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The cause of an integral correction mechanism of the real exchange rate

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ABSTRACT

I find that Rabanal and Rubio-Ramirez (2015)'s international real business cycle model can explain an integral correction mechanism of the real exchange rate. An input adjustment cost in their model implies that the real exchange appreciates following a positive domestic productivity shock and reverts to steady state quickly, but presents a long-run cyclical movement. These particular dynamics help explain the PPP puzzle.

1. Introduction

Rabanal and Rubio-Ramirez (2015) show that an international real business cycle (IRBC) can fit the real exchange rate spectrum, which assigns 70% of the variance to frequencies lower than business cycle frequencies. Before their work, the literature of open economy DSGE models[1] focuses on business cycle frequencies, and hence are not directly comparable to results obtained from time series models, such as the smooth transition autoregression (Lothian and Taylor, 2008 among many others).

This paper finds that Rabanal and Rubio-Ramirez (2015)'s model can also generate an integral correction mechanism (ICM) in the real exchange rate. According to Jiang and Talmain (2017), the ICM is a good parsimonious representation of 18 bilateral real exchange rates between OECD countries. I use this DSGE model to understand real exchange rate dynamics and the Purchasing Power Parity (PPP) Puzzle of Rogoff (1996).

This paper contributes to the literature by bridging open economy DSGE models to updated empirical evidence. Only a few papers work on this matter. For example, Ahmad et al. (2013) show that the real exchange rate in a medium-scale two-country DSGE model is characterised by the smooth transition autoregression. However, Jiang and Talmain (2017) find that the ICM can capture important dynamics of the real exchange rate that the smooth transition autoregression ignores.

The rest of this paper is organised as follows. Sections 2 and 3 present the ICM and the DSGE model respectively. In Sections 4 and 5, I investigate how and why does the DSGE model capture the real exchange rate. The last section concludes the paper.

2. The integral correction mechanism

The integral correction mechanism is given by

$$err_t = \sum_{j=1}^{p} \beta_j^{ecm} err_{t-j} + \beta^{icm} ie_{t-1} + \varepsilon_t, \tag{1}$$

where err_t is the real exchange rate misalignment

$$err_{t-1} = \ln rer_{t-1} - \ln rer_{t-1}^{EQ}, \tag{2}$$

rer^{EQ} denotes the "equilibrium" value of the real exchange rate, and ie is the integral error

$$ie_{t-1} = \sum_{i=0}^{t-1} err_i. \tag{3}$$

Following Lothian and Taylor (2000) and Taylor (2002), I use a constant and a linear deterministic trend as a proxy of the real exchange rate equilibrium. A detailed examination of real exchange rate equilibrium in the ICM can be found in Jiang and Talmain

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[1] Chari, Kehoe, and McGrattan (2002); Steinsson (2008); Corsetti, Dedola, and Leduc (2008); Rabanal, Rubio-Ramirez, and Tuesta (2011); Rabanal and Tuesta (2013, and many others).

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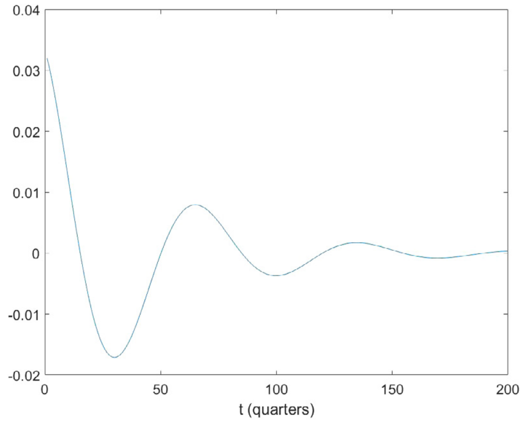

Fig. 1. Impulse response of estimated ICM.

(2017). The key parameter, $\beta^{icm} \leq 0$ controls the integral correction mechanism. β_j^{ecm} implies a stationary AR(p) process. To better understand the ICM dynamics, see Fig. 1 for an impulse response of the real exchange rate estimated using U.S. data. In the ICM, β_j^{ecm} controls the "conventional persistence", e.g., how fast does the real exchange rate revert to the equilibrium position. It also determines the period of the cyclical movement. β^{icm} controls the magnitude of the cyclical movement, which I refer to as the "cyclical persistence". An AR model with some negative coefficients may generate similar behaviour. However, no such estimate has been found in the literature even when a relatively large number of lags is allowed; see for example Steinsson (2008).

3. The DSGE model

The DSGE model I use is that developed by Rabanal and Rubio-Ramirez (2015). The world consists of two symmetric countries: Home and Foreign. There is one real riskless bond on the international financial market. Each country produces country specific tradable intermediate goods using domestic labour and capital. A competitive final goods sector in each country combines these two tradable goods to produce a nontradable final goods, using the production function

$$Y_t = \left[\omega^{\frac{1}{\sigma_{HF}}} Y_{H,t}^{\frac{\sigma_{HF}-1}{\sigma_{HF}}} + (1-\omega)^{\frac{1}{\sigma_{HF}}} \left(\varphi_t Y_{F,t}\right)^{\frac{\sigma_{HF}-1}{\sigma_{HF}}} \right]^{\frac{\sigma_{HF}}{\sigma_{HF}-1}},$$

where $Y_{H,t}$ and $Y_{F,t}$ are domestic and imported intermediate goods respectively, $\omega \in (0, 1)$ denotes the level of home bias or the degree of openness, $\sigma_{HF} > 0$ determines the long-run elasticity of substitution between domestic and imported intermediate goods, $\varphi_t = \left[1 - \frac{\iota}{2} \left(\frac{\frac{Y_{F,t}}{Y_{H,t}}}{\frac{Y_{F,t-1}}{Y_{H,t-1}}} - 1 \right)^2 \right]$ is an input adjustment cost controlled by a parameter $\iota \geq 0$.

Parameters in this production function is calibrated to fit both the spectrum and the ACF of the real exchange rate. I consider both of them because, unlike the population ACF and spectrum, the sample ACF does not correspond exactly to the sample spectrum. Also, it is well known that the sample spectrum cannot be estimated consistently. I choose $\omega = 0.82$, $\sigma_{HF} = 3$, and $\iota = 900$, which means that a change of 1% in the input ratio results in Foreign intermediate goods being 4.5% less efficient in production. Total factor productivity follows a stationary VAR(1)[2] process estimated by Heathcote and Perri (2002):

$$\begin{bmatrix} logA_t \\ logA_t^* \end{bmatrix} = \begin{bmatrix} 0.97 & 0.025 \\ 0.025 & 0.97 \end{bmatrix} \begin{bmatrix} logA_{t-1} \\ logA_{t-1}^* \end{bmatrix} + \begin{bmatrix} \epsilon_t \\ \epsilon_t^* \end{bmatrix},$$

$$\begin{bmatrix} \epsilon_t \\ \epsilon_t^* \end{bmatrix} \sim N\left(\begin{matrix} 0 \\ 0 \end{matrix}, \Sigma \right),$$

$$StD\left(\epsilon_t\right) = 0.0073, StD\left(\epsilon_t^*\right) = 0.0044, Corr\left(\epsilon_t, \epsilon_t^*\right) = 0.29.$$

The rest of the model is standard.

4. How does the DSGE model capture the real exchange rate

I study quarterly U.S. effective real exchange rate. The data is collected from the federal reserve board's major index. I treat U.S. as the home country. And the effective real exchange rate is defined as the price of foreign goods in terms of domestic goods.

The DSGE model generates highly volatile real exchange rate. The standard deviation of the real exchange rate is about 0.1095 in the data and 0.1075 in the model. The upper panel of Fig. 2 shows that the DSGE model also fits the spectrum and the ACF reasonably well. In particular, it captures the fact that the spectrum peaks within frequencies that correspond to 10 to 31 years cycles. The literature usually takes the first order autocorrelation equal to 0.95 as evidence of a high degree of persistence. However, the ACF goes down very fast to a negative level and cyclically moves around zero with a decaying magnitude, which suggests that the real exchange rate is persistent only in the long run and in a non-monotonous way.

To see if the DSGE model can generate an integral correction mechanism. I first estimate parameters in the ICM from data by maximum likelihood with $p = 1$ based on partial autocorrelations of the real exchange rate. β^{icm} is significant at 5% level of significance. I construct a bootstrap distribution for each parameter with 5000 realisations. Then the linearised DSGE model is used to simulate data 5000 times, from which I estimate the ICM and construct a Monte Carlo sample for each ICM parameter. The lower panel of Fig. 2 illustrates that the Monte Carlo distributions largely overlap the Bootstrap distributions. Hence the DSGE model explains the real exchange rate with about right degrees of conventional and cyclical persistence.

5. Why does the DSGE model capture the real exchange rate

To investigate the micro-foundation underlying real exchange rate dynamics, I study impulse responses to a positive Home productivity shock and analyse the sensitivity by varying ι. Fig. 3 reports the impulse responses over 200 periods when $\iota = 0$, 150, and 900.

Case 1. I start with the standard IRBC results with no input adjustment cost. The productivity shock pushes up the capital return, the interest rate, and all real activities in Home. Foreign households shift resources to Home by lending and exporting. Consequently, investment in Foreign decreases but consumption increases because Foreign enjoys a wealth effect and a terms of trade effect that can be seen from the left panel. Higher capital return and the increased productivity have opposite effects on the marginal cost of Home intermediate goods. The decrease in P_H indicates that the effect of a higher capital return is smaller than the effect of higher productivity. P_F increases because of the higher foreign capital rent and no or a mild increase in productivity. In turn, the terms of trade $\frac{P_F}{P_H}$ and RER depreciate (increase).

Case 2. When $\iota \in (0, 245)$, the world economy still finds it optimal to shift resources to Home. Foreign lends and exports to Home as in case 1. This behaviour causes a surge in the input adjustment

[2] Following Rabanal et al. (2011), Rabanal and Rubio-Ramirez (2015) employ cointegrated technology. However, Rabanal et al. (2011) focus on business cycle frequencies. I deviate from them to better fit both the spectrum and the ACF.