries is attributable to fluctuations in the real exchange rates of traded goods, and the role of relative price of nontradable goods is negligible. He also finds that this applies to Mexico using the Mexican monthly data from 1991 to 1999.[3] Betts and Kehoe (2005) got similar finding for U.S. real exchange rate fluctuations. Although Mendoza (2005), Burstein, Eichenbaum and Rebelo (2005), and Betts and Kehoe (2008) show that the relative price of non-tradable goods price are still important in accounting for RER fluctuations [4], it seems reasonable to introduce differentiated home and foreign tradable good and allow for fluctuation in tradable goods prices to account for real exchange rate dynamics.

Our first extended model, hence, introduces imperfect substitution between domestic produced tradable goods and imported tradable goods and was called the imperfect substitution model. Besides the changes of relative price of non-tradable goods to tradable goods, this model provides another source to capture the real exchange rate volatility. The estimation result shows that this extension improves the model's performance in the following dimensions. First, the modified model can match the negative comovement between real interest rate and real exchange rate as well as the negative correlation between RER and trade-balance to GDP ratio. Meanwhile, it can also generate the negative correlation between real interest rate and output and the excess consumption volatility, but only quali-

[3] In Engel (1999, 2000), using a sample of monthly data from 1991 to 1999, he finds that the fraction of the variance of the peso-dollar real exchange rate accounted for by the variance of the Mexico-U.S. ratio of prices of tradable goods adjusted by the nominal exchange rate exceeds 90 percent, regardless of the time horizon over which the data are differenced.

[4] Betts and Kehoe (2008) extend Engel's analysis to a large set of bilateral real exchange rates and find that the measured relation between the bilateral real exchange rate and the relative price of non-traded to traded goods is strong on average. Burstein, Eichenbaum and Rebelo (2005) discuss the real exchange rate dynamics under large devaluations scenario. They find that primary force behind the real exchange rate is the adjustment in the prices of nontradable goods and services. Mendoza (2005) shows that Mexico's nontradables prices display high variability and account for a significant fraction of real exchange rate variability in periods of managed exchange rates.

tatively.

The main reason for the improvement of performance comes from the dominant role of country premium shock in explaining both RER and real interest rate fluctuations. From the impulse response function one can see that in this extended model, a positive country premium shock now generates a much bigger real exchange rate depreciation, compared to the benchmark model. This is because with differentiated domestic and imported tradable goods, demand decrease in consumption and investment can be generated through the change in relative price of domestic and imported tradable goods, as well as change in the relative price of non-tradable to tradable goods. Decrease in consumption and investment leads to decrease in demand for non-tradable goods and through real exchange rate depreciation, a bigger decrease in demand for imported tradable goods. In other words, compared to the benchmark model, the demand effect of interest rate shock will now induce additional relative price changes and RER fluctuations. And consistent with intuition, the RER fluctuation generated by country premium shock depends on the elasticity of substitution between home and imported tradable goods.

Nevertheless, the RER and output volatility generated by the imperfect substitution model is too high compared to the data. It also under-estimates the negative correlation between real interest rate and output. How to further improve the model's performance? To get more significant negative comovement between real interest rate and output/consumption, interest rate shocks need to play more important role in the supply side. Intuitively, financial frictions on firms' borrowing implies interest rate shock will have a supply side effect. This is also consistent with finding in Neumeyer and Perri (2005) and Garcia-Cicco, Pancrazi and Uribe (2010), in which financial frictions have been identified as important in explaining emerging market business cycles. In our benchmark model and imperfect substitution model, we have already introduced working capital constraint. But we find that the imperfect substitution model's performance does not rely on this constraint. This finding is also consistent with Chang and Fernandez (2013)'s conclusion. Recently, Mendoza (2005, 2010) model collateral constraint with collateral value affected by real exchange rate, and finds that the pecuniary effect of relative price changes will amplify shocks' impacts on real economy. This kind of financial friction may help to improve our model's performance since pecuniary effect induced by RER changes can help to match the negative comovement of RER and real interest rate.

Our second modification is inspired by this intuition. We follow the literature on collateral constraint by assuming firm's borrowing capacity is binding by its collateral value (hereafter, we call "collateral constraint model"). Different from Bianchi (2011), we consider a collateral constrain on the producers so as to emphasize impact of interest rate shock on supply side. Obviously, firms' borrowing cost is larger than households saving interest rate due to the existence of the collateral constraint. The introduction of wedge between domestic interest rate and borrowing cost is supported by Fernandez and Gulan (2015), who documents the EMBI and Corporate EMBI. Although these two series comoves but there is a spread between them. Furthermore, the collateral value depends on the RER, or the relative prices between tradable and non-tradable goods prices, which helps to generate the comovement between the RER and real interest rates. It may also help to reduce the excess volatility of RER because now the real exchange rate fluctuation is also constrained by supply side factors.

The estimation of this collateral constraint model confirms that the interaction of pecuniary effect induced by relative price changes and the collateral constraint can help improve the model performance significantly. The collateral constraint model can quantitatively match the volatility of output, consumption, investment and RER, as well as the negative correlation between RER and real interest rate. It also improves on the negative correlation between real interest rate and output/consumption.

For robustness check, we also consider another kind of financial friction, the possible endogenous response of domestic interest rate premium to productivity shocks, as inspired by Neumeyer and Perri (2005, hereafter NP). Chang and Fernandez (2013) also suggest that compared to working capital constraint, this kind of financial friction does better in matching the data in emerging market business cycles. As in the NP paper, the introduction of this financial friction can explain the countercyclical real interest rates. It also does well in generating the negative correlation between RER and real interest rates, however, the main problem is that it overestimate the output volatility and underestimate the relative volatility of RER. This suggest the interaction of pecuniary effect of relative price changes and the financial friction is important in matching the RER volatility observed in the data.

Finally, the variance decomposition indicates that the country premium shock play dominant role in driving fluctuations of almost all variables, including RER dynamics and real interest rate fluctuations. Our findings suggest that country premium shock is important in explaining RER dynamics and its comovement with other macroeconomic variables in the emerging market economies. In this sense, we provide another argument for the importance of country premium shock and financial friction in explaining RBC in emerging economies, from the perspective of RER fluctuations and its comovement with real interest rates.

Our paper belongs to the literature on emerging market business cycles. As discussed at the beginning of the paper, two kinds of shocks are usually considered as the source of aggregate fluctuation in emerging market. Aguiar and Gopinath (2007) use GMM estimation and argue that most business cycle fluctuations could be explained by permanent technology shock. Based on permanent income hypothesis, households' consumption will response more than current output when there is positive permanent technology change and thus it can help to explain the excess consumption volatility puzzle. Another strand of literature emphasizes the importance of interest rate shock and financial friction. Supported by both empirical observation and calibration exercise, Neumeyer and Perri (2005) suggest that country premium explain significant part of Argentina's output fluctuation. Uribe and Yue (2006) use VAR and find US interest rate shock and country spread account for 20% and 12% of movement in aggregate activities respectively. Garcia-Cicco, Pancrazi and Uribe (2010) find RBC model predicts too persistent and too volatile trade balance to GDP ratio while financial friction model generates reasonable trade balance to GDP ratio. Chang and Fernandez (2013) and

Hevia (2014) confirm the dominant role of financial friction as well.

These papers do not include real interest rate data in the estimation and Akinci (2014) is the first paper to fill the gap. She finds that canonical one-sector model fails to generate countercyclical interest rate. So she considers uncertainty shock to explain the negative comovement between interest rate and output/consumption. Meanwhile, typically one-sector model is used in the literature except Seoane (2016). He finds significant parameter drifts processes when estimating the standard one-sector model and these parameter drifts are correlated with real exchange rate dynamics. Thereby he introduces nontradeable sector and includes the real exchange rate data in estimation. But he does not consider real interest rate in his analysis.

Compared to other papers in the literature, our main contribution is as follows. First, we document the difference in RER dynamics and comovements between the emerging economies and the developed SOEs, Second, motivated by this evidence, especially the significant and negative correlation between RER and real interest rates, we include both RER and real interest rate data in the estimation of a two-sector model with tradable and non-tradable goods. We find that the deviation of law of price and the pecuniary effect of real exchange rate changes are important in explaining the RER dynamics and movement observed in emerging market economies. Our Bayesian estimation results also identify country premium shock as the major force in driving RER dynamics and output fluctuations, thus providing another evidence supporting the important role of country premium shock and financial friction in explaining emerging market business cycle.

This paper is also related to literatures on real exchange rate dynamics. This literature focuses on whether the volatility and persistence of real exchange rates can be explained by sticky price models with staggered price setting, pioneered by Chari, Kehoe, and McGrattan (2002). They find in sticky price models the RER volatility can be explained, but not the persistence. So a number of subsequent papers have sought to address this “persistence anomaly” by introducing various forms of strategic complementarity and asymmetry, as well as sticky wages and persistent monetary policy (Bergin and Feenstra 2001; Benigno 2004; Groen and

Matsumoto 2004; Sondergaard 2004 and Bouakez 2005).

These papers usually consider monetary shocks. In contrast, Steisson (2008) shows that in response to a number of different real shocks a two-country sticky-price business cycle model yields hump-shaped dynamics for the real exchange rate. Corsetti, Dedola, Leduc (2008a) find that a two country model with only productivity shock can capture high RER volatility by assuming low trade elasticity, incomplete financial market and home bias. Our paper differs with those papers in several aspects. First, we focus on real exchange rate dynamics as well as its comovement with macroeconomics aggregates in emerging market economies. Second, our estimated real business cycle model can generate the real exchange rate persistence as well as the high volatility observed in the data.

Our paper is inspired by a small but fast growing literature on collateral constraints in small open economy. In this literature, the collateral constraints play an important role in understanding the economic fluctuation and capital flow. For example, Mendoza (2005, 2010) models collateral constraint with collateral value affected by real exchange rate, and finds that the pecuniary effect of relative price changes will amplify shocks' impacts on real economy. Bianchi (2011), Korinek (2011), Jeanne and Korinek (2010) discuss how the collateral constraint with pecuniary externality cause the over-borrowing problem in small open economy. Schmitt-Grohe and Uribe (2017) discuss the multiple equilibria problem in similar setting. We follow their spirit and show that the pecuniary effect of real exchange rate changes cannot be neglected in explaining business cycle.

The rest of paper is organized as follows. Section 2 discusses the empirical findings. In Section 3, we estimate a standard two-sector real business cycle small open economy model with tradable and non-tradable goods using Bayesian methods, including the real interest rate and real exchange rate data in the estimation. Section 4 extends the benchmark model to include imperfect substitution between home and foreign traded goods. We then present its quantitative performance. Section 5 discusses the collateral constrain model. Robustness check results are given in Section 6. Section 7 concludes.

2 Empirical facts

2.1 Business cycle moments

In Table 1A, we present the comparison of second moments of business cycle, especially those related to RER, between the emerging market economies and the developed small open economies. On average, RER volatility relative to output and RER persistence in emerging economies are similar to that of developed small open economies. However, the comovement between RER and other macroeconomic aggregates are quite different between emerging economies and developed SOE. First, real exchange rates are positively correlated with consumption and output in the emerging economies, while in developed economies it is counter-cyclical. They are also negatively correlated trade balance to output ratio at business cycle frequency. More importantly, there is significant and negative correlation between real interest rate and real exchange rate in emerging market economies while this correlation is almost zero in developed small open economies. Second, as discussed in the literature, there exists excess consumption volatility in emerging market economies. We then look at individual emerging market economies data more carefully and document the following three facts. Data description is documented in appendix.

Fact 1 Real effective exchange rates are positively correlated with consumption and output. RER is negatively correlated with trade balance to GDP ratio.

Table **1** documents the correlations with real exchange rate using HP filter detrended data. All emerging countries except South Africa and Colombia have positive and significant correlations between output and RER. We also find strong co-movement between consumption and real exchange rate. The pro-cyclical behavior of real exchange rate is also documented by Mendoza (1995). Specifically, he documents significant positive correlation between REER and output at import price by using annual data, but the correlation between REER and output at constant price is weak. While country risk premium is emphasized in typical literature such as Garcia-Cicco, Pancrazi and Uribe (2010) and Chang and Fernandez (2013), the real exchange rate is always ignored with few exceptions.

Seoane (2016) finds that when putting standard one sector model into estimation, the data prefer models with parameter drifts. He further documents the correlations of these parameters processes with real exchange rate and concludes that time-varying parameters contain relevant information regarding the behavior of the real exchange rate. Our finding of positive comovements of real exchange rate and fundamental variables (output and consumption) is in consistent with his argument. The same table also documents the correlations using log difference variables. The comovements are weaker. On average, the coefficient is 0.07.

Besides, we also document a negative correlation between trade balance to GDP ratio and international relative price. This fact is robust for both HP filter detrended RER series and raw RER data. One potential interpretation of this relations is: when domestic currency depreciates, domestic produced goods gain more international competitiveness and the net export goes up. Or if we assume exogenous interest rate shock are driving force for emerging market, raising exogenous interest rate will result in more saving abroad and households are less willing to consume. Equivalently, we would observe positive change in trade balance to GDP ratio and negative change of domestic consumption price index.

Fact 2 There are significant and negative correlations between real interest rate and real exchange rate.

In Table **1**, All countries except Chile display negative correlation between real interest rate and real exchange rate. On average, the coefficient is -0.29. This negative comovement means that higher country interest rate comes together with depreciation of real exchange rate. Figure **1** plots the patterns of real interest rate and real exchange rate for our sample countries. Take Mexico as example, If the economies' fundamentals are driven by country spread and international interest rate, Figure **1** illustrates that real exchange rate will depreciate as well. Argentina is another typical case. In large devaluation of Argentina Peso in 2001, capital escapes from the country and annualized real interest rate jumps from 10% to 60%. Similar with these two Latin American countries, emerging economies depend highly on external factors: their productions depend on imported factors and significant fractions of their output is exported to rest of worlds. The depreciation of real exchange rate may introduce the substitution effect (impact on imported goods) and income effect (import on export market). Relying on external environment means that real exchange rate is not trivial in these economy at least in the short run. Thereby, our finding provides the exchange rate channel through which financial friction and country premium shock could play a role in emerging markets. Table **2** documents the correlation using log real interest rate and log real exchange rate. Correlation between real exchange rate and real interest rate is weaker compared with the correlation documented using detrended variables. But typical studied countries like Argentina, Brazil and Mexico still display strong interactions between these two rates. This observation motivates us to include these two data in Bayesian estimation exercise when discussing the driving force behind emerging market business cycle.

Fact 3 Real interest rates are countercyclical in emerging market. They are negatively correlated with consumption and investment as well.

Table **1** reports correlations between detrended real interest rate with fundamental variables using HP filtered data. We confirm the finding of Neumeyer and Perri (2005) using updated data. Among all 11 countries, the negative correlations of interest rate and output hold for all country except Chile and South Africa. The consequence of exogenously countercyclical interest rate is following: when there is positive shift of domestic interest rate, households save more and cut down their consumptions. Firms will reduce their production when the market price goes down. This intuition predicts that real interest rate should be negatively correlated with consumption, investment and net export to GDP ratio. And these predictions are confirmed in Table **1**. We also document the correlations of log real interest rate and growth rates of fundamental variables. The negative correlations between real interest rate and fundamental variables are maintained when we include the low frequency data, which is documented in Table **2**.

Our findings suggest that RER dynamics and moments should be considered when investigating emerging market business cycle properties. Therefore, in the following analysis we include the RER and real interest rates data simultaneously in Bayesian estimation and evaluate the performance of a standard two-sector

RBC small open economy model with non-tradable goods and homogenous tradable goods in explaining RER behavior in emerging market economies.

3 The benchmark model

Our benchmark model is a standard two-sector model with homogenous tradable goods. Firms in each sector use labor and capital to produce tradeable and non-tradeable goods. They need to finance for the wage payment. Households provide labor and consume goods. Domestic interest rate is specified following Schmitt-Grohe and Uribe (2003). Final consumption goods are composited by tradeable goods and nontradeable goods. In this benchmark model, tradable goods are homogenous. This specification is the simplest model that allow us to put real interest rate and real exchange rate into estimation simultaneously. This model is similar to Seoane (2016), but he does not consider real interest rate in the estimation.

3.1 Household

There is an infinitely lived representative agent with GHH preference.

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{v_t [\frac{C_t}{X_{t-1}} - \Lambda \tau^{-1} {l_t}^{\tau}]^{1-\gamma} X_{t-1}^{1-\gamma} - 1}{1-\gamma} \tag{3.1}$$

v_t is the preference shock. Λ is a parameter to ensure the allocation of labor in steady state. X_{t-1} is the permanent productivity, which is assumed to be non-stationary. Let $g_t = \frac{X_t}{X_{t-1}}$ denote the non-stationary shock. $\overline{g}$ measures the growth rate in balance growth path. We assume g_t and v_t follow AR(1) processes. We set tradable goods price as numeraire and p_t^N is the relative price of nontradable sector. The real budget constraint is

$$p_t^c C_t + D_t^h + I_t^N + I_t^T = \frac{D_{t+1}^h}{1+r_t} + w_t l_t + R_t^{K,N} K_t^N + R_t^{K,T} K_t^T + \sum_{j=T,N} \Pi_t^j + \Pi_t \tag{3.2}$$

Where $p_t^c C_t$ is the total expenditure on consumption, D_t^h is the holding of debts due at period t, which is borrowed from the financial intermediary. Π_t^j is the profits received from domestic firms and Π_t is profit from bank. Households buy domestic tradable good as investment. $R_t^{K,T}$ and $R_t^{K,N}$ are the capital rental rates. Households' income includes wage payment, capital rents and profits transferred from the intermediate sector. When changing its capital stocks, households pay quadratic adjustment costs. ϕ^j governs capital adjustment cost in sector j. The capital motions are

$$K_{t+1}^j = (1-\delta)K_t^j + I_t^j - \frac{\phi^j}{2}(\frac{K_{t+1}^j}{K_t^j} - \overline{g})^2 K_t^j, \text{ for } j = \{T, N\} \tag{3.3}$$

r_t is the domestic interest rate on household debt. and it is assumed to be decided by the following equation,

$$1 + r_t = r^* + \psi[\exp(\frac{\widetilde{D}_{t+1}}{X_t} - d)] + \mu_t \tag{3.4}$$

To introduce stationary equilibrium, we follow Schmitt-Grohe and Uribe (2003) by assuming the domestic interest rate is external debt elastic. The variable $\widetilde{D}_{t+1}$ is the aggregate level of external debt and $d_{t+1} = \frac{\widetilde{D}_{t+1}}{X_t}$ is the detrended debt level. d represents the steady state level of normalized debt and r^* is real interest rate in steady state. Once country borrows too much from abroad ($\frac{\widetilde{D}_{t+1}}{X_t} > d$), the premium will be positive. $\psi > 0$ governs the elasticity of interest rate to changes in indebtedness. The country premium shock μ_t is assumed to follow a AR(1) process.

The household chooses $C_t, l_t, D_{t+1}^h, K_{t+1}^T, I_t^T, K_{t+1}^N, I_t^N$ to maximize its utility, subject to budget constraint (3.2), capital motion (3.3) and no-Ponzi game $\lim_{j\longrightarrow\infty} E_t(\frac{D_{t+j}}{\Pi_{s=0}^j(1+r_s)}) \leq 0$. Lagrangian multiplier is $\lambda_t X_{t-1}^{-\gamma}$. First order conditions are:

$$[\frac{C_t}{X_{t-1}} - \Lambda\tau^{-1} l_t^\tau]^{-\gamma} X_{t-1}^{-\gamma} = \lambda_t X_{t-1}^{-\gamma} p_t^c \tag{3.5}$$

$$[\frac{C_t}{X_{t-1}} - \Lambda\tau^{-1} l_t^\tau]^{-\gamma} X_{t-1}^{1-\gamma} \Lambda l_t^{\tau-1} = \lambda_t X_{t-1}^{-\gamma} w_t \tag{3.6}$$

$$\lambda_t X_{t-1}^{-\gamma} \frac{1}{1+r_t} = \beta E_t \lambda_{t+1} X_t^{-\gamma} \tag{3.7}$$

For $j = \{T,N\}$:

$$\lambda_t X_{t-1}^{-\gamma}\left[1+\phi^j(\frac{K_{t+1}^j}{K_t^j}-\overline{g})\right] = \beta E\left\{\lambda_{t+1}X_t^{-\gamma}\left[\begin{array}{c} R_{t+1}^{K,j}+(1-\delta) \\ -\frac{\phi^j}{2}(\frac{K_{t+2}^j}{K_{t+1}^j}-\overline{g})^2+\phi^j(\frac{K_{t+2}^j}{K_{t+1}^j}-\overline{g})\frac{K_{t+2}^j}{K_{t+1}^j}\end{array}\right]\right\} \tag{3.8}$$

3.1.1 Consumption aggregator

Final consumption good C_t is produced by using nontradable good C_t^N and tradable good C_t^T. The production function is CES form, with κ being the elasticity of substitution between two inputs, and ς as the expenditure share on tradable input.

$$C_t = [\omega^{\frac{1}{\kappa}} C_t^{T\,\frac{\kappa-1}{\kappa}} + (1-\omega)^{\frac{1}{\kappa}} C_t^{N\,\frac{\kappa-1}{\kappa}}]^{\frac{\kappa}{\kappa-1}} \tag{3.9}$$

Demands of C_t^N and C_t^T are:

$$C_t^N = (1-\omega)(\frac{p_t^N}{p_t^c})^{-\kappa}C_t \tag{3.10}$$

$$C_t^T = \omega(\frac{p_t^T}{p_t^c})^{-\kappa}C_t \tag{3.11}$$

The composite consumption price index and the tradable good price index is:

$$p_t^c = [\omega(p_t^T)^{1-\kappa}+(1-\omega)(p_t^N)^{1-\kappa}]^{\frac{1}{1-\kappa}} \tag{3.12}$$

3.2 Firms

Firms that produce tradable goods Y_t^T or nontradable goods Y_t^N are competitive. They take prices as given and minimize production cost by choosing capital and labor. Following the logic of Aguiar and Gopinath (2007), the trend shock is country-specific as it's always related with government policy, therefore we assume the trend productivity shock g_t is a common shock for both sectors. A_t^j is the transitory shock and follows AR(1) process. For j producer, $j \in \{T,N\}$, the production function is:

$$Y_t^j = A_t^j (K_t^{j,s})^{1-\alpha_j}(X_t l_t^j)^{\alpha_j} \tag{3.13}$$

Firms are assumed to suffer from capital constraint. Our specification follows Uribe and Schmitt-Grohe (2016). For each unit of wage payment, firms need to hold ϖ^j units of real money, denoted as MB_t^j.The working capital constraint is

$$MB_t^j \geq \varpi^j w_t l_t^j \tag{3.14}$$

Firms can borrow or lend at rate r_t and distribute dividends. Net profit of firms could be specified as

$$\Pi_t^j = p_t^j Y_t^j - w_t l_t^j - R_t^{K,j} K_t^{j,s} - (MB_t^j - MB_{t-1}^j) + \frac{D_{t+1}^{f,j}}{1+r_t} - D_t^{f,j} \tag{3.15}$$

This equation means that the dividend equal to revenue minus change in cash and plus the increase in international debt. $D_{t+1}^{f,j}$ is the debt borrowed from financial intermediary and due in period $t+1$.Firms choose l_t^j, K_{t+1}^j, MB_t^j and $D_{t+1}^{f,j}$ to maximize profit

$$\max_{l_t^j, K_{t+1}^j, MB_t^j, D_{t+1}^j} E_0 \Sigma_{t=0}^{\infty} [\beta^t \lambda_t X_{t-1}^{-\gamma} \Pi_t^j]$$

$\lambda_t X_{t-1}^{-\gamma}$ is the stochastic discount factor, and Lagrangian equation is

$$L = E_0 \Sigma_{t=0}^{\infty} \beta^t \lambda_t X_{t-1}^{-\gamma} \begin{bmatrix} p_t^j Y_t^j - w_t l_t^j - R_t^{K,j} K_t^j - (MB_t^j - MB_{t-1}^j) \\ + \frac{D_{t+1}^{f,j}}{1+r_t} - D_t^{f,j} + \mu_{ct}^j \left(MB_t^j - \varpi^j w_t l_t^j \right) \end{bmatrix} \tag{3.16}$$

where $\beta^t \lambda_t X_{t-1}^{-\gamma} \mu_{ct}^j$ denotes Lagrangian multiplier on working capital constraint. Optimal choices on $D_{t+1}^{f,j}, K_t^j, l_t^j, MB_t^j$ are

$$\lambda_t = \beta g_t^{-\gamma} (1+r_t) E_t \lambda_{t+1} \tag{3.17}$$

$$R_t^{K,j} = p_t^j (1-\alpha_j) A_t^j \left(\frac{u_t^j K_t^j}{X_t l_t^j}\right)^{-\alpha_j} \tag{3.18}$$

$$w_t (1 + \mu_{ct}^j \varpi^j) = p_t^j \alpha_j A_t^j X_t \left(\frac{u_t^j K_t^j}{X_t l_t^j}\right)^{1-\alpha_j} \tag{3.19}$$

$$\lambda_t (1 - \mu_{ct}^j) = \beta g_t^{-\gamma} E_t \lambda_{t+1} \tag{3.20}$$

Equation (3.17) and (3.20)s imply:

$$\mu_{ct}^j = \frac{r_t}{1+r_t} \tag{3.21}$$

We can get the choices of labor and capital as the following way:

$$w_t(1+\frac{r_t}{1+r_t}\varpi^j) = p_t^j\alpha_j A_t^j X_t(\frac{u_t^j K_t^j}{X_t l_t^j})^{1-\alpha_j} \tag{3.22}$$

$$R_t^{K,j} = p_t^j(1-\alpha_j)A_t^j(\frac{u_t^j K_t^j}{X_t l_t^j})^{-\alpha_j} \tag{3.23}$$

3.3 Equilibrium

Similar with Uribe and Stephanie Schmitt-Grohe (2017), we assume that there is a continuum of identical and perfectly competitive banks. They borrow funds in international financial markets and lend them to domestic households and firms. Meanwhile, the bank accept deposit from firms. The bank balance sheet is the following:

$$\frac{D_{t+1}^h + D_{t+1}^{f,T} + D_{t+1}^{f,N}}{1+r_t} = \frac{\widetilde{D}_{t+1}}{1+r_t} + MB_t^T + MB_t^N \tag{3.24}$$

$\widetilde{D}_{t+1}$ is the international debt position of the whole country in period t. The left-hand size is the bank's asset. The right-hand size is the liabilities. Bank's profit

$$\Pi = D_t^h + D_t^{f,T} + D_t^{f,N} - \widetilde{D}_t - MB_{t-1}^H - MB_{t-1}^N \tag{3.25}$$

Besides the optimal behaviors of households and firms, the equilibrium requires market clearing conditions listed below and the specification of shock processes.

$$l_t = l_t^N + l_t^T \tag{3.26}$$

$$Y_t^N = C_t^N \tag{3.27}$$

$$Y_t^T = C_t^T + TB_t + I_t^T + I_t^T \tag{3.28}$$

Let $\Theta_t = \{g_t, v_t, A_t^T, A_t^N, \mu_t\}$ and Θ is their steady state level. The AR(1) process is

$$\ln(\frac{\Theta_t}{\Theta}) = \rho^\Theta \ln(\frac{\Theta_{t-1}}{\Theta}) + \varepsilon_t^\Theta; \varepsilon_t^\Theta \sim N(0, \sigma_\Theta^2) \tag{3.29}$$

3.4 Quantitative result: case of Mexico

3.4.1 Calibration and estimation strategy

Calibration Our interest is on shocks and frictions that may affect the business cycle movement. For preference and production parameters, we either use the common value in literature or calibrate to match moments in data. Summary of calibrated parameters for Mexican economy is in Table **3**. Since our benchmark estimation uses quarterly Mexican data, our choices of parameters follow Aguiar and Gopinath (2007) closely. Namely, the discount factor β is 0.98. Labor income share $\alpha^T = \alpha^N = 0.68$. Capital depreciation rates for tradable and nontradable is $\delta = 0.05$. Our parameters governing GHH preference are from Garcia-Cicco, Pancrazi and Uribe (2010). τ is calibrated to be 1.6 so that labor supply elasticity is $1/(\tau-1) = 1.7$. The curvature of period utility $\gamma = 2$. We let $\Lambda = 2.2$ such that household allocates about 35% time for working in steady state. $\overline{g}$ is the steady state growth rate and we use it to calibrate the average output growth rate in data, which is around 0.64%. We also match two key moments in data: The first one is the average trade balance to GDP ratio, which is around 2% in data. The second one is the average level of logarithm of real effective exchange rate in data, which is 1.6%.

Prior Let $G(a,b)$ and $B(a,b)$ denote for Gamma and Beta distribution with a being mean and b being standard deviation. First part of estimated structural parameters is the shock persistence and standard deviation: $\Lambda = \{\rho_j, \sigma_j\}, j \in \{g, A^T, A^N, \eta, \mu\}$. Same as in Seoane (2016), prior distribution for shock persistence is $B(0.7, 0.1)$. The output volatility of our sample is 1.36% and consumption volatility is 1.7%, so we choose prior distributions for volatility to be $G(0.015, 0.01)$. We assume no home bias in prior. The prior distribution for ω is Beta distribution with mean equal to 0.5 and standard deviation equal to 0.1. Literature in estimating the elasticity of substitution between tradables and nontradables κ such as Akinci (2011) finds that the value is around 0.5. A distribution $B(0.5, 0.1)$ is assumed to be the prior for κ. ϖ^N and ϖ^T capture working capital constraint and Both Chang and Fernandez (2013) and Seoane (2016) find that these value is around 0.75. We assume their priors are $B(0.75, 0.1)$. Regarding the capital adjustment cost, Uribe and Schmitt-Grohe (2016)[5] find that the capital adjustment cost for nontradable sector and export sector in Mexico is 0.6 and 1.01 separately. Our estimation follows these value. Mean of priors of capital adjustment cost is one and the distribution is $G(1, 0.5)$. In the same exercise, they also report the debt elasticity of the interest rate ψ, which is 0.24 for Mexico. We assume the prior is $B(0.1, 0.05)$.

Data The data is from 1994Q1 to 2012Q4. Available data are output, consumption, investment, trade balance, real effective exchange rate and real interest rate. To address the difference between theoretical variables and variables in data, we define real exchange rate as the ratio of domestic consumer price index to consumer price index in rest of world $REER_t = \frac{p_t^c}{P_t^*}$, where $p_t^* = 1$. An increase in RER means a real appreciation of domestic currency and loss of international competitiveness. The real GDP measured in constant price in data and corresponding measurement in model is $GDP_t = \frac{Y_t^T + p_t^N Y_t^N}{p_t^c}$. The trade balance to GDP ratio is $tby_t = \frac{TB_t}{p_t^c GDP_t}$. Investment data is the aggregation of both sector's and the model counterpart is $I_t = \frac{(I_t^T + I_t^N)}{p_t^c}$. The consumption and real interest rate are consistent between model and data.

Posterior The posterior distributions of estimations are reported in Table **4**. Distributions are characterized by median, 5% and 95% confidence interval. The distributions are simulated by Metropolis-Hasting algorithm with two million draws. We target a 25% acceptance rate.

For the benchmark model, the posterior medians of capital adjustment costs both deviate from their prior mean. The median of external debt elasticity is similar with the value in Seoane (2016). This value implies that 1% international debt change raises the domestic interest rate by 0.09%. We also find that ω is around 0.14, meaning that the weight on tradable goods is relatively small. Besides, all shock processes are highly persistent. Stationary technology shock in tradable sector is much larger than stationary technology shock in nontradable sector. Median of measurement errors of consumption, investment and trade balance to GDP

[5] In their table 8.3.

ratio are around 1/3 of their standard deviations. We also report the log likelihood and log marginal likelihood as statistics to judge the model performance.

3.4.2 Model performance

Table **5** documents the theoretical moments using the posterior medians of estimated parameters and their empirical moments. The model can match the standard deviation of investment and trade balance to GDP ratio, but fails to generate excess volatility of consumption. This is because the predicted output is too volatile. Variance decomposition in Table **6** reveals that the stationary technology shock in nontradable sector accounts for around 50% of output's fluctuation and this shock also explains around 24% of consumption variance. In effect, if we shut down the standard deviation of stationary technology shock in nontradable sector, the standard deviation of output is equal to 1.461% and the standard deviation of consumption is 1.462%. Illustrated by Figure **2**, temporary technology shocks have larger impact on the output than on household's consumption. Households smooth their consumption and the consumption volatility implied by these temporary technology shocks is smaller than the volatility of output. Similar with the literature, we can match the auto-correlation of consumption and output qualitatively but not quantitatively. The model fails to match first order autocorrelation of investment both qualitatively and quantitatively.

Real exchange rate Similar in Seoane (2016), our benchmark model generates RER persistence. However, it underestimates the RER volatility, both absolutely and relatively to GDP. In addition, the model generates positive comovement between real exchange rate and output, as well as positive comovement between real exchange rate and consumption. Variance decomposition indicates that most of relative price fluctuation is driven by stationary technology shock in both sectors. The IRF in Figure **2** and Figure**3** plot RER's response to stationary technology shocks. When there is positive and temporary productivity shock in tradable sector, the relative price of nontradable goes up so as to clear the market of tradable goods. The real exchange rate appreciates and comoves positively with output and consumption. A positive and temporary productivity shock in nontradable sector will generate negative comovement of real exchange rate and output. Besides, the low value of expenditure share on tradable goods ω, whose median is 0.14, is important for exchange rate volatility. When we choose $\omega = 0.5$, standard deviation of RER is around 5.25 And the magnitude of RER's response to stationary technology shock AT is only half as large as the ones documented in Figure **2**.

Real interest rate The model-generated coefficient between real exchange rate and output is 0.10 while its empirical counterpart is -0.17. The model-predicted correlation between consumption and real interest rate is 0.04 but the coefficient is -0.24 in data. Finally, the negative correlation between real exchange rate and real interest rate is matched qualitatively but not quantitatively. The observed correlation is -0.51 in data while the model generated correlation around -0.23.

We plot the impulse response to one standard deviation (0.484%) of permanent technology shock in Figure **4**. A positive trend shock stimulates domestic output growth rate by 0.4% initially. Households expect higher future income and consume more than current production. This permanent income hypothesis explains the initial 1% increase in consumption growth rate. The excess response of consumption results in growing of external debt and consequently positive shift of borrowing cost. The real interest rate increase by 0.01% initially. In sum, the trend shock generates sizable and positive comovement between output and real interest rate. The variance decomposition indicates that trend shock explains around 42% of output and 32% of real interest rate. In effect, when we assume zero standard deviation of the trend shock, the comovement between real exchange rate and real interest rate is -0.039. This counterfactual exercise indicates that trend shock is responsible for positive comovement of real interest rate and output growth rate.

What's left is why the country premium shock play no role in driving economic fundamentals. Figure **5** plots the economy's response to one percentage country premium shock. In this economy, a positive country risk premium shock μ_t raises the country borrowing cost. Initially, the incentive to save abroad dominates and output in tradable sector goes up for a short period. In the following period, Given the higher borrowing cost, firms decrease their inputs because it's costlier to finance working capital. Meanwhile, households reduce their current consumption so as to save abroad. The mix effect of real interest rate on output is not consistent with data and it's not surprising that the model does not relies on country premium shock to drive the output fluctuation.

4 The imperfect substitution model

Our exercise so far finds that standard two-sector model fails to generate the countercyclical interest rate. The reason is because the data puts weight on trend shock to explain both output fluctuation and real interest rate dynamics when we use the standard model in estimation. Meanwhile, real exchange rate is fully captured by stationary technology shock in tradable sector. Therefore, the standard model underestimates the correlation between real interest rate and real exchange rate. A strong assumption of this standard model is that the real exchange rate fluctuation is due to changes in the relative price of nontradable goods. In fact, there is a debate on driving force behind real exchange rate movements. Evidences are Burstein, Eichenbuam and Rebelo (2005) and Mendoza (2005) find empirical evidence to prefer the change of price in nontradable goods as the main driving force behind real exchange rate dynamics. Another wisdom (Engel, 1999; Betts and Kehoe, 2006) finds that deviation from the law of one price for tradable goods captures a large fraction of real exchange rate fluctuation. Our second exercise is inspired by the fact that real exchange rate may not be merely driven by relative price of nontradable good. Our motivation here is not to provide variance analysis on which prices matter on real exchange rate dynamics but to release our strong assumption in benchmark model and to provide another potential driving force of real exchange rate dynamics. In other word, we provide more freedom when estimation searches parameters and shocks to match data.

4.1 The imperfect substitution model

The economy is similar as previous one. We denote the domestic produced good with superscript $\{H\}$ and imported good with $\{F\}$. Supply side is same as previous one. We assume the imported good is the numeraire goods. To save words, we use "the imperfect substitution model" to represent the model with imperfect substitution between home and foreign tradables in coming section.

4.1.1 Tradable consumption goods

Domestic tradable goods C_t^H and foreign produced tradable goods C_t^F are imperfect substituted with each other. Inputs are aggregated in in CES form to get composite tradable goods C_t^T. θ is the elasticity of substitutions between tradeable and ξ is the share on domestic tradable goods. Our benchmark model is a special case of this CES aggregator where we force $\theta \longrightarrow \infty$.

$$C_t^T = [\xi^{\frac{1}{\theta}}(C_t^H)^{\frac{\theta-1}{\theta}} + (1-\xi)^{\frac{1}{\theta}}(C_t^F)^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}} \tag{4.30}$$

The demands of domestic tradable and foreign tradable are:

$$C_t^H = \xi(\frac{p_t^H}{p_t^T})^{-\theta}C_t^T \tag{4.31}$$

$$C_t^F = (1-\xi)(\frac{p_t^F}{p_t^T})^{-\theta}C_t^T \tag{4.32}$$

The tradable goods' price index:

$$p_t^T = [\xi(p_t^H)^{1-\theta} + (1-\xi)(p_t^F)^{1-\theta}]^{\frac{1}{1-\theta}} \tag{4.33}$$

4.1.2 Exports

Domestic tradable good producer exports its product to the rest of world. In small open economy framework, the fraction of export is so small that the world price index is not affected by domestic goods. That is, the world price index is equal to the imported good price index. Foreign households have the same trade elasticity

θ as domestic households. World consumption c_t^* is assumed to follow AR(1) process. World demand on domestic good $C_{H,t}^*$ is specified as following:

$$C_{H,t}^* = (1-\xi^*)(p_{H,t})^{-\theta} C_t^* \tag{4.34}$$

The trade balance is

$$TB_t = (1-\xi^*) p_{H,t}^{1-\theta} C_t^* - C_t^F \tag{4.35}$$

4.2 Estimation of imperfect substitution model: case of Mexico

4.2.1 Model performance

Posterior Most parameters are same as in previous model. The prior of share on domestic tradable goods ξ is $B(0.5, 0.1)$ while the prior of elasticity between domestic tradables and imported goods is $G(2, 0.5)$. Other estimation strategies are same as previous exercises. The posterior distributions are reported in Table **4**. Both log posterior and log marginal likelihood reveal that model with imperfect substitution between home and foreign traded goods are preferred by data. Measurement errors of all variables are slightly smaller compared with estimation on model with homogeneous tradable goods. The measurement errors of output, real interest rate and real exchange rate will hit zero bound if they are allowed in estimation. Posterior median of domestic interest rate' sensitivity to fundamentals ψ is 0.013 while the corresponding value in previous estimation is 0.09. We emphasize that the posterior median of standard deviation of trend shock is 0.0027, compared with 0.005 in benchmark model. The posterior medians of standard deviation of country premium shock are identical in both benchmark model and model with imperfect substitution.

Variance decomposition Before discussing the model generated moments, we highlight the importance of various shocks, which is documented in Table **6**. A noticeable change is that the stationary technology shock in both tradable sector and nontradable sector is no longer important. More interestingly, we find that both permanent technology shock and country premium shock play both nontrivial roles in understanding most variables' variations. Concretely speaking, the share of permanent technology shock to capture output variation is 59%. This shock also explains nearly 67% of consumption variation and 65% of RER movement. The country premium shock drives the real interest rate dynamics while it only accounts for 60% of real interest rate variance in our benchmark exercise. Meanwhile, this premium shock captures around 30% of output fluctuation and 34% of real exchange rate movement.

Business cycle moments The simulated moments based on posterior median of parameters are reported in Table **5**. Given the differences of shocks' importance, our imperfect substitution model performs better in three dimensions. First, regarding the standard deviations, our modified model is capable to generate the excess volatility of consumption qualitatively. Output's standard deviation and consumption's standard deviation are closer to their empirical counterparts compared with results in previous exercise. Second, this modified model generates qualitatively negative comovement between real interest rate and output, which is -0.06 in our theoretical model and it's -0.17 in data. The negative correlation between real interest rate and consumption is also matched qualitatively. Thirdly, this modified model improves comovement between real interest rate and real exchange rate as well. In this model, the coefficient is -0.45 and it's -0.51 in data. Another minor change is the correlation between RER and trade balance to GDP ratio. Previously the model let RER purely driven by stationary technology shock and its comovement with trade balance is underestimated. In this modified model, the driving forces of RER and tby are pretty similar and the coefficient of their correlation is -0.85, compared with -0.58 in data.

Role of trade elasticity To understand why data prefer trend shock and country premium shock when we distinguish home tradables from foreign tradables, it's helpful to check the shocks' impulse response function in this imperfect substitution model. Different from benchmark economy, the economy's response to a standard deviation of positive trend shock is much larger. First, domestic output growth rate increases by 0.8% initially, a size twice larger than one in benchmark model. The impact of trend shock on investment is also twice larger. A more impressive result is the response of real exchange rate, which is more than 3.9%

initially. When there is one percentage change in country premium shock, response of output is definitely negative. The initial drop of output is more than 0.8% while the drop in consumption is nearly 1%. Additionally, the relative price drop more than 4%.

We argue that the significant change of relative price is due to the estimated low elasticity of substitution between domestic tradables and foreign tradables. Note that the posterior median of θ approaches unit. The increasing domestic saving rate stimulate households to save abroad and generate positive net trade balance. Given that the trade elasticity is near one, price changes will hardly change export value. The positive trade balance in (4.35) comes from decreases of import goods. Consequently, the domestic tradable goods price decreases so as to substitute the imported consumption. Meanwhile, tradables goods and non-tradables goods are complementary given that κ is less than unit. The decrease of tradable goods price generates a large drop in nontradable goods price. In Figure **5**, we show a clear pattern on the response of real exchange rate by setting various value for θ. The response of RER become smaller as the elasticity of substitution becomes larger.

4.3 Model without working capital constraint

Given that the country premium shock is important in this model, it's worthy to check the channel. We first argue that our result does not reply on our specifying of working capital constraint. The exercise is conducted by forcing $\varpi_j = 0$. The results are reported in Table **4.** The estimated parameters and shock processes do not deviate from the ones with working capital constraint. Business cycle moments and variance decomposition are similar as well. Variance decomposition based on this model still allocates a significant role of country risk premium shock, indicating that the interest rate's impact on real economy works through household's intertemporal choice, or the demand side, but not through firms' production decision, or the supply side. The country premium shock is more like a demand shock to household in this model.

5 The collateral constraint model

Our previous exercise indicates that the country premium shock is nontrivial and this shock works through household's demand change but not through the working capital constraint. A recent research by Fernandez and Gulan (2015) find there is a spread between the Corporate EMBI and sovereign EMBI. This extension is inspired by this finding and try to model the difference between households' saving interest rate and firms' borrowing cost. We borrow the collateral constraint specification in Liu, Wang and Zha (2013). That is, firms' borrowing is constrained by the collateral value. To keep the model consistent with previous discussion, we assume only the capital stock can be used as collateral and no other collateral goods is introduced. This collateral generates the wedge between the firms' borrowing cost and household's saving interest rate. The specification of demand side is identical to previous sections.

6 Entrepreneur

There are two sector $j = \{H, N\}$. We assume that the entrepreneur's objective function is

$$E \sum_{t=0} \beta^{e,t} \left\{ \frac{(C^j_{et})^{1-\gamma}}{1-\gamma} \right\} \tag{6.36}$$

Production is

$$Y^j_t = A^j_t [K^j_t]^{1-\alpha^j} (X_t L^j_t)^{\alpha^j} \tag{6.37}$$

Y^j_t is the output, K^j_t, L^j_t denote the input capital and labor. ϕ^j governs capital adjustment cost in sector j. The capital motions are

$$K^j_{t+1} = (1-\delta)K^j_t + I^j_t - \frac{\phi^j}{2}(\frac{K^j_{t+1}}{K^j_t} - \overline{g})^2 K^j_t \tag{6.38}$$

The collateral constraint

$$D^{f,j}_{t+1} \leq \theta^j_t E_t[q^j_{k,t+1} K^j_t] \tag{6.39}$$

$q^j_{k,t+1}$ is the shadow price of capital in consumption units. Suppose the firm need MB^j_t to pay the wage. The working capital constraint is

$$MB^j_t \geq \varpi^j w_t L^j_t \tag{6.40}$$

The entrepreneur need to buy tradable goods as investment goods. The entrepreneur's profit is

$$p^j_t C^j_{et} = p^j_t Y^j_t - p^H_t I^j_t - w_t L^j_t + \frac{D^{f,j}_{t+1}}{1+r_t} - D^{f,j}_t - (MB^j_t - MB^j_{t-1}) \tag{6.41}$$

Let $\lambda^{ej}_t X^{-\gamma}_{t-1}, \mu^j_{kt}\lambda^{ej}_t X^{-\gamma}_{t-1}, \mu^j_{bt}\lambda^{ej}_t X^{-\gamma}_{t-1}, \mu^j_{ct}\lambda^{ej}_t X^{-\gamma}_{t-1}$ be the multiplier for flow of funds constraint (6.41), capital accumulation (6.38), collateral constraint (6.39) and working capital constraint (6.40) . Immediately, we have $q^j_{k,t} = \mu^j_{kt}$ according to the definition. FOCs on $C^j_{et}, L^j_t, I^j_t, K^j_t, D^{f,j}_{t+1}, MB^j_t$ are

$$(C^j_{et})^{-\gamma} = \lambda^{ej}_t X^{-\gamma}_{t-1} p^j_t \tag{6.42}$$

$$w_t(1+\mu^j_{ct}\varpi^j) = \alpha^j \frac{p^j_t Y^j_t}{L^j_t} \tag{6.43}$$

$$p^H_t = \mu^j_{kt} \tag{6.44}$$

$$\mu^j_{kt}\lambda^{ej}_t \left[1+\phi^j(\frac{K^j_{t+1}}{K^j_t} - \overline{g})\right] - \lambda^{ej}_t \mu^j_{bt}\theta^j_t E_t \mu^j_{kt+1} \tag{6.45}$$

$$= \beta^e E_t \lambda^{ej}_{t+1} g^{-\gamma}_t \left[\begin{array}{c} (1-\alpha^j)\frac{Y^j_{t+1}p^j_{t+1}}{K^j_{t+1}} \\ +\mu^j_{kt+1}\left((1-\delta) - \frac{\phi^j}{2}(\frac{K^j_{t+2}}{K^j_{t+1}} - \overline{g})^2 + \phi^j(\frac{K^j_{t+2}}{K^j_{t+1}} - \overline{g})\frac{K^j_{t+2}}{K^j_{t+1}}\right) \end{array} \right]$$

$$\frac{1}{1+r_t} = \beta^e E_t \left[\frac{\lambda^{ej}_{t+1}}{\lambda^{ej}_t} g^{-\gamma}_t\right] + \mu^j_{bt} \tag{6.46}$$

$$\lambda^{ej}_t (1-\mu^j_{ct}) = \beta^e E_t \left[\lambda^{ej}_{t+1} g^{-\gamma}_t\right] \tag{6.47}$$

Rearrange the term, we have

$$(1-\mu^j_{ct}) + \mu^j_{bt} = \frac{1}{1+r_t} \tag{6.48}$$

$$\mu^j_{ct} = \frac{r_t}{1+r_t} + \mu^j_{bt} \tag{6.49}$$

Compare with standard model without collateral constraint, we find that the wedge contents another term μ^j_{bt} which is the marginal value of collateral.

6.1 Equilibrium

The bank balance sheet

$$\frac{D^h_{t+1}+D^{f,H}_{t+1}+D^{f,N}_{t+1}}{1+r_t}=\frac{\widetilde{D}_{t+1}}{1+r_t}+MB^T_t+MB^N_t \tag{6.50}$$

Bank's profit

$$\Pi=D^h_t+D^{f,T}_t+D^{f,N}_t-\widetilde{D}_t-MB^H_{t-1}-MB^N_{t-1} \tag{6.51}$$

$\widetilde{D}_t$ is the international debt position of the whole country. Besides the optimal behaviors of households and firms, the equilibrium requires market clearing conditions listed below and the specification of shock processes.

$$l_t = l^N_t+l^H_t \tag{6.52}$$

$$Y^N_t = C^N_t \tag{6.53}$$

$$Y^H_t = C^H_t+C^{*,H}_t+I^H_t+I^H_t \tag{6.54}$$

6.2 Estimation and model performance

On the parameter calibration, we let $\beta^e=0.96$ so that the entrepreneur is less patient than the household and the credit constraint is binding. The new parameters are θ^T and θ^N, which govern the fraction of capital stock that can be used as collateral value in steady state. Liu, Wang and Zha (2013) find this value is 0.75 in U.S. We specify the mean of prior distribution as 0.5, since Mexico is less financial-developed and land is not considered. The collateral shocks processes are also specified. To check the role of collateral constraint, we also estimate a model without working capital constraint. The estimated posteriors are documented in Table 7. The log posterior indicates that the collateral constraint model performs better compared with the imperfect substitution model, while the log marginal density provides the inverse prediction. This symptom is also discussed in Chang and Fernandez (2013). They conclude that marginal likelihood comparisons are known to favor models with few parameters. Thereby, the mix information provided by log posterior and log marginal density is inconclusive.

However, the data significantly prefer collateral constraint model with working capital constraint to the model without working capital constraint.

The simulated business cycle model is documented in Table 8. Interestingly, our collateral constraint model matches the empirical counterpart pretty well in all dimensions. The aggregate output volatility is 1.42, reasonably close to the one in data. The consumption volatility is 1.69, which exceeds the output volatility and is also close to the empirical one. Besides, real exchange rate volatility is matched as well. The model can also generate the countercyclical interest rate quantitatively. Compared with the imperfect substitution model, this model with collateral constraint also generate reasonable first order correlations of all variables. The variance decomposition in Table **9** indicates that the country premium shock play a dominant role in driving fluctuations of all variables.

7 Robustness

7.1 Financial friction model in Neumeyer and Perri (2005)

In this robustness check, we consider the possible endogenous response of domestic interest rate to productivity shocks, as inspired by Neumeyer and Perri (2005, hereafter NP).

$$\begin{aligned} 1+r_t &= r^* + \psi[\exp(\frac{\widetilde{D}_{t+1}}{X_t} - d)] + \mu_t \\ &\quad + \widetilde{\psi}(g_t - \overline{g}) + \widetilde{\psi}(A_t^T - A^{T,ss}) + \widetilde{\psi}(A_t^N - A^{N,ss}) \end{aligned} \tag{7.55}$$

$\widetilde{\psi}$ captures the interest rate's elasticity to productivity shocks. The prior for the elasticity of interest rate to productivity shocks is identical to the prior for the elasticity of interest rate to external debt.

The estimation results are documented in Table 10. Simulated business cycle moments and variance decomposition are documented in Table 11 and Table 12. The estimation result of benchmark NP model is similar except some parameters governing the real interest rate and country premium shocks. For instance, the median of external debt elasticity is 0.044, half of the value in benchmark estimation. This is because real interest rate dynamics can be driven by the productivity shock in the NP model, as the estimation of the median of productivity shock elasticity is 0.042. This feature also results in the smaller estimated standard deviation of country premium shock. In the benchmark model, the median is 0.34% while the median is 0.23% in the NP model.

As in Chang and Fernandez (2013), we also find that introducing endogenous response of country spread to productivity shock help to improve the model performance relative to the benchmark model. In Table 5, we find that our benchmark NP model can generate relative excess consumption volatility. Besides, the real interest rate is countercyclical as this rate responds negatively to productivity shocks. It also does well in generating the negative correlation between RER and real interest rates. [6]

However, compared to the collateral constraint model , this model main problem is that it overestimate the output volatility (50 percent) and underestimate the RER volatility, both in absolute magnitude and relative to output. This suggest the interaction of pecuniary effect of relative price changes and the financial friction is important in matching the RER volatility observed in the data. Besides, our collateral constraint model does better in matching the cyclical behavior of real interest rate and matching the autocorrelations of output and consumption. Finally, we also consider the collateral constraint model with NP friction, and find that the model generates too volatile output, implying that collateral constraint model without NP friction is enough to match the data.

[6] The imperfect substitution model with NP is also estimated. We find that introducing interest rate's endogenous response to productivity shock does not help to improve the imperfect substitution model's performance in matching business cycle moments. The imperfect substitution +NP model can generate excess volatility of consumption and real exchange rate. The countercyclical interest rate is also captured. But still the output volatility is too big compared to the data.

8 Conclusion

In this paper, we revisit the debate on the source of emerging market business cycle fluctuation. We first confirm the countercyclical behavior of real interest rate and the procyclical behavior of real effective exchange rate. More surprisingly, we document the negative comovement between real interest rate and real exchange rate. Motivated by these empirical finding, we build a two-sector model and include both real interest rate and real exchange rate in estimation. We find that a standard two-sector model with homogenous tradable goods fails to match both countercyclical real interest rate and underestimates the negative correlation between these two rates. This symptom is due to trivial role of country premium shock in explaining the output's fluctuation. In the modified model, we release the homogenous tradable goods assumption and allow imperfect substitution between tradable goods, aiming at providing freedom to match real exchange rate when doing estimation. The estimation still put an important role of trend shock in capturing the output and consumption dynamics. Yet, the role of country premium shock is much more important compared with the estimation on benchmark model. This change enables the model to generate countercyclical real interest rate behavior. Meanwhile, the negative comovement between real exchange rate and real interest rate is matched. We find that the country premium shock works through demand side in the imperfect substitution model. In a model with collateral constraint, the role of country premium shock is enhanced. In other word, we propose an alternative mechanism that interest rate shock affects real economy, which is through the collateral constraint. The simulated moments based on the collateral constraint model is better in all dimensions.

References

[1] Aguiar, Mark and Gita Gopinath. 2007. ”Emerging Market Business Cycles: The Cycle is the Trend.” Journal of Political Economy 115 (1): 69-102.

[2] Akinci, Ozge. 2013. ”Global Financial Conditions, Country Spreads and Macroeconomic Fluctuations in Emerging Countries.” Journal of International Economics 91 (2): 358-371.

[3] ———. 2014. ”Financial Frictions and Macroeconomic Fluctuations in Emerging Economies.” International Finance Discussion Papers, Board of Governors of the Federal Reserve System (1120).

[4] An, Sungbae and Frank Schorfheide. 2007. ”Bayesian Analysis of DSGE Models.” Econometric Reviews 26 (2-4): 113-172.

[5] Arellano, Cristina. 2003. ”Default Risk, the Real Exchange Rate and Income Fluctuations in Emerging Economies.” Manuscript, Duke University.

[6] ———. 2008. ”Default Risk and Income Fluctuations in Emerging Economies.” The American Economic Review 98 (3): 690-712.

[7] Betts, Caroline M. and Timothy J. Kehoe. 2006. ”US Real Exchange Rate Fluctuations and Relative Price Fluctuations.” Journal of Monetary Economics 53 (7): 1297-1326.

[8] Boz, Emine, C. Durdu, and Nan Li. 2015. ”Emerging Market Business Cycles: The Role of Labor Market Frictions.” Journal of Money, Credit and Banking 47 (1): 31-72.

[9] Burstein, Ariel, Martin Eichenbaum, and Sergio Rebelo. 2005. ”Large Devaluations and the Real Exchange Rate.” Journal of Political Economy 113 (4): 742-784.

[10] Calvo, Guillermo A., Leonardo Leiderman, and Carmen M. Reinhart. 1993. ”Capital Inflows and Real Exchange Rate Appreciation in Latin America: The Role of External Factors.” Staff Papers 40 (1): 108-151.

[11] Chang, Roberto and Andres Fernandez. 2013. ”On the Sources of Aggregate Fluctuations in Emerging Economies.” International Economic Review 54 (4): 1265-1293.

[12] Corsetti, Giancarlo, Luca Dedola, and Sylvain Leduc. 2008. ”International Risk Sharing and the Transmission of Productivity Shocks.” The Review of Economic Studies 75 (2): 443-473.

[13] Engel, Charles. 1999. ”Accounting for US Real Exchange Rate Changes.” Journal of Political Economy 107 (3): 507-538.

[14] Fernandez, Andres and Adam Gulan. 2015. ”Interest Rates, Leverage, and Business Cycles in Emerging Economies: The Role of Financial Frictions.” American Economic Journal: Macroeconomics 7 (3): 153-188.

[15] Fernandez, Andres, Stephanie Schmitt-Groh? and Martin Uribe. 2017. ”World Shocks, World Prices, and Business Cycles an Empirical Investigation.” Journal of International Economics. forthcoming

[16] Garcia-Cicco, Javier, Roberto Pancrazi, and Martin Uribe. 2010. ”Real Business Cycles in Emerging Countries?” The American Economic Review 100 (5): 2510-2531.

[17] Gopinath, Gita. 2004. ”Lending Booms, Sharp Reversals and Real Exchange Rate Dynamics.” Journal of International Economics 62 (1): 1-23.

[18] Hevia, Constantino. 2014. ”Emerging Market Fluctuations: What Makes the Difference?” Journal of International Economics 94 (1): 33-49.

[19] Kehoe, Timothy J. and Kim J. Ruhl. 2009. ”Sudden Stops, Sectoral Reallocations, and the Real Exchange Rate.” Journal of Development Economics 89 (2): 235-249.

[20] Liu, Zheng, Pengfei Wang, and Tao Zha. 2013. ”Land-price Dynamics and Macroeconomic Fluctuations.” Econometrica 81 (3): 1147-1184.

[21] Mendoza, Enrique G. 1995. ”The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations.” International Economic Review: 101-137.

[22] ———. 2005. ”Real Exchange Rate Volatility and the Price of Nontradable Goods in Economies Prone to Sudden Stops.” Economia 6 (1): 103-148.

[23] ———. 2010. ”Sudden Stops, Financial Crises and Leverage.” The American Economic Review 100 (5): 1941-1966.

[24] Neumeyer, Pablo A. and Fabrizio Perri. 2005. ”Business Cycles in Emerging Economies: The Role of Interest Rates.” Journal of Monetary Economics 52 (2): 345-380.

[25] Pfeifer, Johannes. 2014. ”A Guide to Specifying Observation Equations for the Estimation of DSGE Models.” Research Series: 1-150..

[26] Restuccia, Diego, Margarida Duarte, and Andrea L. Waddle. 2007. ”Exchange Rates and Business Cycles Across Countries.” Economic Quarterly: 57-76.

[27] Schmitt-Grohe Stephanie and Martin Uribe. 2003. ”Closing Small Open Economy Models.” Journal of International Economics 61 (1): 163-185.

[28] Schmitt-Grohe Stephanie and Martin Uribe. 2016. ”Multiple Equilibria in Open Economy Models with Collateral Constraints: Overborrowing Revisited”. Working paper.

[29] Seoane, Hernan D. 2016. ”Parameter Drifts, Misspecification and the Real Exchange Rate in Emerging Countries.” Journal of International Economics 98: 204-215.

[30] Uribe, Martin and Stephanie Schmitt-Grohe 2017. Open Economy Macroeconomics Princeton University Press.

[31] Uribe, Martin and Vivian Z. Yue. 2006. ”Country Spreads and Emerging Countries: Who Drives Whom?” Journal of International Economics 69 (1): 6-36.

9 Appendix

9.1 Data

This subsection provides data details for our empirical motivation. Choice of emerging markets is subject to data availability. A detailed data source and period are documented in Table 1 in Chen (2015).

National account Quarterly national account data, including real Gross Domestic Product (Y), consumption (C), gross fixed capital formation (I), import and export of goods and services, are measured in local currency. For developed countries, all national account variables are available in chain-linked volumes. Observations of Brazil, Israel and Korea are from OECD measured in chain-linked volumes. Data of South Africa and Mexico are also from OECD but measured in constant prices. Other emerging countries data are from IMF international financial statistics (IFS) in nominal term. For raw data in nominal prices, we get the real variables by dividing the GDP deflator.

Real exchange rate CPI based real effective exchange rate (REER) is used to represent the real exchange rate. According to definition of IMF, REER is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs. Since we study small open economy, real effective exchange rate is a proper measurement of international price between home and rest of world. Quarterly REER data from IFS are preferred if available. Otherwise, we use data from Bank for International Settlements (BIS). Since BIS only reports the monthly data, we simply regard the value of last month for each quarter as the quarterly value. All national account and real exchange rate data are seasonal adjusted by using Census x12 method if necessary.

Interest rate[7] All interest rate data are directly borrowed from Uribe and Schmitt-Grohe (2016). Real interest rate is the sum of country spread (measured by J.P. Morgan's EMBI stripped spread) and US real interest rate (measured by

[7] data is available at http://www.columbia.edu/˜mu2166/book/irs/

3 month T-bill rate minus US GDP inflation). All series are logged to eliminate scale effect and annualized. Note that due to data availability, we do not present comovements regarding real interest rate for Israel, Indonesia and Philippines.

1 Appendix

1.1 Data

This subsection provides data details for our empirical motivation. Choice of emerging markets is subject to data availability. A detailed data source and period are documented in Table 1 in Chen (2015).

National account Quarterly national account data, including real Gross Domestic Product (Y), consumption (C), gross fixed capital formation (I), import and export of goods and services, are measured in local currency. For developed countries, all national account variables are available in chain-linked volumes. Observations of Brazil, Israel and Korea are from OECD measured in chain-linked volumes. Data of South Africa and Mexico are also from OECD but measured in constant prices. Other emerging countries data are from IMF international financial statistics (IFS) in nominal term. For raw data in nominal prices, we get the real variables by dividing the GDP deflator.

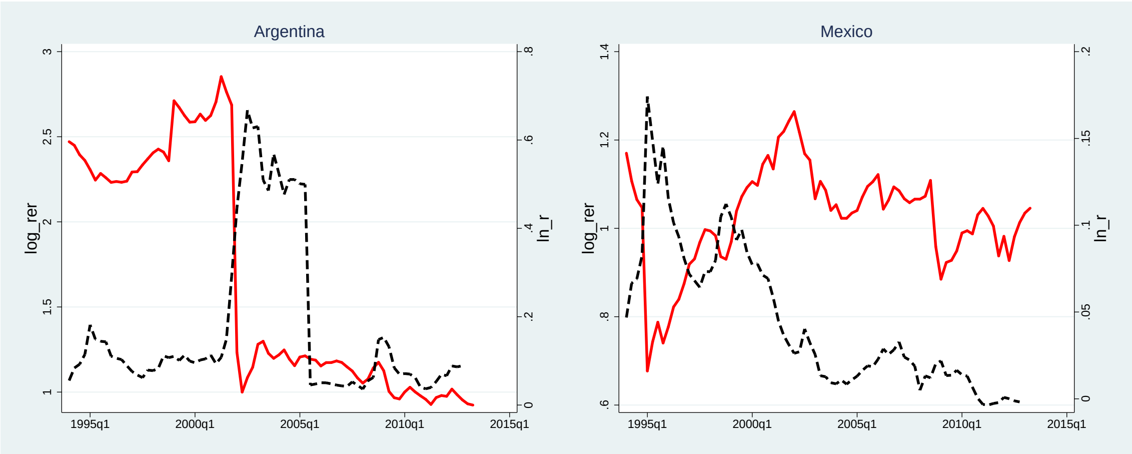
Real exchange rate CPI based real effective exchange rate (REER) is used to represent the real exchange rate. According to definition of IMF, REER is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs. Since we study small open economy, real effective exchange rate is a proper measurement of international price between home and rest of world. Quarterly REER data from IFS are preferred if available. Otherwise, we use data from Bank for International Settlements (BIS). Since BIS only reports the monthly data, we simply regard the value of last month for each quarter as the quarterly value. All national account and real exchange rate data are seasonal adjusted by using Census x12 method if necessary.

Interest rate[1] All interest rate data are directly borrowed from Uribe and Schmitt-Grohe (2016). Real interest rate is the sum of country spread (measured by J.P. Morgan's EMBI stripped spread) and US real interest rate (measured by 3 month T-bill rate minus US GDP inflation). All series are logged to eliminate scale effect and annualized. Note that due to data availability, we do not present comovements regarding real interest rate for Israel, Indonesia and Philippines.

[1] data is available at http://www.columbia.edu/˜mu2166/book/irs/

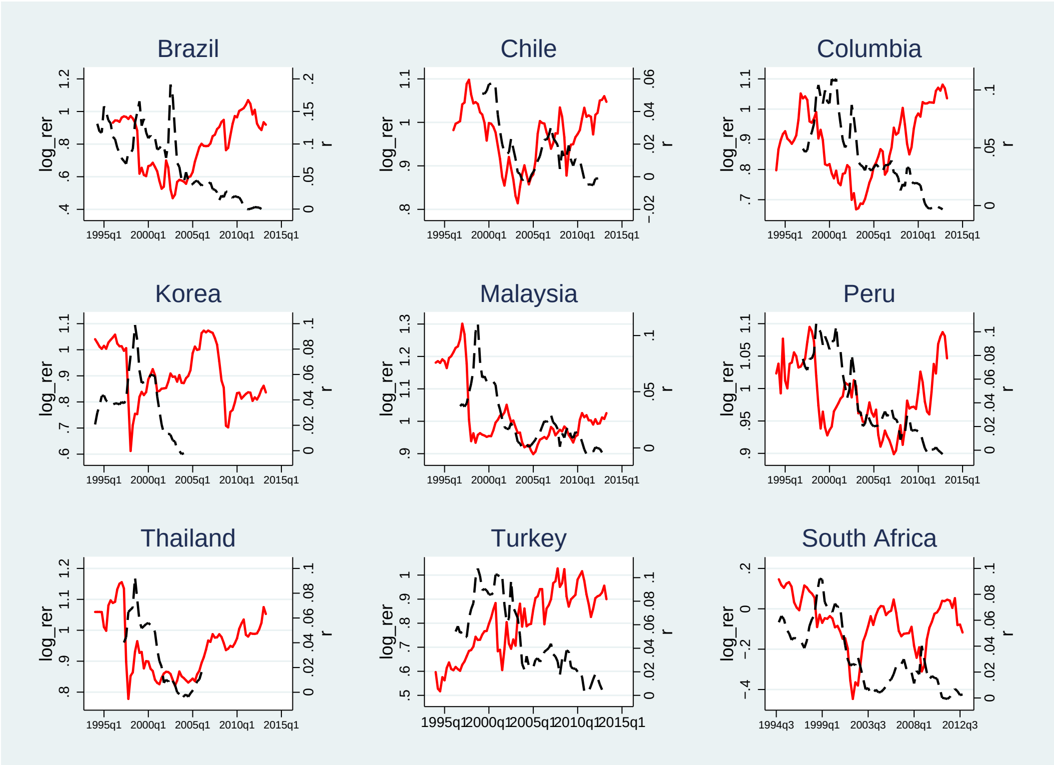
1.2 Figures and tables

Figure 1: Real interest rate and real exchange rate in emerging markets.



Note: The red solid line is log of real effective exchange rate. The black dash line is log of real interest rate.

Figure 1 (Cont.): Real interest rate and real exchange rate in emerging markets.



Note: The red solid line is log of real effective exchange rate. The black dash line is log of real interest rate.

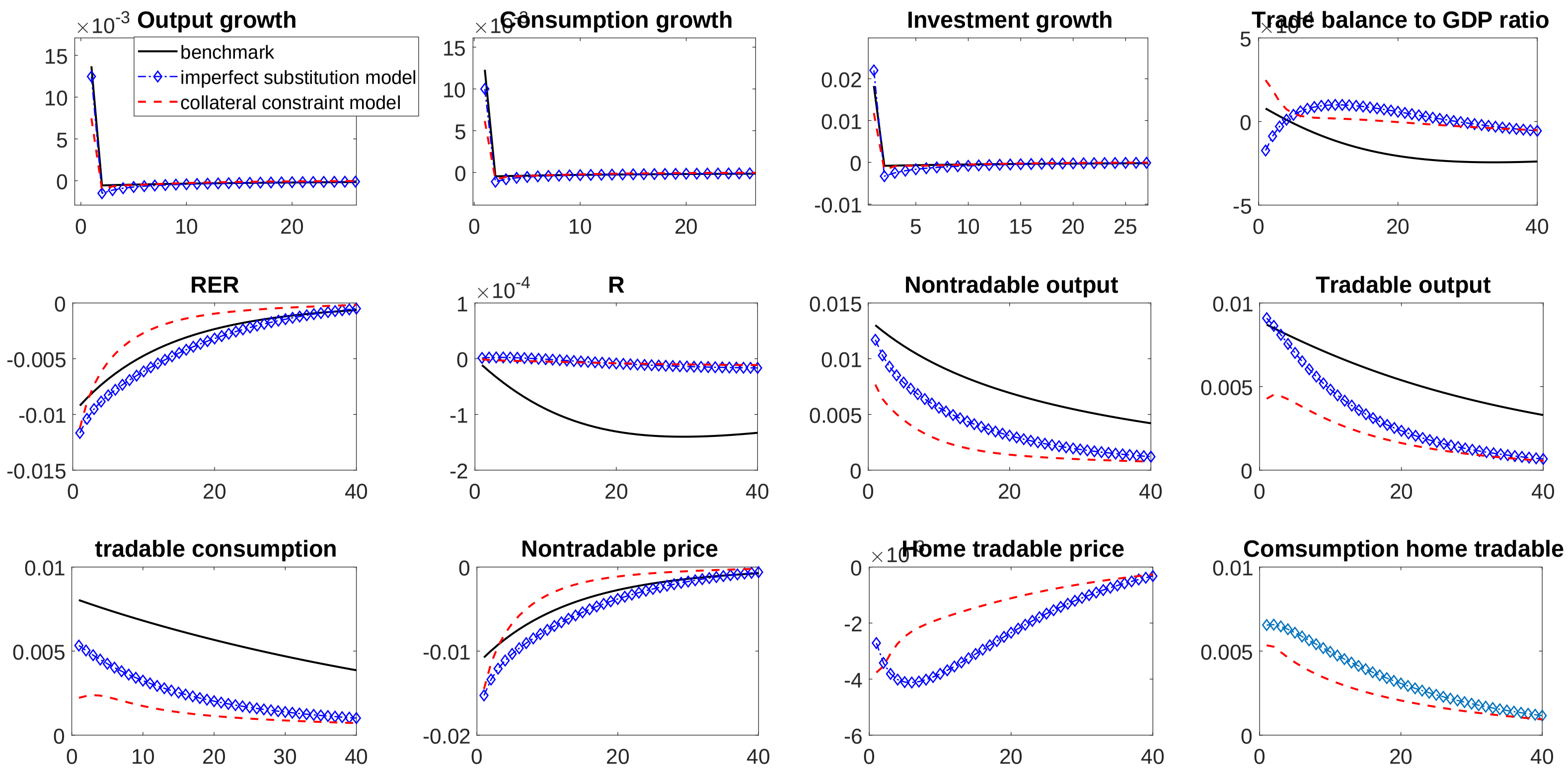


Figure 2: Impulse response function to one standard deviation of temporary technology shock AN

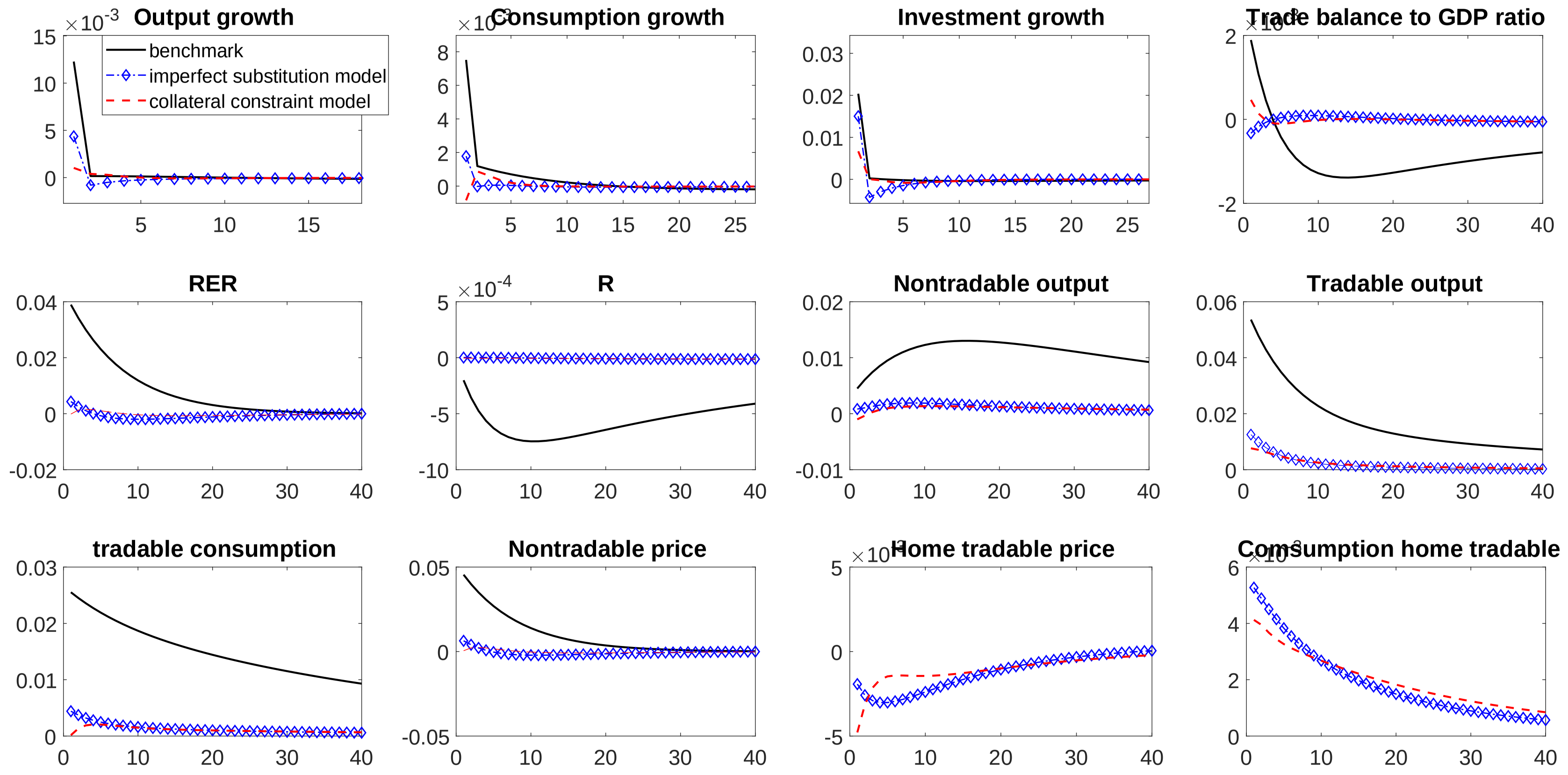


Figure 3: Impulse response function to one standard deviation of temporary technology shock AT

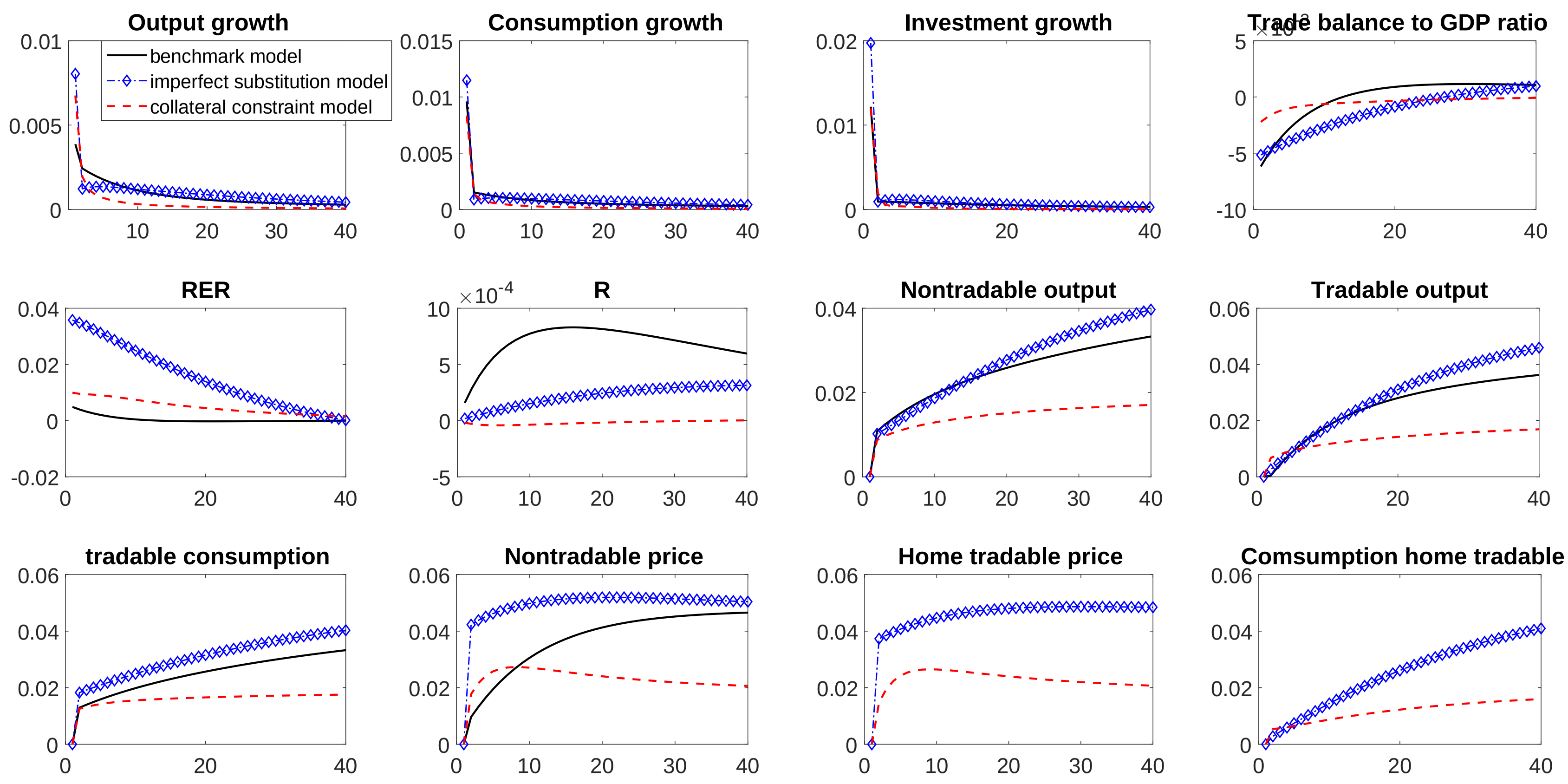


Figure 4: Impulse response function to one standard deviation of trend technology shock g

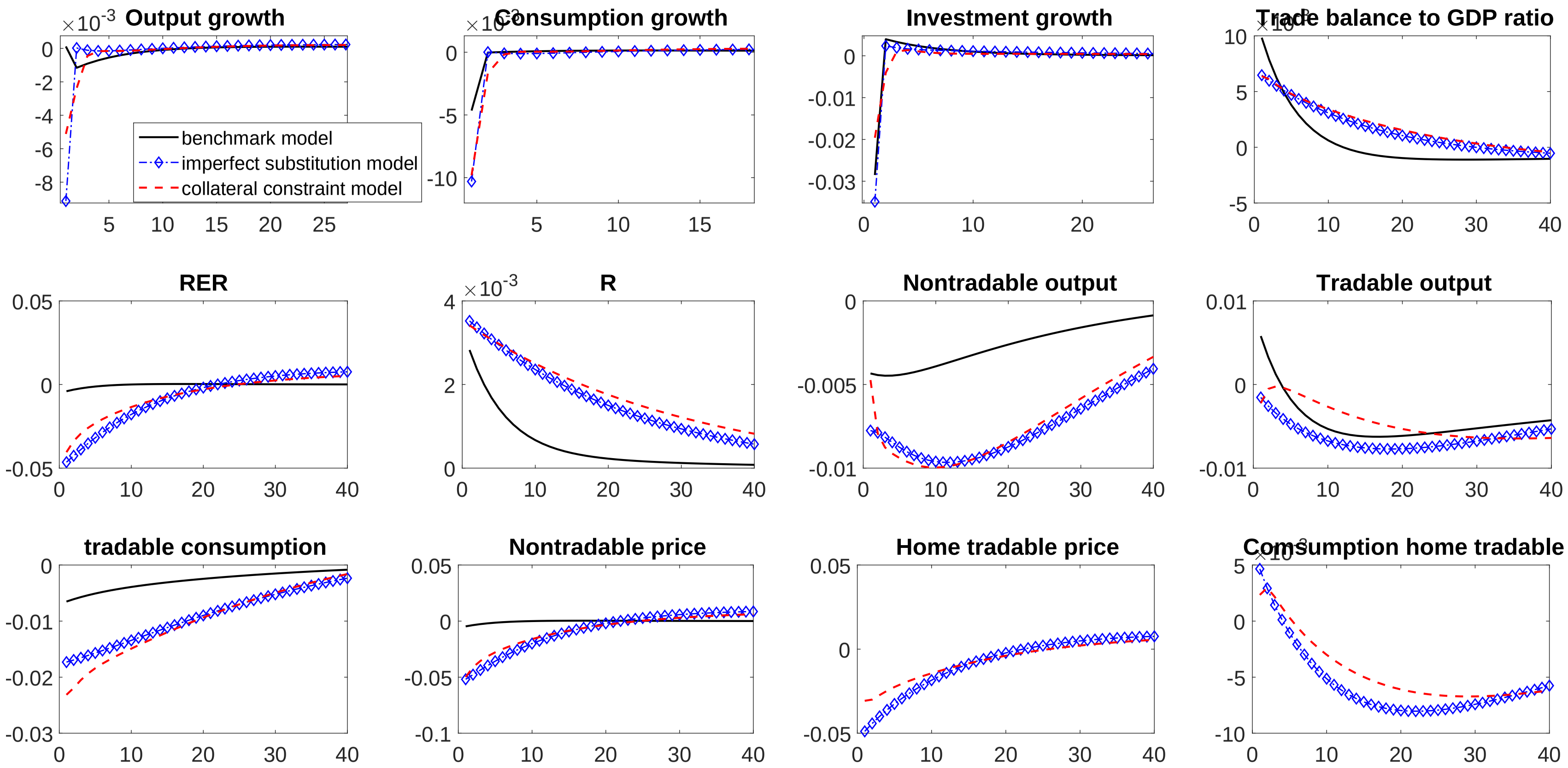


Figure 5: Impulse response function to one standard deviation of country premium shock μ

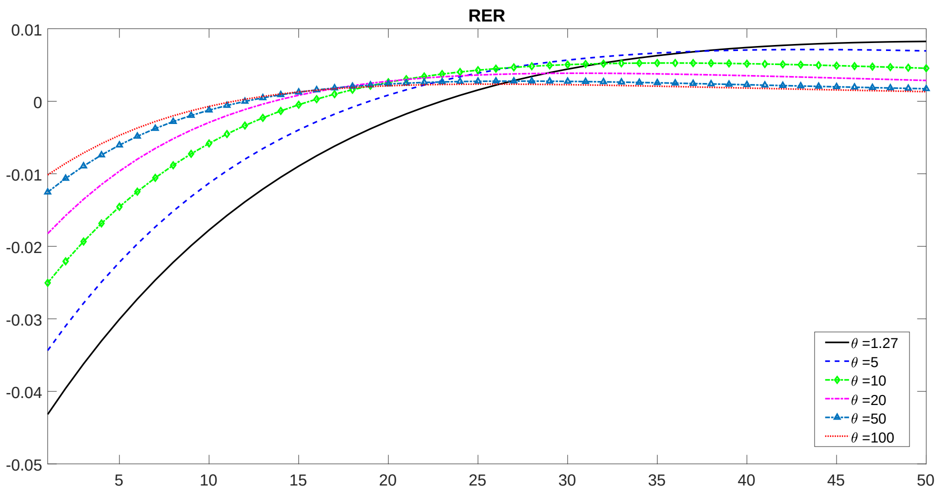


Figure 6: Impulse response function to one standard deviation of country premium shock μ, for different θ

1A Comparison of Business Cycle Moments

	$\sigma(g^Y)$	$\frac{\sigma(g^C)}{\sigma(g^Y)}$	$\frac{\sigma(g^I)}{\sigma(g^Y)}$	$\frac{\sigma(tby)}{\sigma(g^Y)}$	$\frac{\sigma(RER)}{\sigma(g^Y)}$	$\frac{\sigma(R)}{\sigma(g^Y)}$
Emerging markets	1.93	1.34	2.84	2.14	7.21	2.31
Small developed economies	0.90	0.92	3.40	3.79	6.95	2.34
	$\rho(g^Y,RER)$	$\rho(g^C,RER)$	$\rho(tby,RER)$	$\rho(R,RER)$	$\rho(R,g^Y)$	$\rho(RER)$
Emerging markets	0.07	0.13	-0.46	-0.17	-0.17	0.86
Small developed economies	-0.13	-0.04	-0.40	0.02	0.08	0.94

Note: ratio is the average of emerging markets or the average of small developed economies.

Table 1: Correlations with detrended interest rate and real exchange rate: Emerging markets

	$corr(Y,R)$	$corr(C,R)$	$corr(I,R)$	$corr(tby,R)$	$corr(RER,R)$	$corr(Y,RER)$	$corr(C,RER)$	$corr(I,RER)$	$corr(tby,RER)$
Argentina	**-0.57**	**-0.60**	**-0.53**	**0.53**	**-0.66**	**0.49**	**0.61**	**0.46**	**-0.55**
p value	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Brazil	**-0.16**	**-0.20**	**-0.12**	**0.05**	**-0.39**	**0.42**	**0.39**	**0.45**	**-0.19**
p value	0.21	0.10	0.33	0.68	0.00	0.00	0.00	0.00	0.10
Chile	**0.37**	**-0.10**	**0.00**	**0.20**	**0.44**	**0.58**	**0.11**	**0.15**	**0.06**
p value	0.01	0.49	1.00	0.14	0.00	0.00	0.34	0.18	0.58
Colombia	**-0.04**	**-0.01**	**-0.26**	**0.35**	**-0.17**	**0.00**	**-0.08**	**0.07**	**-0.01**
p value	0.77	0.93	0.04	0.00	0.19	0.97	0.46	0.50	0.93
Indonesia						**0.42**	**0.31**	**-0.03**	**-0.34**
p value						0.00	0.01	0.83	0.00
Israel						**0.32**	**0.32**	**0.24**	**0.01**
p value						0.00	0.00	0.03	0.97
Korea	**-0.69**	**-0.75**	**-0.68**	**0.51**	**-0.57**	**0.41**	**0.49**	**0.40**	**-0.25**
p value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malaysia	**-0.52**	**-0.61**	**-0.57**	**0.56**	**-0.53**	**0.23**	**-0.20**	**-0.09**	**-0.20**
p value	0.00	0.00	0.00	0.00	0.00	0.27	0.35	0.65	0.34
Mexico	**-0.30**	**-0.31**	**-0.47**	**0.23**	**-0.69**	**0.66**	**0.73**	**0.72**	**-0.39**
p value	0.01	0.01	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Peru	**-0.07**	**-0.21**	**0.15**	**-0.04**	**-0.26**	**0.08**	**0.46**	**0.10**	**-0.20**
p value	0.58	0.10	0.24	0.77	0.04	0.47	0.00	0.36	0.08
Philippines						**0.32**	**0.17**	**0.43**	**-0.10**
p value						0.12	0.42	0.03	0.64
South Africa	**-0.02**	**0.04**	**0.05**	**0.03**	**-0.16**	**-0.08**	**0.16**	**-0.04**	**-0.13**
p value	0.84	0.75	0.66	0.77	0.17	0.36	0.05	0.61	0.13
Thailand	**-0.62**	**-0.68**	**-0.59**	**0.38**	**-0.10**	**0.39**	**0.41**	**0.35**	**-0.25**
p value	0.00	0.00	0.00	0.02	0.55	0.00	0.00	0.00	0.02
Turkey	**-0.17**	**-0.30**	**-0.28**	**0.44**	**-0.13**	**0.33**	**0.48**	**0.25**	**-0.23**
p value	0.16	0.01	0.02	0.00	0.30	0.00	0.00	0.02	0.03
Average	**-0.25**	**-0.34**	**-0.30**	**0.30**	**-0.29**	**0.33**	**0.31**	**0.25**	**-0.20**

Note: Y is real value added. C is real consumption. I is real investment. tby is trade balance to GDP ratio. R is real interest rate. RER is real effective exchange rate. All variables except tby in this table is detrended by using HP filter.

Table 2: Correlations with interest rate: Emerging markets

	$corr(g^Y,R)$	$corr(g^C,R)$	$corr(g^I,R)$	$corr(tby,R)$	$corr(RER,R)$	$corr(g^Y,RER)$	$corr(g^C,RER)$	$corr(g^I,RER)$	$corr(tby,RER)$
Argentina	**0.12**	**0.08**	**0.26**	**0.75**	**-0.19**	**-0.26**	**-0.21**	**-0.29**	**-0.56**
p value	0.29	0.48	0.02	0.00	0.10	0.02	0.06	0.01	0.00
Brazil	**-0.15**	**-0.33**	**-0.24**	**0.07**	**-0.53**	**0.09**	**0.22**	**0.24**	**-0.68**
p value	0.24	0.01	0.06	0.55	0.00	0.46	0.06	0.04	0.00
Chile	**-0.05**	**-0.06**	**-0.08**	**-0.08**	**0.15**	**0.07**	**0.23**	**0.00**	**-0.29**
p value	0.70	0.67	0.56	0.56	0.28	0.57	0.04	0.98	0.01
Colombia	**0.01**	**0.07**	**-0.12**	**0.00**	**-0.45**	**-0.07**	**-0.04**	**-0.14**	**-0.10**
p value	0.91	0.57	0.34	0.99	0.00	0.53	0.75	0.23	0.36
Indonesia						**0.70**	**0.09**	**0.47**	**-0.67**
p value						0.00	0.46	0.00	0.00
Israel						**-0.09**	**0.08**	**-0.16**	**-0.56**
p value						0.42	0.50	0.16	0.00
Korea	**-0.13**	**-0.07**	**-0.27**	**0.14**	**-0.35**	**0.28**	**0.32**	**0.25**	**-0.46**
p value	0.41	0.67	0.10	0.37	0.02	0.00	0.00	0.00	0.00
Malaysia	**-0.22**	**-0.16**	**-0.29**	**0.14**	**0.06**	**-0.07**	**0.26**	**-0.09**	**-0.67**
p value	0.08	0.20	0.02	0.28	0.62	0.75	0.23	0.66	0.00
Mexico	**-0.17**	**-0.25**	**-0.20**	**0.87**	**-0.53**	**0.20**	**0.33**	**0.26**	**-0.55**
p value	0.13	0.03	0.08	0.00	0.00	0.07	0.00	0.02	0.00
Peru	**-0.34**	**-0.21**	**-0.38**	**-0.69**	**0.07**	**-0.13**	**0.02**	**-0.07**	**-0.64**
p value	0.01	0.11	0.00	0.00	0.57	0.23	0.83	0.51	0.00
Philippines						**0.28**	**0.29**	**0.13**	**-0.51**
p value						0.19	0.17	0.54	0.01
South Africa	**-0.18**	**-0.20**	**-0.22**	**0.64**	**0.14**	**-0.10**	**0.08**	**-0.09**	**0.13**
p value	0.14	0.09	0.06	0.00	0.24	0.24	0.33	0.27	0.13
Thailand	**-0.46**	**-0.36**	**-0.41**	**0.67**	**0.39**	**0.07**	**0.09**	**0.03**	**-0.49**
p value	0.01	0.03	0.01	0.00	0.02	0.55	0.41	0.77	0.00
Turkey	**-0.25**	**-0.14**	**-0.32**	**0.70**	**-0.64**	**0.06**	**0.12**	**0.20**	**-0.36**
p value	0.04	0.27	0.01	0.00	0.00	0.58	0.29	0.07	0.00
Average	**-0.17**	**-0.15**	**-0.21**	**0.29**	**-0.17**	**0.07**	**0.13**	**0.05**	**-0.46**

Note: g^Y, g^C and g^I are log difference for real output, real consumption, real investment respectively. R and RER are logged real interest rate and real effective exchange rate.

Table 3: Parameters for benchmark model

Value	Meaning	Source
$\beta = 0.98$	quarterly discount factor	AG,2007
$\gamma = 2$	curvature of period utility function	AG,2007
$\Lambda = 2.2$	parameter to ensure the allocation of labor in steady state	calibrated
$\tau = 1.6$	$1/(\tau - 1)$ is the labor supply elasticity	GPU,2010
$\alpha^T = \alpha^N = 0.68$	labor income share	AG,2007
$\delta^{T,ss} = \delta^{N,ss} = 0.05$	capital depreciation rate	AG,2007
$\ln RER = 0.016$	steady state level of real effective exchange rate	calibrated
$tby = 0.02$	steady state level of trade balance to GDP ratio	calibrated

AG denotes Aguiar and Gopinath (2007); GPU donotes Garcia-Cicco, Pancrazi and Uribe (2010)

Table 4: Posterior for benchmark model and imperfect substitution model

	Prior			benchmark model			imperfect substitution model			imperfect substitution modell without wc		
param.	mean	dist.	pstdev	Post. Median	5%	95%	Post. Median	5%	95%	Post. Median	5%	95%
ϖ^N	0.75	beta	0.1	0.7802	0.6234	0.9227	0.7496	0.5770	0.9048			
ϖ^H	0.75	beta	0.1	0.7652	0.6028	0.9175	0.7684	0.6048	0.9155			
ϕ^T	1	gamma	0.5	6.4227	5.2739	7.8742	1.8057	1.0755	2.5751	1.7521	1.0083	2.5247
ϕ^N	1	gamma	0.5	7.5209	6.8223	7.9247	0.7937	0.2568	1.4101	0.8035	0.2606	1.4364
ψ	0.1	gamma	0.05	0.0911	0.0473	0.1389	0.0118	0.0028	0.0228	0.0111	0.0027	0.0212
ω	0.5	beta	0.1	0.1448	0.1034	0.1899	0.2692	0.1714	0.3801	0.2781	0.1824	0.3844
ξ	0.5	beta	0.1				0.6457	0.4891	0.7903	0.6272	0.4736	0.7668
κ	0.5	gamma	0.1	0.4624	0.3133	0.6157	0.4707	0.3242	0.6284	0.4742	0.3247	0.6324
θ	2	gamma	0.5				1.2683	1.0669	1.4783	1.1943	1.0190	1.3831
ρ^{AT}	0.7	beta	0.1	0.8674	0.8300	0.9029	0.7401	0.5686	0.9037	0.7438	0.5699	0.9032
ρ^{AN}	0.7	beta	0.1	0.9417	0.8883	0.9812	0.8893	0.8308	0.9428	0.8916	0.8333	0.9438
ρ^g	0.7	beta	0.1	0.8937	0.8467	0.9367	0.9503	0.9113	0.9810	0.9545	0.9185	0.9821
ρ^v	0.7	beta	0.1	0.9363	0.6756	0.9837	0.7192	0.5500	0.8802	0.7192	0.5478	0.8818
ρ^μ	0.7	beta	0.1	0.9864	0.9712	0.9960	0.9628	0.9503	0.9752	0.9628	0.9501	0.9752
standard deviation of shocks												
ε^g	0.015	gamma	0.01	0.0050	0.0035	0.0066	0.0029	0.0018	0.0042	0.0027	0.0017	0.0039
ε^{AT}	0.015	gamma	0.01	0.0466	0.0381	0.0557	0.0093	0.0036	0.0093	0.0033	0.0148	0.0669
ε^{AN}	0.015	gamma	0.01	0.0087	0.0068	0.0109	0.0094	0.0074	0.0093	0.0074	0.0116	0.0113
ε^v	0.015	gamma	0.01	0.0532	0.0026	0.0890	0.0102	0.0018	0.0187	0.0108	0.0019	0.0198
ε^μ	0.015	gamma	0.01	0.0034	0.0026	0.0043	0.0037	0.0032	0.0042	0.0037	0.0031	0.0042
ρ^{CS}	0.7	beta	0.1				0.9002	0.8644	0.9344	0.0521	0.0391	0.0663
measurement errors												
me^C	0.01	gamma	0.01	0.0061	0.0036	0.0086	0.0054	0.0043	0.0066	0.0056	0.0045	0.0068
me^I	0.01	gamma	0.01	0.0153	0.0107	0.0197	0.0127	0.0085	0.0168	0.0127	0.0085	0.0169
me^{tby}	0.01	gamma	0.01	0.0049	0.0031	0.0068	0.0054	0.0044	0.0064	0.0053	0.0043	0.0063
me^{RER}	0.01	gamma	0.01	0.0301	0.0194	0.0412						
me^R	0.01	gamma	0.01	0.0017	0.0011	0.0023						
log posterior density				1275.9344			1416.1464			1413.4459		
log marginal density				1194.8677			1332.8047			1332.6704		

Table 5: Model business cycle moment: Mexico

	g^Y	g^C	g^I	tby	RER	R
Standard Deviations:						
benchmark model	**2.01**	**1.92**	4.46	2.43	**8.58**	0.92
imperfect substitutoin model	**1.94**	**1.95**	5.05	2.88	**20.42**	1.25
imperfect substitutoin model without wc	**1.889**	**1.894**	4.92	2.91	**20.53**	1.26
data	**1.36**	**1.70**	4.19	2.99	**12.09**	0.98
Correlation with g^Y:						
benchmark model		0.84	0.66	-0.08	0.26	**0.10**
imperfect substitutoin model		0.96	0.87	-0.25	0.33	**-0.06**
imperfect substitutoin model without wc		0.96	0.85	-0.24	0.32	**-0.05**
data		0.87	0.83	0.02	0.20	**-0.17**
Correlation with g^C:						
benchmark model			0.70	-0.22	0.27	**0.04**
imperfect substitutoin model			0.85	-0.26	0.34	**-0.07**
imperfect substitutoin model without wc			0.83	-0.25	0.33	**-0.05**
data			0.80	-0.04	0.33	**-0.24**
Correlation with RER						
benchmark model				**-0.13**		**-0.23**
imperfect substitutoin model				**-0.85**		**-0.45**
imperfect substitutoin model without wc				**-0.85**		**-0.47**
data				**-0.58**		**-0.51**
First Order Autocorr.:						
benchmark model	0.12	0.12	-0.01	0.88	0.91	0.94
imperfect substitutoin model	0.08	0.08	-0.04	0.95	0.95	0.96
imperfect substitutoin model without wc	0.09	0.09	-0.04	0.96	0.95	0.96
data	0.46	0.35	0.36	0.95	0.86	0.95

we use posterior median as parameters value so as to get moments simulated by models.

Table 6: Variance decomposition: imperfect substitutoin models

benchmark model						
	A^H	A^N	v	g	CS	μ
g^Y	1.38	50.03	0.03	42.12		6.04
g^C	0.34	24.00	0.07	53.83		21.42
g^I	0.24	5.18	0.08	7.63		86.90
tby	0.09	0.14	0.03	20.32		79.40
RER	17.35	47.79	0.14	15.02		17.36
R	0.22	0.38	0.07	32.56		66.54
imperfect substitutoin model						
	A^H	A^N	v	g	CS	μ
g^Y	1.14	8.67	0.01	59.36	0.01	30.31
g^C	0.14	4.02	0.10	67.31	0.01	28.05
g^I	2.02	3.88	0.25	32.09	0.02	61.53
tby	0.01	0.01	0.00	66.29	0.04	33.66
RER	0.03	0.31	0.00	65.66	0.07	33.80
R	0.00	0.00	0.00	9.84	0.01	90.16
imperfect substitutoin model without wc						
	A^H	A^N	g	v	μ	
g^Y	1.11	8.13	0.00	67.46	0.02	22.49
g^C	0.15	3.86	0.09	75.38	0.01	20.25
g^I	2.00	3.59	0.22	36.89	0.02	57.05
tby	0.01	0.01	0.00	70.67	0.04	29.25
RER	0.03	0.31	0.00	68.16	0.08	31.39
R	0.00	0.00	0.00	10.68	0.01	89.31

Table 7: Posterior for collateral constraint model

	Prior			collateral constraint model			collateral constraint model without wc		
param.	mean	dist.	pstdev	Post. Median	5%	95%	Post. Median	5%	95%
ϖ^N	0.75	beta	0.1	0.8956	0.8169	0.9656			
ϖ^H	0.75	beta	0.1	0.8599	0.7566	0.9519			
θ^N	0.5	beta	0.1	0.1542	0.1080	0.2026	0.0487	0.0471	0.0524
θ^H	0.5	beta	0.1	0.4327	0.3427	0.5201	0.0505	0.0471	0.0589
ϕ^T	1	gamma	0.5	2.1036	1.4219	2.7804	1.0271	0.3142	1.7745
ϕ^N	1	gamma	0.5	1.6866	1.0919	2.3094	1.2857	0.3409	2.4053
ψ	0.1	gamma	0.05	0.0117	0.0026	0.0238	0.0179	0.0039	0.0359
ω	0.5	beta	0.1	0.2555	0.2045	0.3046	0.2229	0.1623	0.2853
Ξ	0.5	beta	0.1	0.4080	0.2677	0.5500	0.5205	0.3797	0.6831
κ	0.5	gamma	0.1	0.4382	0.2988	0.5868	0.4387	0.2812	0.6113
θ	0.5	gamma	0.1	1.4014	1.1115	1.7218	1.5482	1.2832	1.7991
ρ^{AT}	0.7	beta	0.1	0.7530	0.5851	0.9176	0.7263	0.7052	0.7511
ρ^{AN}	0.7	beta	0.1	0.8780	0.8023	0.9456	0.7713	0.6012	0.9048
ρ^{g}	0.7	beta	0.1	0.6718	0.5644	0.7767	0.7290	0.5959	0.8410
ρ^{ν}	0.7	beta	0.1	0.9394	0.9096	0.9655	0.8752	0.8190	0.9210
ρ^{μ}	0.7	beta	0.1	0.9718	0.9589	0.9838	0.9786	0.9684	0.9884
ρ^{CS}	0.7	beta	0.1	0.8672	0.8057	0.9230	0.9287	0.8904	0.9628
$\rho^{\theta H}$	0.7	beta	0.1	0.8677	0.7918	0.9375	0.7815	0.6198	0.9161
$\rho^{\theta N}$	0.7	beta	0.1	0.7180	0.5492	0.8722	0.7607	0.6279	0.8874
standard deviation of shocks									
ε^{g}	0.015	gamma	0.01	0.0062	0.0032	0.0091	0.0040	0.0013	0.0068
ε^{AT}	0.015	gamma	0.01	0.0079	0.0011	0.0156	0.0248	0.0127	0.0388
ε^{AN}	0.015	gamma	0.01	0.0061	0.0042	0.0078	0.0062	0.0043	0.0081
ε^{ν}	0.015	gamma	0.01	0.0770	0.0553	0.1005	0.0964	0.0821	0.1115
ε^{μ}	0.015	gamma	0.01	0.0036	0.0031	0.0040	0.0035	0.0030	0.0040
ε^{CS}	0.015	gamma	0.01	0.0402	0.0263	0.0557	0.0390	0.0278	0.0521
$\varepsilon^{\theta H}$	0.015	gamma	0.01	0.0508	0.0366	0.0663	0.0518	0.0054	0.0918
$\varepsilon^{\theta N}$	0.015	gamma	0.01	0.0090	0.0010	0.0183	0.0371	0.0049	0.0647
measurement errors									
me^C	0.01	gamma	0.01	0.0045	0.0033	0.0057	0.0045	0.0032	0.0059
me^I	0.01	gamma	0.01	0.0143	0.0102	0.0185	0.0230	0.0175	0.0291
me^{tby}	0.01	gamma	0.01	0.0059	0.0048	0.0071	0.0075	0.0060	0.0093
log posterior density				1419.2665			1296.3837		
log marginal density				1320.8921			1210.3574		

Table 8: Collateral constraint model business cycle moment: Mexico

	g^Y	g^C	g^I	tby	RER	R
Standard Deviations:						
collateral constraint model	**1.42**	**1.69**	3.64	2.78	**13.78**	1.32
collateral constraint model without wc	**1.69**	**1.72**	8.00	2.69	**15.54**	1.42
data	**1.36**	**1.70**	4.19	2.99	**12.09**	0.98
Correlation with g^Y:						
collateral constraint model		0.90	0.81	-0.23	0.34	**-0.11**
collateral constraint model without wc		0.88	0.81	-0.17	0.21	**-0.04**
data		0.87	0.83	0.02	0.20	**-0.17**
Correlation with g^C:						
collateral constraint model			0.78	-0.25	0.37	**-0.11**
collateral constraint model without wc			0.64	-0.24	0.29	**-0.07**
data			0.80	-0.04	0.33	**-0.24**
Correlation with RER						
collateral constraint model				**-0.87**		**-0.49**
collateral constraint model without wc				**-0.91**		**-0.53**
data				**-0.58**		**-0.51**
First Order Autocorr.:						
collateral constraint model	0.18	0.15	0.08	0.95	0.90	0.97
collateral constraint model without wc	-0.17	-0.01	-0.45	0.91	0.89	0.97
data	0.46	0.35	0.36	0.95	0.86	0.95

we use posterior median as parameters value so as to get moments simulated by models.

Table 9: Variance decomposition: collateral constraint models

collateral constraint model								
	A^H	A^N	v	g	CS	μ	θ^H	θ^N
g^Y	0.38	26.79	0.01	24.74	0.23	46.63	0.17	0.62
g^C	0.29	9.42	0.04	17.69	0.06	71.54	0.10	0.30
g^I	1.75	9.26	0.02	9.32	0.01	78.70	0.47	0.45
tby	0.03	0.04	0.07	1.22	0.05	98.53	0.01	0.00
RER	0.04	1.18	0.05	3.59	0.12	94.83	0.04	0.00
R	0.00	0.00	0.00	0.01	0.00	99.98	0.00	0.00

collateral constraint model without wc								
	A^H	A^N	v	g	CS	μ	θ^H	θ^N
g^Y	0.55	17.75	0.04	27.18	0.24	52.84	0.05	0.08
g^C	0.08	10.26	0.06	25.78	0.04	62.97	0.00	0.00
g^I	0.19	0.95	0.06	5.81	0.24	92.07	0.16	0.32
tby	0.03	0.05	0.04	1.77	0.04	98.01	0.00	0.00
RER	0.01	0.64	0.04	3.85	0.19	95.12	0.00	0.01
R	0.00	0.00	0.00	0.02	0.00	99.97	0.00	0.00

Table 10: Robustness check: Posterior for model with Neumeyer and Perri (2005) friction

	Prior			benchmark model with NP			imperfect substitution model with NP			collateral constraint modell with NP		
param.	mean	dist.	pstdev	Post. Median	5%	95%	Post. Median	5%	95%	Post. Median	5%	95%
ϖ^N	0.75	beta	0.1	0.7690	0.6080	0.9188	0.7434	0.5731	0.9034	0.8661	0.7708	0.9516
ϖ^H	0.75	beta	0.1	0.7648	0.6004	0.9163	0.7645	0.5926	0.9190	0.7781	0.6329	0.9196
θ^N	0.5	beta	0.1							0.1978	0.1338	0.2656
θ^H	0.5	beta	0.1							0.3888	0.2958	0.4808
ϕ^T	1	gamma	0.5	6.4494	5.2692	7.9103	1.7873	1.0503	2.5492	1.1966	0.5031	1.9066
ϕ^N	1	gamma	0.5	7.5972	6.9772	7.9247	0.7784	0.2364	1.3860	1.9359	1.1913	2.7447
ψ	0.1	gamma	0.05	0.0438	0.0122	0.0725	0.0123	0.0033	0.0237	0.0087	0.0024	0.0168
$\widetilde{\psi}$	0.1	gamma	0.05	0.0423	0.0312	0.0555	0.0949	0.0238	0.0711	0.0498	0.0949	
ω	0.5	beta	0.1	0.1091	0.0732	0.1479	0.2688	0.1703	0.3796	0.2336	0.2010	0.2665
ξ	0.5	beta	0.1				0.6462	0.4935	0.7912	0.4378	0.3102	0.5657
κ	0.5	gamma	0.1	0.4571	0.3110	0.6132	0.4687	0.3154	0.6326	0.4304	0.2945	0.5685
θ	2	gamma	0.5				1.2730	1.0716	1.4929	2.0716	1.8765	2.2761
ρ^{AT}	0.7	beta	0.1	0.8644	0.8333	0.8923	0.7986	0.6434	0.9132	0.9816	0.9749	0.9877
ρ^{AN}	0.7	beta	0.1	0.9673	0.9191	0.9958	0.8851	0.8245	0.9411	0.8381	0.7088	0.9348
ρ^g	0.7	beta	0.1	0.9025	0.8470	0.9602	0.9561	0.9250	0.9817	0.7113	0.6424	0.7806
ρ^ν	0.7	beta	0.1	0.8153	0.6435	0.9767	0.7106	0.5401	0.8764	0.9311	0.8937	0.9611
ρ^μ	0.7	beta	0.1	0.9757	0.8715	0.9960	0.9595	0.9466	0.9722	0.8511	0.7423	0.9419
ρ^{CS}	0.7	beta	0.1				0.8993	0.8634	0.9341	0.8655	0.7941	0.9279
ρ^{θ^H}	0.5	beta	0.1							0.7311	0.5606	0.8850
ρ^{θ^N}	0.5	beta	0.1							0.7208	0.5602	0.8767
standard deviation of shocks												
ε^g	0.015	gamma	0.01	0.0050	0.0025	0.0072	0.0027	0.0018	0.0039	0.0091	0.0061	0.0118
ε^{AT}	0.015	gamma	0.01	0.0560	0.0459	0.0669	0.0098	0.0039	0.0153	0.0419	0.0308	0.0539
ε^{AN}	0.015	gamma	0.01	0.0093	0.0072	0.0113	0.0093	0.0073	0.0117	0.0048	0.0024	0.0072
ε^ν	0.015	gamma	0.01	0.0301	0.0022	0.0841	0.0098	0.0017	0.0179	0.0735	0.0520	0.0962
ε^μ	0.015	gamma	0.01	0.0023	0.0018	0.0028	0.0037	0.0032	0.0042	0.0019	0.0014	0.0024
ε^{CS}	0.015	gamma	0.01		0.0391		0.0516	0.0390	0.0654	0.0477	0.0346	0.0618
ε^{θ^H}	0.5	beta	0.1							0.0254	0.0117	0.0404
ε^{θ^N}	0.5	beta	0.1							0.0076	0.0009	0.0157
measurement errors												
me^C	0.01	gamma	0.01	0.0076	0.0043	0.0104	0.0054	0.0042	0.0066	0.0048	0.0035	0.0060
me^I	0.01	gamma	0.01	0.0169	0.0121	0.0214	0.0128	0.0088	0.0171	0.0157	0.0115	0.0200
me^{tby}	0.01	gamma	0.01	0.0041	0.0018	0.0065	0.0054	0.0043	0.0065	0.0056	0.0045	0.0069
me^{RER}	0.01	gamma	0.01	0.0155	0.0000	0.0264						
me^R	0.01	gamma	0.01	0.0012	0.0007	0.0018						
log posterior density				1295.9093			1418.6598			1423.2229		
log marginal density				1209.1369			1332.8506			1332.7701		

Table 11: Robustness check: Business moments for model with Neumeyer and Perri (2005) friction

	g^Y	g^C	g^I	tby	RER	R
Standard Deviations:						
benchmark model with NP	**2.09**	**2.12**	5.12	2.68	**10.74**	0.95
imperfect substitution model with NP	**1.95**	**1.98**	5.05	2.99	**20.67**	1.22
collateral constraint modell with NP	**1.90**	**2.13**	4.33	3.28	**18.58**	1.35
data	**1.36**	**1.70**	4.19	2.99	**12.09**	0.98
Correlation with g^Y:						
benchmark model with NP		0.87	0.77	-0.23	0.30	**-0.06**
imperfect substitution model with NP		0.95	0.87	-0.24	0.33	**-0.08**
collateral constraint model with NP		0.94	0.86	-0.61	0.68	**-0.39**
data		0.87	0.83	0.02	0.20	**-0.17**
Correlation with g^C:						
benchmark model with NP			0.70	-0.31	0.28	**-0.08**
imperfect substitution modell with NP			0.86	-0.25	0.34	**-0.09**
collateral constraint modell with NP			0.86	-0.55	0.62	**-0.35**
data			0.80	-0.04	0.33	**-0.24**
Correlation with RER						
benchmark model with NP				**-0.22**		**-0.51**
imperfect substitution model with NP				**-0.86**		**-0.49**
collateral constraint model with NP				**-0.93**		**-0.49**
data				**-0.58**		**-0.51**
First Order Autocorr.:						
benchmark model with NP	0.16	0.13	-0.03	0.89	0.88	0.94
imperfect substitution model with NP	0.09	0.08	-0.04	0.95	0.95	0.96
collateral constraint model with NP	0.51	0.41	0.38	0.96	0.94	0.97
data	0.46	0.35	0.36	0.95	0.86	0.95

we use posterior median as parameters value so as to get moments simulated by models.

Table 12: Robustness check: Variance decomposition for model with Neumeyer and Perri (2005) friction

benchmark NP model								
	A^H	A^N	v	g	CS	μ	θ^H	θ^N
g^Y	0.79	45.93	0.07	41.82		10.01		
g^C	0.25	24.46	0.11	52.17		22.37		
g^I	0.32	5.63	8.60	0.06		85.39		
tby	0.04	0.20	0.02	21.93		77.85		
RER	10.48	46.29	0.14	18.32		21.37		
R	0.27	0.50	0.02	26.56		72.56		
imperfect substitutoin model with NP								
	A^H	A^N	v	g	CS	μ	θ^H	θ^N
g^Y	1.05	7.95	0.01	64.56	0.01	25.51		
g^C	0.14	3.62	0.09	72.50	0.01	23.37		
g^I	1.86	3.62	0.23	39.32	0.01	54.71		
tby	0.01	0.01	0.00	75.82	0.03	24.12		
RER	0.03	0.28	0.00	73.77	0.06	25.75		
R	0.00	0.00	0.00	12.39	0.01	87.60		
collateral constraint model with NP								
	A^H	A^N	v	g	CS	μ	θ^H	θ^N
g^Y	0.38	26.79	0.01	24.74	0.23	46.63	0.17	0.62
g^C	0.29	9.42	0.04	17.69	0.06	71.54	0.10	0.30
g^I	1.75	9.26	0.02	9.32	0.01	78.70	0.47	0.45
tby	0.03	0.04	0.07	1.22	0.05	98.53	0.01	0.00
RER	0.04	1.18	0.05	3.59	0.12	94.83	0.04	0.00
R	0.00	0.00	0.00	0.01	0.00	99.98	0.00	0.00