Can RBC Models Explain Business Cycles in Korea?

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Abstract

I examine whether an RBC model with recursive utility can generate a higher volatility of consumption relative to output and strong negative correlations between output and the trade balance and/or the real interest rate, phenomena that have been observed in the business cycles of emerging economies, including Korea. I calibrate a model based explicitly on Korean data for the period 1996 to 2011 and do a Bayesian estimation of the model. The estimation results suggest that there are, to say the least, some elements of success in describing the Korean economy based on the simple RBC model with recursive utility. It explains the relative volatility between consumption (investment) and output very well. It further implies that output and the trade balance and/or the real interest rate are negatively correlated, though the magnitudes of the correlations are quite small compared to the corresponding magnitudes in the data. Simulation results further show that the baseline model supplemented with an endogenous channel of financial frictions performs marginally better than the baseline model in the sense that it generates more strong countercyclicality of the trade balance and/or the real interest rate.

JEL classification: E3, O5

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1 Introduction

Some researchers have recently observed that business cycles in emerging economies can be characterized very differently from those in advanced economies. For example, in emerging economies, consumption is relatively more volatile than output, the trade balance is strongly countercyclical, and the cost of foreign borrowing is countercyclical. I will call these the stylized facts in emerging economy business cycles.

Notably, Aguiar and Gopinath (2007, henceforth AG) showed that the standard RBC model with a growth shock can successfully explain the stylized facts in emerging economy business cycles. AG argue that a shock to the growth rate implies an even larger increase in future income, implying that consumption responds more than current period income, reducing savings and generating a large trade deficit. On the contrary, if the shock is transitory, agents will increase savings. Consumption will increase by less and the trade balance will deteriorate by less or even improve.

Previous research on emerging economy business cycles examines Korean data in pointing out the stylized facts, but their estimations and discussions mainly focus on Latin American economies such as Mexico and Argentina. Thus, examining the issue based explicitly on Korean data both in calibration and in estimation would fill the gap in the literature, which is the aim of this paper.

In order to examine the issue, I employ the recursive utility of Epstein and Zin (1991) and Weil (1989) instead of the CRRA utility function commonly used in the literature on emerging economy business cycles. It is well known that the degree of relative risk aversion equals the inverse of the elasticity of intertemporal substitution (EIS hereafter) in the CRRA utility function and they are not disentangled. It is not a serious problem in itself in most cases. However, it turns out that the Korean data severely restrict the choice of the value for the parameter in the CRRA utility function. It restricts the value of the degree of relative risk aversion (or the inverse of the EIS) to one, in order to have a discount factor (β) of less than one. Specifically, as I show in Section 2, the CRRA utility function implies that the real interest rate (1 + r) in the steady state equals (1 + g)γ/β, where γ denotes the degree of relative risk aversion, and g represents the steady state value of the growth rate. Put
differently, $\beta = (1 + g)^\gamma / (1 + r)$. Unless the mean growth rate is far less than the steady state value of the real interest rate, $\beta$ (the discount factor) is greater than one. Unfortunately however, in the Korean data, the mean growth rate of real GDP is slightly less than the highest measure of the mean real interest rate for the sample period. Therefore, we should fix $\gamma$ at one in order to have $\beta$ less than one. Even in this case, $\beta$ turns out to be 0.9998 in the Korea data, which is virtually one. To circumvent this problem, I adopt the recursive utility of Epstein and Zin (1991) and Weil (1989), which separates the degree of relative risk aversion from the EIS. To my knowledge, this has not been tried before in the literature on emerging economy business cycles.

I calibrate a model based on Korean data for the period 1996 to 2011 and do a Bayesian estimation of the model. The estimation and simulation results suggest that it is fair to say that a simple RBC model with a growth shock can reasonably well explain the business cycle stylized facts in the Korean economy despite its simplicity. It explains the relative volatility between consumption (investment) and output very well. The simulated relative volatility of consumption (investment) to output is 1.29 (2.79), and very close to the actual number from the data, 1.32 (3.00). It further implies that output and the trade balance and/or the real interest rate are negatively correlated, though the magnitudes of the correlations are quite small compared to the corresponding magnitudes in the data.

Further simulations suggest that it is the EIS, not the coefficient of relative risk aversion, that contributes most to the increase in the relative volatility of consumption in the model. We can understand it easily if we recall that the degree of risk aversion reflects the intratemporal substitution across states, whereas the EIS reflects the intertemporal substitution across time. As we can see in the text, I set the prior mean of the EIS at 1.5 in the Bayesian estimation, which is larger than the implicit EIS ($= \text{unity} = \text{inverse of } \gamma$) in the model with the CRRA utility function. Higher EIS implies a larger volatility of consumption if other things are equal.

Some researchers argue for the importance of incorporating some aspects of financial frictions into the standard RBC model in order to explain the stylized facts in emerging economy business cycles. For example, Neumeyer and Perri (2005), Uribe and Yue (2006), Garcia-Cicco et al. (2010), and Chang and
Fernandez (2012) argue for the importance of interest rate shocks and financial frictions in explaining the stylized facts in emerging economy business cycles. I consider two forms of financial frictions: the endogenous risk premium channel and the exogenous risk premium channel. The former supposes that the country risk premium is endogenously related to the domestic state of the economy and the latter simply adds an exogenous shock to the baseline model of the risk premium. After the simulation, I find that the endogenous risk premium channel marginally outperforms the baseline model. In particular, it generates stronger countercyclicality of the trade balance and/or the real interest rate.

In section 2, I introduce the simple RBC model with a growth shock proposed by AG and Garcia-Cicco et al. (2010) and discuss some uneasiness in matching the implications of the model with the Korean data. I then incorporate the recursive utility of Epstein and Zin (1991) and Weil (1989) into the simple RBC model in order to circumvent the problem. I describe the Korean data and present the Bayesian estimation results from the standard RBC model with recursive utility and a growth shock, which I call the baseline model, in Section 3. I do some additional analyses in order to check the robustness of the estimation results in Section 4. The robustness check is performed by changing the values of the calibrated parameters, then by incorporating both the endogenous and exogenous risk premium channels into the baseline model in order to reflect some aspects of financial frictions. Section 5 briefly concludes.

2 The model

2.1 The standard RBC model

Here, I introduce the simple RBC model with a growth shock proposed by AG and Garcia-Cicco et al. (2010), among others. The production function takes a Cobb-Douglas form with the labor augmenting technology:

\[
Y_t = a_t K_t^\alpha (X_t h_t)^{1-\alpha},
\]

where \(Y_t\) and \(h_t\) denote output and work hours in period \(t\), and \(K_t\) denotes the capital stock at the beginning of period \(t\). The parameter \(\alpha\) denotes the capital share in output. The temporary productivity shock, \(a_t\), follows a first-order autoregressive process:

\[\]
\begin{align*}
\ln a_t &= \rho_A \ln a_{t-1} + \varepsilon_{At}, \quad -1 < \rho_A < 1,
\end{align*}
with \( \varepsilon_{At} \sim N(0, \sigma_A) \). The trend component, \( X_t \), is a random walk with a drift and its growth rate \( g_t \equiv \frac{X_t}{X_{t-1}} \) follows the following process:
\begin{align*}
\ln(g_{t+1}/g) &= \varepsilon_{gt+1},
\end{align*}
where \( g \) denotes the mean of \( g_t \) and \( \varepsilon_{gt} \sim N(0, \sigma_g) \). The equation of motion for the capital stock is given by:
\begin{align*}
K_{t+1} &= (1 - \delta)K_t + I_t,
\end{align*}
where \( I_t \) and \( \delta \) denote investment in period \( t \) and the depreciation rate, respectively.

The budget constraint of a representative agent is given by:
\begin{align*}
D_t + C_t + I_t + \frac{\kappa}{2} \left( \frac{K_{t+1}}{K_t} - g \right)^2 K_t = Y_t + \frac{D_{t+1}}{1 + r_t},
\end{align*}
where \( D_{t+1} \) denotes the bond issued in period \( t \) at the discount rate of \( r_t \). \( C_t \) is consumption in period \( t \). The parameter \( \kappa \) measures the degree of adjustment costs. The domestic real interest rate, \( r_t \), is the sum of the foreign interest rate (\( r^* \)) and the risk premium, \( \phi(\exp(\bar{D}_t/X_t - \bar{a}) - 1) \).
\begin{align*}
 r_t &= r^* + \phi(\exp(\bar{D}_t/X_t - \bar{a}) - 1),
\end{align*}
where \( \bar{D}_t \) is the aggregate level of external debt per capita, which the agent takes as exogenous. In equilibrium, \( D_t = \bar{D}_t \). The parameter \( \bar{a} \) represents the mean of external debt per capita. I assume that \( r^*_t \) is constant following Garcia-Cicco et al. (2010) and Otsu (2008).

The representative agent’s utility function takes the form suggested in Greenwood et al. (1988) and she solves the following problem subject to the budget constraint (5):
\begin{align*}
Max \quad E_0 \sum_{t=0}^\infty \beta^t \left[ C_t - \theta \omega^{-1} X_{t-1} h_t^{\omega} \right]^{1-\gamma} - 1,
\end{align*}
where \( \theta, \omega, \gamma \) are parameters. This type of preference allows the labor supply to be independent of consumption levels. It leads to high substitution between leisure and consumption and, accordingly, a low income effect on the labor supply and large responses of consumption and labor to productivity shocks.

The first-order conditions with respect to \( c_t, h_t, d_t, k_{t+1} \) in stationary forms (divided by \( X_{t-1} \), and expressed in lower case letters) are:

\[
[c_t - \theta \omega^{-1} h_t^{\omega}]^{-\gamma} = \lambda_t \tag{8}
\]

\[
\theta h_t^{\omega-1} = (1 - \alpha) \alpha_t \left( \frac{k_t}{h_t} \right)^{\alpha} (g_t)^{1-\alpha} \tag{9}
\]

\[
\lambda_t = \beta \left[ 1 + r^* + \psi(e^{d_t - \bar{d}} - 1) \right] \frac{E_t \lambda_{t+1}}{g_t} \tag{10}
\]

\[
\frac{1 + \kappa \left( \frac{k_{t+1}}{k_t} g_t - g \right)}{g_t} \lambda_t \tag{11}
\]

\[
\left[ 1 + \kappa \left( \frac{k_{t+2}}{k_{t+1}} g_{t+1} - g \right) \right] \lambda_t = \frac{\beta}{E_t \lambda_{t+1}} \left[ 1 - \delta + \alpha a_{t+1} \left( \frac{g_{t+1} h_{t+1}}{k_{t+1}} \right)^{1-\alpha} - \frac{\kappa}{2} \left( \frac{k_{t+2}}{k_{t+1}} g_{t+1} - g \right)^2 \right] \tag{12}
\]

where \( \lambda_t \) represents the Lagrange multiplier for the budget constraint facing the household. Equation (8) states that the Lagrange multiplier represents the marginal utility of consumption. Equation (9) states that the demand for labor (the marginal product of labor) on the right-hand side of the equation equals the supply of labor (the ratio of the marginal disutility of labor to the marginal utility of consumption) on the left-hand side of the equation. Equation (10) and Equation (11) are the usual Euler equation and the capital Euler equation, respectively.

The remaining equilibrium conditions are:

\[
d_t + c_t + i_t + \frac{\kappa}{2} \left( \frac{k_{t+1}}{k_t} g_t - g \right)^2 k_t = y_t + \frac{d_{t+1}}{1 + r_t} g_t \tag{13}
\]

\[
r_t = r^* + \psi(e^{d_t - \bar{d}} - 1) \tag{14}
\]
\[ k_{t+1}g_t = (1 - \delta)k_t + i_t \]  \hspace{2cm} (15)

\[ y_t = a_1k_t^\alpha (g_t h_t)^{1-\alpha} \]  \hspace{2cm} (16)

### 2.2 The simple RBC model and the Korean data

Before we proceed, let me first point out that, in order to explain movements in the real interest rate in Korea, we need to suppose a relatively lower discount rate (or relatively higher value of \( \beta \)) compared to other emerging economies such as Mexico and Argentina, which have been the main focus of the recent literature. We need to make this supposition because the sample mean (gross) growth rate, \( g \), is large relative to the sample mean (gross) real interest rate \((1 + r)\).

From equations (10) and (14), we know that the (net) real interest rate in the steady state is given by

\[ r = r^* = \frac{g^\gamma}{\beta} - 1. \]  \hspace{2cm} (17)

It can be rewritten as

\[ \beta = \frac{g^\gamma}{1 + r} \]  \hspace{2cm} (18)

Equation (18) suggests that the discount factor \( \beta \) should be greater than one if the steady state value of the mean (gross) growth rate, \( g \), is large relative to the steady state (gross) real interest rate \((1 + r)\). Other things equal, the lower the steady state value of the real interest rate the higher the discount factor. Thus we need a measure of the real interest rate that is large relative to the steady state value of the mean (gross) growth rate, \( g \), in order to avoid an uncomfortable situation where the discount factor \( \beta \) is larger than one.

Figure 1 plots various measures of the real interest rate in Korea for the sample period between 1996:I and 2011:IV. In the figure, I show three measures of the real interest rate. They are the real interest rate calculated as the difference between three measures of the nominal interest rate and the four-quarter moving average of the CPI inflation rate. The three measures of the nominal rate are the three-year Treasury bond (TB3Y) yield, the rate for AA-rated
corporate bonds (CB(AA-)), and the average new lending rate of all depository banks (ANLRDB). This choice is restricted by the availability of data for the sample and the representativeness of market conditions. All the rates tend to move together and peak in the second quarter of 1998, during which time the IMF and the Korean government agreed to switch from a high interest rate policy to a more modest rate policy. After that all the rates tend to go down and stay below 4% for most of the period except for the credit crunch in 2002 and the initial stage of the financial crisis in 2008. The average annual real interest rate ranges from 3.10% to 4.39%, depending on the measure of the nominal interest rate. It is at its highest when the average new lending rate of all depository banks is used as a measure of the nominal rate.

We should note that even the highest measure of the average quarterly real interest rate (1.1%) reported in Figure 1 is much lower than the values implied by AG (the quarterly rate of 3.4% for Mexico) and Garcia-Cicco et al. (2010) (the annual rate of 9.5% for Argentina). It restricts our choice of values for \( \gamma \), which measures the degree of relative risk aversion. The most commonly accepted values for \( \gamma \) range from two to four in the business cycle research. It is thought to be much larger than that if our main focus is to explain movements in financial variables. The fact that the sample mean of the real interest rate is relatively low in Korea restricts the choice of the value for \( \gamma \) to one. More specifically, the average quarterly (gross) growth rate of GDP, \( g \), for the sample is 1.010754, and the average quarterly gross real interest rate, \( 1 + r = 1.011 \). If the exponent of the preference, \( \gamma \), equals two, then the discount factor \((\beta)\) calculated from equation (18) is 1.0105 and is larger than one. Thus, I need to fix the parameter \( \gamma \) at one in order not to have the discount factor larger than one and let \( \beta \) be determined at the level that satisfies the steady state equilibrium condition (18). Even in this case, \( \beta \) turns out to be 0.9998. It is virtually one.

2.3 The model with recursive utility

Unlike the previous research in this area, I employ the recursive utility of Epstein and Zin (1991) and Weil (1989) in explaining the stylized facts in emerging economy business cycles. One advantage of using this type of utility is that we can separate the degree of (relative) risk aversion from the EIS. As is well
known, the CRRA utility function does not disentangle the two parameters. The degree of relative risk aversion equals the inverse of the EIS in the CRRA utility function.

I suppose that the agent’s objective function is given by

\[
V_t = \left\{ (1 - \beta) C_t^{\frac{1+\gamma}{\theta}} + \beta \left( E_t \left[ V_{t+1}^{1-\gamma} \right] \right)^{\frac{\theta}{1-\gamma}} \right\} \frac{1}{1-\gamma},
\]

(19)

where \( \theta = \frac{1+\gamma}{1-\gamma} \), the parameters \( \gamma \) and \( \psi \) represent the degree of relative risk aversion and the EIS, respectively. If \( \gamma = \frac{1}{\psi} \), \( \theta = 1 \), and the objective function \( V_t \) collapses to the usual CRRA utility function. The specific form of the value function in (19) is borrowed from Chen, Favilukis, Ludvigson (2013), and Dew-Becker (2012a), among others, though their main focus is not (emerging economy) business cycles.

The stochastic discount factor and the Euler equation in stationary forms are given by

\[
m_{t,t+1} = \beta E_t \left[ \frac{c_{t+1}^{1-\theta} g_t}{c_t} \frac{(v_{t+1} g_t)^{(\theta-1)(1-\gamma)}}{(E_t (v_{t+1} g_t)^{1-\gamma})^{\frac{\theta}{\theta-1}}} \right],
\]

(20)

and

\[
1 = E_t \left[ \beta \frac{c_{t+1}^{1-\theta} g_t}{c_t} \frac{(v_{t+1} g_t)^{(\theta-1)(1-\gamma)}}{(E_t (v_{t+1} g_t)^{1-\gamma})^{\frac{\theta}{\theta-1}}} (1 + r_t) \right],
\]

(21)

respectively.

Note that the value function in (19) does not have work hours in it. The reason that I do not consider the labor market in this paper is that it is known that the simple RBC model with a growth shock presented in subsection 2.1 does not explain well the stylized facts in emerging economy labor markets: large fluctuations in wages and subdued fluctuations in employment. Refer to Boz, Durdu and Li (2012) and Bahng (2012) for the detailed discussions and references therein. Another reason that I do not include work hours in the utility function is to remove the interaction between consumption and labor. If the period utility depends nonseparably on both consumption and labor,
the marginal utility of consumption depends on labor. Furthermore, even if consumption and labor are separable in the period utility, the stochastic discount factor is affected by labor through the value function for the next period, $V_{t+1}$, as noted in Dew-Becker (2012b).

The main purpose of this paper is to examine if the simple RBC model with recursive utility can generate a higher volatility of consumption relative to output and strong negative correlations between output and the trade balance (and/or the real interest rate), phenomena that have been observed in Korean business cycles. For that reason, I suppose that the labor supply is inelastically fixed at unity. Then the production function (16) is given by

$$y_t = a_t k_t^n (g_t)^{1-\alpha}$$  \hspace{1cm} (22)

The use of recursive utility also changes the capital Euler equation:

$$1 + \kappa \left( \frac{k_{t+1}}{k_t} g_t - g \right) = E_t \left[ m_{t,t+1} \left( 1 - \delta + \alpha a_{t+1} \left( \frac{g_{t+1}}{k_{t+1}} \right)^{1-\alpha} \right) + \kappa \left( \frac{k_{t+2}}{k_{t+1}} g_{t+1} \right) - \frac{\kappa}{2} \left( \frac{k_{t+2}}{k_{t+1}} g_{t+1} - g \right)^2 \right]$$ \hspace{1cm} (23)

The remaining equilibrium conditions are equations (13)-(15). I will call the model described in this subsection the baseline model.

For later use, let us derive the real interest rate in the steady state when we employ recursive utility. From the Euler equation (21), we know that the steady state level of the (net) real interest rate is given by

$$r = r^* = \frac{g^{1+\gamma} - 1}{\beta} - 1,$$ \hspace{1cm} (24)

which implies that

$$\beta = \frac{g^{1+\gamma} - 1}{1 + r} = \frac{g^\theta}{1 + r}.$$ \hspace{1cm} (25)

The second equality follows from the definition of $\theta$. From this equation, we know that the steady state value of the real interest rate is not governed by the degree of relative risk aversion but by the EIS. It implies that we do not have to set the value of $\gamma$ at a very restrictive value of one in order to calibrate the model with the Korean data.
3 Data and estimation results

Now I turn to a discussion of the Korean data and the estimation methods.

3.1 Data and calibration

All the data are from the Economic Statistics System of the Bank of Korea (http://ecos.bok.or.kr). As a measure of real output, consumption, investment, and the trade balance, I use the logarithm of real GDP net of government spending, the logarithm of private consumption, the logarithm of total capital formation, and the level of the trade balance, respectively. They are all in the series 10.4.2.2 of the Economic Statistics System of the Bank of Korea. All the data are HP filtered in order to have stationary series.

The sample period is 1996:I - 2011:IV. This period is chosen for several reasons. First, the excess volatility of consumption relative to output is not a prominent phenomenon in Korean business cycles before the Asian currency crisis of 1997. The relative volatility of consumption to output for the period 1970-1995 is 0.53. Consumption was much smoother than output for the period, as it is in advanced economies. Second, the Korean government liberalized the financial market in the early 1990s and has let the interest rate determined in the market step by step since 1992. Before then, interest rates were controlled by the government. Third, the period includes two crises: the Asian currency crisis in 1997 and the global financial crisis in 2008. The two crises contributed a lot to the excess volatility of consumption relative to output.

For the sample period, the average quarterly growth rate \((g)\) of real GDP net of government spending in Korea is 1.0754\%. The average quarterly net real interest rate \((r)\) for the sample period is 1.1\%. Real interest rates are constructed as the difference between the average new lending rate of all depository banks (series 4.2.2.1) and the four-quarter moving average of the CPI inflation rate (series 7.3.1). The choice of the nominal interest rates was explained in section 2. I set the capital coefficient at \(\alpha = 0.4\), based on the fact that the labor income share (series 10.1.1) in the Korean economy measured as the ratio of compensation for employees to GDP for the period 1996 to 2011 fluctuates around 60\%. I set the depreciation rate at \(\delta = 0.025\), implying an annual depreciation rate of 10\%, which is commonly used in the literature. I set the
steady state value of the trade balance ($tb$) to GDP ratio to 1%, which is close to the sample mean of 1.7%.

For the parameters of the utility function, I set the value of $\gamma$, the degree of relative risk aversion, to two. We may need a (very) high-value of the degree of relative risk aversion if our main purpose is to explain movements in financial variables. For example, Tallarini (2000) considers the case of $\gamma = 100$, while Bansal and Yaron (2004) set $\gamma = 10$, Piazzesi and Schneider (2006) have $\gamma = 59$, and Chen, Favilukis and Ludvigson (2013) estimate $\gamma$ to be $17 \sim 60$. However, the main purpose of this paper is not to explain movements in financial variables but to explain the stylized facts in Korean business cycles. Thus, I just fix it at two.

3.2 Bayesian estimation and simulation results

For the estimation and simulation, I do a Bayesian estimation. I execute the Bayesian estimation in Dynare version 4.2.3. Readers who are interested in the details of the estimation are referred to Griffoli’s (2007-2008) Dynare User Guide. One thing that I should note here is that this version of Dynare does not allow the higher order approximation of the model for the estimation. However, it is well known that the log linearization is good enough if the main focus of the research is not to do welfare analysis or to investigate the financial market but to examine the business cycle. Another thing that I should note is that the log linearization of the model with recursive utility is seemingly equivalent to that of the usual CRRA utility function. However, in the log-linear approximation, the coefficients are a combination of both the degree of relative risk aversion and the EIS. This means that the estimation and, accordingly, the simulation are affected by both parameters, though the steady state value of the real interest rate is governed solely by the EIS as we can see in equation (25).

I set the prior distribution for the AR(1) parameters for the shock process as the beta distribution. I set the priors for the parameters with positive values as the gamma distribution, and the standard deviation of shock processes as the inverse-gamma distribution. I set the prior mean of the EIS at 1.5, which is in the range of values mostly used in the literature. For example, Piazzesi and Schneider (2006) set $\psi$ at 1, and Bansal and Yaron (2004) set it at 1.5. Chen, Favilukis and Ludvigson (2013) estimate it to be $\approx 2$, and Binsbergen et al.

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(2012) estimate it to be 1.72.

Table 1 reports the parameter values both calibrated and estimated from the Bayesian estimation and the key moments simulated from the estimation. The model data are simulated 300,000 times. For the estimation, I use $y$ and $r$ as observed variables and the log data density is 334.37. From the table, we can see that the standard RBC model with recursive utility can describe very well the Korean economy as far as the relative volatility of consumption (investment) to output is concerned. The relative volatility of consumption (investment) to output is estimated to be 1.3 (2.8), which is very close to the values from the data. However, it is not so impressive in explaining the correlations between output and the trade balance and/or the real interest rate. The correlations are not as large as the values from the data, though they are negative.

In order to have some idea about how the adoption of the recursive utility instead of the CRRA utility function improves the performance of the simple RBC model in explaining Korean business cycles, I do the Bayesian estimation for the baseline model with the CRRA utility function. Table 2 reports the parameter values both calibrated and estimated from the Bayesian estimation and the key moments simulated from the estimation. In estimation, the only difference is that I set the value of \( \gamma \) at one, as discussed in subsection 2.2. From the table, it is worthwhile to note that the relative volatility of consumption to output is 0.55 and the correlation between output and the trade balance is 0.19. Thus, we can say that the adoption of the recursive utility instead of the CRRA utility function improves the performance of the simple RBC model in the direction of raising the relative volatility of consumption to output and, accordingly, strengthening the negative correlation between output and the trade balance if other things are equal. This is because the recursive utility allows us to set the EIS at a higher value than the CRRA utility function in confronting the Korean data. In table 1, I set the prior mean of the EIS (\( \psi \)) at 1.5, whereas here I implicitly set it to unity, since it equals the inverse of \( \gamma \). A higher EIS implies larger fluctuations in expected consumption growth given fluctuations in real interest rates.\footnote{Changing the value of \( \gamma \) to 1.1 or 0.9 in Table 1 does not change the results qualitatively.}

In sum, we can say that there are, to say the least, some elements of success in describing the Korean economy based on the simple RBC model with recursive
utility. It explains the relative volatility between consumption (investment) and output very well. It further implies that output and the trade balance and/or the real interest rate are negatively correlated, though the magnitudes of the correlations are quite small compared to the corresponding magnitudes in the data.

4 Robustness

4.1 Calibration

Here, I briefly discuss what happens if I use different values for the calibrated parameters. The main role of the investment adjustment cost parameter (κ) is to reduce the volatility of investment. If I increase the value of the adjustment cost parameter up to 5 with the other parameters unchanged, the volatility of investment declines dramatically and becomes even smaller than the volatility of consumption and output, which is not supported by the data. Similarly, increasing the depreciation rate (δ) mainly dampens the volatility of investment, leaving other second moments not changed much. The main role of the elasticity of the real interest rate to the external debt level (φ) is to make the system stationary. Thus, if it is set too high, the system does not converge. Changing the value for the degree of relative risk aversion (γ) up to 4 does not change the results qualitatively. This is because it represents the intratemporal substitution (across states) and its role in explaining the consumption volatility (across time) is not the first order.

4.2 Other shocks

Neumeyer and Perri (2005), Uribe and Yue (2006), Garcia-Cicco et al. (2010) and Chang and Fernandez (2012), among others, argue that the AG-type model supplemented with financial frictions does a better job of explaining the stylized facts in emerging economy business cycles. Thus, I add various financial frictions to the baseline AG-type model in the previous section and see if the RBC models with some aspects of financial frictions improve the performance of the baseline model.

There are many types of financial frictions in the literature, but I will consider just two of them: the endogenous risk premium channel and the exogenous
risk premium channel. The endogenous risk premium channel supposes that the country risk premium is endogenously related to the domestic state of the economy. For example, the country risk premium goes down if the market expects higher productivity or higher growth in the future. Specifically, I will consider the following case:

\[ r_t = r^* + \phi(\exp(d_{t-1} - \bar{d}) - 1) - \eta E_t \exp(a_{t+1} - 1). \]  

Here, the country risk depends inversely on the expected productivity, \( a_{t+1} \). This case is considered in Neumeyer and Perri (2005), Faia and Monacelli (2007) in a different context, and Chang and Fernandez (2012), among others. One advantage of this type of risk premium is that we can have a countercyclical risk premium; the risk premium goes down if the market expects higher productivity in the future.

I also consider the formulation of the risk premium suggested in Garcia-Cicco et al. (2010), which I will call the exogenous risk premium channel:

\[ r_t = r^* + \phi(\exp(d_{t-1} - \bar{d}) - 1) + \eta \exp(\mu_t) - 1, \]  

where

\[ \ln \mu_t = \rho_{\mu} \ln \mu_{t-1} + \varepsilon_{\mu t}, \quad -1 < \rho_{\mu} < 1 \]  

with \( \varepsilon_{\mu t} \sim N(0, \sigma_{\mu}) \). The exogenous risk premium channel simply adds another shock, \( \mu_t \), to the baseline model of the risk premium. It may possibly stem from financial imperfections, which lead to stochastic shifts in the country premium that are uncorrelated with the state of domestic fundamentals such as \( a_t \) and \( g_t \).

| 14 |

Table 3 reports the estimated parameter values (posterior mean), the key moments simulated from the estimation, and the log data densities. From the table, we can see that the endogenous risk premium channel does improve the performance of the simple RBC model with recursive utility in terms of the log data density and correlations between output and the trade balance and/or the real interest rate. The log data density is 384.43, which is larger than that

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\(^2\)I also considered \( g_{t+1} \) instead of \( a_{t+1} \), but the results do not change qualitatively from those reported in Table 1.
in Table 1. Furthermore, the correlations between $y$ and $tb$ ($corr(tb, y)$) and between $y$ and $r$ ($corr(r, y)$) are negative and larger in absolute values than those in Table 1. These results are not surprising since the endogenous risk premium channel strengthens the countercyclicality of the risk premium. Nonetheless, the endogenous risk premium channel does not outperform the baseline model in every respect. The endogenous risk premium channel does not explain the relative volatilities better than the baseline RBC model. In particular, the ratio of $\sigma_i/\sigma_y$ is less than 2, whereas the actual ratio from the data is about 3. Thus, we can say that the endogenous risk premium channel performs marginally better than the simple RBC model in describing the stylized facts in Korean business cycles. On the contrary, the exogenous risk premium channel does not perform better than the baseline model. All the magnitudes of the key moments are pretty far from the corresponding values in the data. However, its log data density is much larger than that of the baseline model or the endogenous risk premium channel. The reason why the exogenous risk premium channel shows such a high log data density may be that it uses three variables as observed variables in the estimation instead of two.\(^3\)

5 Conclusion

Previous studies considered Korean data in pointing out the stylized facts in emerging economy business cycles; excess volatility of consumption relative to output, and strong negative correlations between output and the trade balance and/or the real interest rate. However, their main focus centered on Latin American economies such as Mexico and Argentina.

This paper explicitly focuses on describing and estimating the Korean economy. In order to do that, I incorporated recursive utility into an AG-type RBC model. Recursive utility allows us to separate the degree of relative risk aversion from the EIS. This advantage helps us to circumvent the problem associated with matching the implications of the model with the Korean data, as discussed

\(^3\)One thing to note in Table 3 is that the estimate of the AR(1) coefficient for the transitory technology shock, $\rho_t$, is very close to unity. Thus, I did a Bayesian estimation of the simple RBC with a trend shock only. Though I do not report the results to save space, it turns out that consumption is too volatile relative to output. It is a couple of times as volatile as output. Furthermore, there is almost no mechanism in the simple model to reduce the relative volatility of consumption.
The Bayesian estimation based on Korean data shows that there are, to say the least, some elements of success in describing the Korean economy based on the simple RBC model with recursive utility. It explains the relative volatility between consumption (investment) and output very well. It further implies that output and the trade balance and/or the real interest rate are negatively correlated, though the magnitudes of the correlations are quite small compared to the corresponding magnitudes in the data.

I also examined whether the same model supplemented with some aspects of financial frictions can account for the stylized facts better than the baseline model. As a simple way to reflect financial frictions, I suppose that the domestic real interest rate depends either on the expected (transitory) productivity shock or on the exogenous risk premium shock. I call the former the endogenous risk premium channel and the latter the exogenous risk premium channel. Simulation results suggest that the endogenous risk premium channel performs marginally better than the baseline RBC model with recursive utility in describing the stylized facts in Korean business cycles. In particular, it implies that the trade balance and the real interest rate are more countercyclical than they are in the baseline model.

Though the results are encouraging, they are not very satisfactory. In particular, the correlations between output and the trade balance and/or the real interest rate are not strongly countercyclical. Thus, in future research it would be interesting to introduce various mechanisms and/or frictions into the model to see if they can improve the explanatory power of the simple RBC model. Another interesting line of future work would be explaining the labor market in emerging economies. Recently, Boz et al. (2012) argued that the RBC model with Mortensen-Pissarides type of search-matching frictions can explain labor market regularities in emerging economies. Extending the analysis presented here to a model with a labor decision to see if such a model can successfully explain the stylized facts in emerging economy business cycles including the labor market would also be interesting future work.
References


Table 1. Parameter values and the key moments from Bayesian estimation of the Korean economy: A simple RBC model with recursive utility

<table>
<thead>
<tr>
<th>Calibrated parameters</th>
<th>( g )</th>
<th>1.010754</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 1 + r )</td>
<td>1.01</td>
<td></td>
</tr>
<tr>
<td>( \gamma )</td>
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<td></td>
</tr>
<tr>
<td>( \beta )</td>
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<td></td>
</tr>
<tr>
<td>( \frac{tb}{y} )</td>
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<td></td>
</tr>
<tr>
<td>( \delta )</td>
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<tr>
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</tr>
<tr>
<td>( \phi )</td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th>Estimated parameters</th>
<th>Prior mean</th>
<th>Posterior mean</th>
<th>90 % C.I.</th>
<th>Prior distribution</th>
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</thead>
<tbody>
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<td>( \rho_a )</td>
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Log data density = 334.38

Observed variables in the estimation: \( y, r \)

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<thead>
<tr>
<th>Moments</th>
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<th>Simulation</th>
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<tr>
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<tr>
<td>( corr(r, y) )</td>
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<td>-0.07</td>
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Table 2. Parameter values and the key moments from Bayesian estimation of the Korean economy: A simple RBC model with CRRA utility

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<td>$\delta$</td>
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<tr>
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<td>$\phi$</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated parameters</th>
<th>Prior mean</th>
<th>Posterior mean</th>
<th>90 % C.I.</th>
<th>Prior distribution</th>
</tr>
</thead>
<tbody>
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Log data density = 308.94

Observed variables in the estimation: $y$, $r$

<table>
<thead>
<tr>
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Table 3. Parameter values and the key moments from Bayesian estimation of the Korean economy: The baseline model with financial frictions

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<th>Parameter</th>
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<tbody>
<tr>
<td>$\psi$</td>
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<td>Log data density</td>
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<td>$y, r, c$</td>
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<tr>
<td>Moments</td>
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<tr>
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<td>$\text{corr}(r, y)$</td>
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Figure 1. Real Interest Rates