Interest Arbitrage and Long-term Interest Rates in Korea*

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Abstract

The Bank of Korea has raised its policy rate by 1.75 %p since mid-2005 but yields on 3-year government bonds increased by just 1%p for the same period. There is a hypothesis that interest arbitrage, which happened when the covered interest rate parity condition was broken in 2006 and 2007, increased the demand for Korean bonds and, as a result, decreased long-term interest rates. We set up a small open DSGE model and estimate it using Bayesian methods to

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see whether the argument is right. The estimation results indicate that a decrease in the risk premium in the foreign exchange market, which is a necessary condition for interest arbitrage, is significantly associated with a decrease in long-term interest rates. In addition, the link between the foreign exchange market and the domestic bond market has been more strengthened since the Asian currency crisis.

Keywords: Small Open DSGE model, Interest Arbitrage, Risk Premium, Long-term Interest Rates

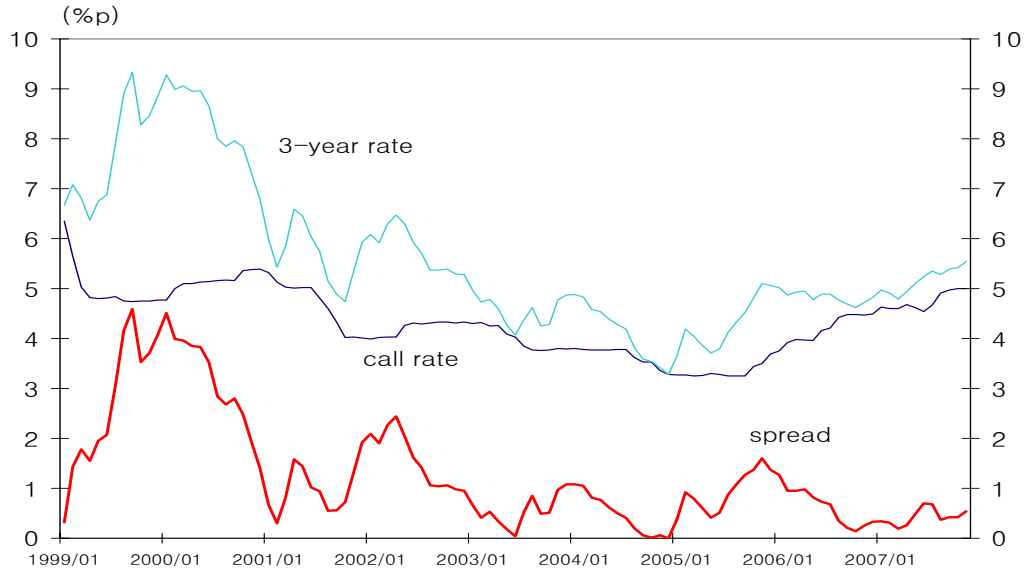
JEL Classification Codes: E43, E51, F41

1 Introduction

During the period from mid-2004 to mid-2006, when the Federal Reserve raised the federal funds rate steadily from 1% up to 5.25%, yields on 10-year Treasury bonds barely went up but rather lingered at around 4.5%. Alan Greenspan, the then-chairman of the Fed, described the unexpected situation as a "conundrum." South Korea has also witnessed a similar conundrum since mid-2005. The Bank of Korea raised the call rate, which is its policy rate, by 1.75 %p until mid-2007 but yields on 3-year government bonds increased by just about 1%p. Figure 1 shows that the long-term rate even fell in most of 2006.

One of the suspected reasons for the situation was interest arbitrage which involved buying Korean bonds. Interest arbitrage can occur when the covered

Figure 1: A Conundrum?



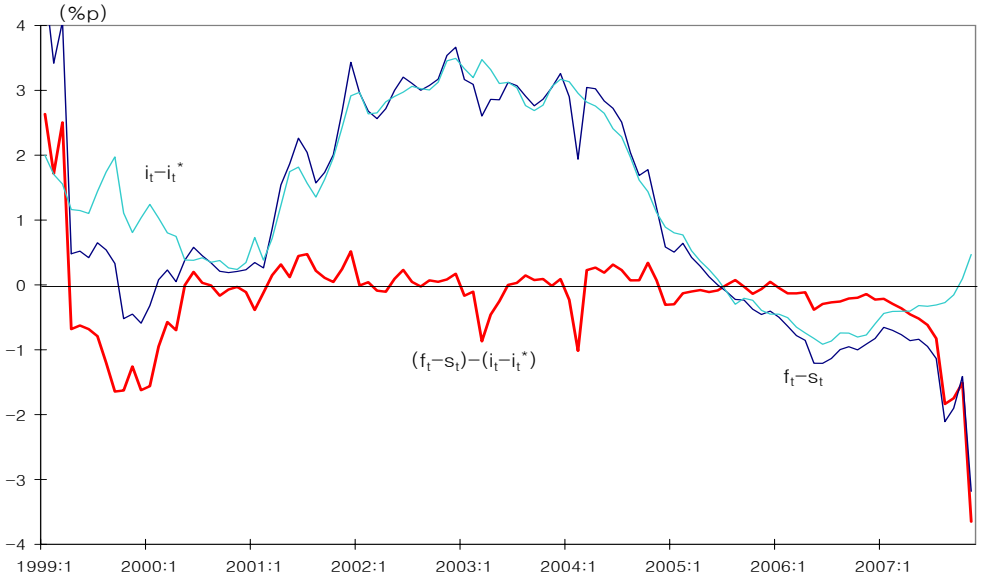
interest rate parity (CIRP) condition is broken. The condition posits that

$$i_t = i_t^* + f_t - s_t$$

where i_t is the home interest rate, i_t^* is the foreign interest rate, s_t is the log of the spot exchange rate measured as the home currency price of the foreign currency (Won/Dollar), and f_t is the log of the forward exchange rate. In 2006, the swap rate, which is $f_t - s_t$, fell sharply as Korea's exporting firms sold a large amount of dollars in the forward market (See Figure 2). This made Korean bonds more profitable and arbitragers took the advantage of the opportunity for riskless arbitrage gains.

One kind of interest arbitrage was done as follows: arbitragers, mainly banks, borrowed dollars at the rate of i_t^*, sold the dollars and bought the Korean currency, the won, at the swap rate of $f_t - s_t$ in the foreign exchange

Figure 2: Swap Rates and Interest Rates



Note: i_t is the 90-day CD rate in Korea, i_t^* is the 3-month LIBOR in dollars, s_t is the log of the spot exchange rate, and f_t is the log of the forward exchange rate in the NDF (non-deliverable forward) market.

swap market, and bought Korean bonds at the rate of i_t. Then the profit of the arbitrageur would be $i_t - i_t^* - f_t + s_t$. This trading activities tend to boost the swap rate and/or lower the home interest rate until the covered interest rate parity condition holds again.[1] The aim of this paper is to answer whether the interest arbitrage accounted for the decrease in long-term rates in Korea.

We set up a small open dynamic stochastic general equilibrium (DSGE)

[1]Even though there is evidence that banks did the interest arbitrage trading, the parity condition was not recovered for a long time. This might be due to regulations on foreign borrowing but this paper does not deal with it.

model and estimated it with Korean data using Bayesian methods. The main result of this paper is that the interest arbitrage was significantly associated with the decrease in long-term interest rates. This means that shocks in foreign exchange markets hindered long-term rates from increasing even when the Bank of Korea raised short-term interest rates.

For the recent several years, there have been much developments in the so-called New Open Economy Macroeconomics (NOEM) literature since Obstfeld and Rogoff (1995). Especially, Clarida, Gali and Gertler (2001), Gali and Monacelli (2005) and Monacelli (2003) developed now-standard open economy models incorporating the New Keynesian features as in Clarida, Gail and Gerler (1999) and Woodford (2003). While most of the works were theoretical ones, empirical analysis also started to be done by Adolfson et. al. (2005), Best (2006), Elekdag, Justiniano and Tchakarov (2005), Justiniano and Preston (2004), Bergin (2003), Lubik and Schorfheide (2003), Lubik and Schorfheide (2005), Dib (2003), and Ambler, Dib and Rebei (2003).

This paper is organized as follows. Section 2 sets up a small open economy model. Section 3 describes data and estimation results. Section 4 concludes.

2 A Small Open Economy Model

In this section, we set up a small open economy model with sticky prices and incomplete exchange rate pass-through, based on that of Monacelli (2003) which became now standard in the literature. We then incorporated the housing sector according to Yoo (2007), recognizing that housing plays an

important role in Korea's business cycles. Hereafter, foreign variables are denoted by a superscript asterisk (*).

2.1 Households

Households choose consumption, c_t, housing goods (or service), h_t, real balance, M_t/P_t, labor supply, l_t, one-period risk-free nominal bonds,[2] B_t and foreign bonds, B_t^*, to maximize the following objective function:

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, h_t, \frac{M_t}{P_t}, l_t\right).$$

The utility function is assumed to be

$$u\left(c_t, h_t, \frac{M_t}{P_t}, l_t\right) = \frac{1}{1-\omega_c} x_t^{1-\omega_c} + \frac{1}{1-\omega_m}\left(\frac{M_t}{P_t e_t}\right)^{1-\omega_m} - \chi l_t$$

where e_t is a money demand shock. x_t is a composite index given by

$$x_t = \left(\alpha^{\frac{1}{\eta}} c_t^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} (v_t h_t)^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}$$

where α is the share of consumption compared with housing goods, η is the elasticity of substitution between consumption and housing goods, and v_t is a housing demand shock. c_t is another composite consumption index of domestice goods, $c_{H,t}$, and foreign goods, $c_{F,t}$, given by

$$c_t = \left(\theta^{\frac{1}{\psi}} c_{H,t}^{\frac{\psi-1}{\psi}} + (1-\theta)^{\frac{1}{\psi}} c_{F,t}^{\frac{\psi-1}{\psi}}\right)^{\frac{\psi}{\psi-1}} \tag{1}$$

where θ is the share of domestic goods in the domestic consumption bundle and ψ is the elasticity of substitution between domestic and foreign goods.

[2] The asset market is assumed to be incomplete in this paper.

Let P_t be the price index of the price of consumption goods, $P_{c,t}$, and the price of housing goods, $P_{h,t}$, as

$$P_t = \left(\alpha P_{c,t}^{1-\eta} + (1-\alpha) P_{h,t}^{1-\eta}\right)^{\frac{1}{1-\eta}} \tag{2}$$

and $P_{c,t}$ be the consumer price index of the price of domestic goods, $P_{H,t}$, and the price of foreign goods, $P_{F,t}$, given by

$$P_{c,t} = \left(\theta P_{H,t}^{1-\psi} + (1-\theta) P_{F,t}^{1-\psi}\right)^{\frac{1}{1-\psi}} \tag{3}$$

The budget constraint of the households is as follows:

$$\begin{aligned} & P_{c,t}c_t + P_{h,t}h_t + \frac{B_t}{R_t u_t} + \frac{S_t B_t^*}{R_t^* f(b_t) w_t} + M_t \\ \leq\ & W_t l_t + P_{h,t}h_{t-1} + B_{t-1} + S_t B_{t-1}^* + M_{t-1} + T_t + D_t \end{aligned} \tag{4}$$

for all $t = 0, 1, 2, \cdots$, where R_t, R_t^*, W_t, T_t, D_t, S_t are the (gross) nominal interest rate, the foreign interest rates, nominal wage, increment of money supply which is provided either by the central bank or by commercial banks, nominal dividend which are paid by the domestic firms, and the the exchange rate measured as the home currency price of the foreign currency, respectively. $f(b_t)$ denotes a endogenous risk premium term that domestic households have to pay when they borrow from the foreign country because the asset market is imperfect.[3] The risk premium is assumed to depend on the net foreign assets as follows:

$$f(b_t) = \exp(-\lambda b_t) \tag{5}$$

[3] The endogenous risk premium term can be considered the country risk premium.

where $b_t = \frac{S_t B_t^*}{P_{c,t} y_t}$ and $\lambda > 0$.[4] u_t is an external finance premium shock and w_t is an exogenous risk premium shock, both of which play a very important role in this paper and of which the meaning will be clarified later. The shocks are assumed to follow the following stochastic processes:

$$\ln(u_t) = \rho_u \ln(u_{t-1}) + \epsilon_{u,t} \tag{6}$$

$$\ln(w_t) = \rho_w \ln(w_{t-1}) + \epsilon_{w,t} \tag{7}$$

$$\ln(v_t) = \rho_v \ln(v_{t-1}) + \epsilon_{v,t} \tag{8}$$

$$\ln(e_t) = \rho_e \ln(e_{t-1}) + \epsilon_{e,t} \tag{9}$$

where $\epsilon_{u,t}$, $\epsilon_{w,t}$, $\epsilon_{v,t}$, and $\epsilon_{e,t}$ are i.i.d innovations which are normally distributed with the standard deviations σ_u, σ_w, σ_v, and σ_e, respectively.

Let $\pi_t = P_t/P_{t-1}$, $\pi_{c,t} = P_{c,t}/P_{c,t-1}$, $q_t = P_{h,t}/P_{c,t}$, $m_t = M_t/P_t$, $m_{c,t} = M_t/P_{c,t}$. Define $u_c(t)$, $u_h(t)$, $u_m(t)$, and $u_l(t)$ be the derivatives of the utility function with respect to the first to the fourth variable. Then, the first order conditions can be arranged into

$$u_c(t) = \beta R_t u_t E_t u_c(t+1) \frac{1}{\pi_{c,t+1}} \tag{10}$$

$$q_t = \frac{u_h(t)}{u_c(t)} + E_t \beta \frac{u_c(t+1)}{u_c(t)} q_{t+1} \tag{11}$$

$$u_m(t) = \frac{R_t u_t - 1}{R_t u_t} u_c(t) \times \left(\alpha + (1-\alpha) q_t^{1-\eta}\right)^{\frac{1}{1-\eta}} \tag{12}$$

$$u_c(t) = \beta R_t^* \frac{f(b_t)}{1+\lambda b_t} w_t E_t u_c(t+1) \frac{S_{t+1}}{S_t} \frac{1}{\pi_{c,t+1}} \tag{13}$$

$$\frac{\chi}{u_c(t)} = \frac{W_t}{P_{c,t}}. \tag{14}$$

[4] The specification ensures that a small open economy model has a unique steady state. See Schimitt-Grohé and Uribe (2003) for the details.

2.2 Domestic Producers

There are a continuum of monopolistically competitive domestic firms, indexed by $i \in [0, 1]$. Firm i hires labor from households and produces $y(i)$ by the following technology:

$$y_t(i) \quad = \quad z_t l_t(i) \tag{15}$$

where z_t is a productivity shock, which is assumed to follow the following stochastic process:

$$\ln(z_t) \quad = \quad \rho_z \ln(z_{t-1}) + \epsilon_{z,t}. \tag{16}$$

$\epsilon_{z,t}$ is an i.i.d innovation which is normally distributed with the standard deviation σ_z. The final product, y_t, is produced using $y_t(i)$ according to

$$y_t \quad = \quad \left(\int_0^1 y_t(i)^{\frac{\phi-1}{\phi}} di \right)^{\frac{\phi}{\phi-1}} \tag{17}$$

where $\phi > 0$.

Following Calvo (1983), let's assume that a fraction ω_H of firms cannot adjust their prices optimally in any period t. Then a firm i chooses $P_{H,t}(i)$ to maximize

$$E_t \sum_{k=0}^{\infty} \omega_H^k \beta^k \frac{u_c(t+k)}{u_c(t)} \frac{D_{H,t+k}(i)}{P_{H,t+k}} \tag{18}$$

where

$$\frac{D_{H,t+k}(i)}{P_{H,t+k}} = \frac{P_{H,t}(i)}{P_{H,t+k}} y_{t+k}(i) - \frac{MC_{H,t+k}}{P_{H,t+k}} y_{t+k}(i) \tag{19}$$

and

$$mc_{H,t} \equiv \frac{MC_{H,t}}{P_{H,t}} = \frac{W_t}{z_t}\frac{1}{P_{H,t}}. \tag{20}$$

The first order condition under a symmetric equilibrium is

$$E_t \sum_{k=0}^{\infty} \omega_H^k \beta^k \frac{u_c(t+k)}{u_c(t)} \left(P_{H,t}^{new} + \frac{\phi}{1-\phi} MC_{H,t+k} \right) P_{H,t+k}^{\phi-1} y_{t+k} = 0 \tag{21}$$

where $P_{H,t}^{new}$ is the newly-set equilibrium price. The domestic aggregate price index evolves according to

$$P_{H,t}^{1-\phi} = (1-\omega_H) P_{H,t}^{new\,1-\phi} + \omega_H P_{H,t-1}^{1-\phi}. \tag{22}$$

2.3 Domestic Importers

Retails firms also face a Calvo-style price-setting problem as domestic firms do in the previous section except that the marginal cost of the retail firm is $S_t P_{F,t}^*$. Since a fraction ω_F of firms cannot adjust their prices optimally in any period t, a retail firm i chooses $P_{F,t}(i)$ to maximize

$$E_t \sum_{k=0}^{\infty} \omega_F^k \beta^k \frac{u_c(t+k)}{u_c(t)} \frac{D_{F,t+k}(i)}{P_{F,t+k}} \tag{23}$$

where

$$\frac{D_{F,t+k}(i)}{P_{F,t+k}} = \frac{P_{F,t}(i)}{P_{F,t+k}} c_{F,t+k}(i) - \frac{MC_{F,t+k}}{P_{F,t+k}} c_{F,t+k}(i). \tag{24}$$

and

$$mc_{F,t} \equiv \frac{MC_{F,t}}{P_{F,t}} = \frac{S_t P_{F,t}^*}{P_{F,t}}. \tag{25}$$

The first order condition under a symmetric equilibrium is

$$E_t \sum_{k=0}^{\infty} \omega_F^k \beta^k \frac{u_c(t+k)}{u_c(t)} \left(P_{F,t}^{new} + \frac{\phi}{1-\phi} MC_{F,t+k} \right) P_{F,t+k}^{\phi-1} c_{F,t+k} = 0 \tag{26}$$

where $P_{F,t}^{new}$ is the newly-set equilibrium price. The import price index evolves according to

$$P_{F,t}^{1-\phi} = (1-\omega_F) P_{F,t}^{new\,1-\phi} + \omega_F P_{F,t-1}^{1-\phi}. \tag{27}$$

2.4 Monetary Policy

The central bank is assumed to adjust the short-term interest rate, R_t, following a Taylor-type rule:

$$R_t = R_{t-1}^{\alpha_r} y_t^{\alpha_y} \pi_{c,t}^{\alpha_\pi} e^{\epsilon_{r,t}} \tag{28}$$

where $\epsilon_{r,t}$ is an i.i.d innovation which is normally distributed with the standard deviation σ_r.

2.5 Foreign Country

The foreign country is large relative to the home country, which means that

$$c_{F,t}^* = c_t^* = y_t^* \tag{29}$$

$$P_{F,t}^* = P_t^* \tag{30}$$

$$c_{H,t}^* = \frac{\theta}{1-\theta} \left(\frac{P_{H,t}^*}{P_{F,t}^*} \right) y_t^*. \tag{31}$$

We also assume that the export price of the domestic goods is determined by

$$P_{H,t}^* = \frac{P_{H,t}}{S_t}. \tag{32}$$

2.6 Market Clearing

Finally, market clearing conditions are

$$y_t = \left(\theta^{\frac{1}{\psi}} c_{H,t}^{\frac{\psi-1}{\psi}} + (1-\theta)^{\frac{1}{\psi}} (c_{H,t}^*)^{\frac{\psi-1}{\psi}}\right)^{\frac{\psi}{\psi-1}} a_t \tag{33}$$

$$M_t = M_{t-1} + T_t \tag{34}$$

$$B_t = 0 \tag{35}$$

$$\frac{S_t B_t^*}{R_t^* f(b_t) w_t} = S_t B_{t-1}^* + P_{H,t} y_t - P_{c,t} c_t \tag{36}$$

where a_t is an expenditure shock, which is assumed to follow the following stochastic process:

$$\ln(a_t) = \rho_a \ln(a_{t-1}) + \epsilon_{a,t} \tag{37}$$

$\epsilon_{a,t}$ is an i.i.d innovation which is normally distributed with the standard deviation σ_a.

2.7 Linearized Version

Let's define the real exchange rate, $\xi_t \equiv \frac{S_t P_{c,t}^*}{P_{c,t}}$ and the law-of-one-price gap, $\zeta_t \equiv \frac{S_t P_{F,t}^*}{P_{F,t}}$. Let $\hat{n}_t \equiv \ln(n_t/n)$ where n is the steady state value of a variable n_t. Then the equations in the previous sections can be arranged to the following linearized equations.

From the households' maximization problem, an IS curve is derived as

$$\hat{c}_t = E_t \hat{c}_{t+1} - \frac{1}{\omega_{cc}}(\hat{R}_t - E_t \hat{\pi}_{c,t+1} + \hat{u}_t) - \frac{\omega_{ch}}{\omega_{cc}}(\hat{v}_t - E_t \hat{v}_{t+1}) \tag{38}$$

where $\omega_{cc} \equiv \alpha(\omega_c - 1/\eta) + 1/\eta$, $\omega_{ch} \equiv (1-\alpha)(\omega_c - 1/\eta)$. The external finance premium shock, u_t, represents the difference between the short-term

interest rate and the return on assets held by households, such as long-term bonds.[5] Even though the central bank raises the short-term rate, the effects of the action on consumption or inflation can be diminished by decreases in u_t. Smets and Wouters (2007) also has the similar shock in their model and interprets the shock as the external finance premium, which was modeled in Bernanke, Gertler and Gilchrist (1999) and Christiano, Motto and Rostagno (2004).

The house price is determined by

$$\begin{aligned} \hat{q}_t &= \beta E_t \hat{q}_{t+1} + \omega_{cc}(\hat{c}_t - \beta E_t \hat{c}_{t+1}) - (1-\beta)(\omega_{hc}\hat{c}_t + (\omega_{hh}-1)\hat{v}_t) \\ &\quad + \omega_{ch}(\hat{v}_t - \beta E_t \hat{v}_{t+1}) \end{aligned} \tag{39}$$

where $\omega_{hh} \equiv (1-\alpha)(\omega_c - 1/\eta) + 1/\eta$, $\omega_{hc} \equiv \alpha(\omega_c - 1/\eta)$.

The money demand function is derived as

$$\begin{aligned} \hat{m}_{c,t} &= -\frac{1}{(R-1)\omega_m}(\hat{R}_t + \hat{u}_t) + \frac{\omega_{cc}}{\omega_m}\hat{c}_t + \left(1 - \frac{1}{\omega_m}\right)(1-\alpha)\hat{q}_t \\ &\quad + \frac{\omega_{ch}}{\omega_m}\hat{v}_t + \left(1 - \frac{1}{\omega_m}\right)\hat{e}_t. \end{aligned} \tag{40}$$

Two points are worthy of noting in the money demand function. First, the house price is one of the determinants of money demand, as explained Yoo (2007). Second, money demand depends on the long-term interest rate, $\hat{R}_t + \hat{u}_t$, not just on the short-term rate, $\hat{R}_t$.

The uncovered interest rate parity condition is also obtained as

$$\hat{R}_t + \hat{u}_t = \hat{R}_t^* + E_t\hat{S}_{t+1} - \hat{S}_t + \hat{w}_t - \lambda'\hat{b}_t \tag{41}$$

[5] The external finance premium shock can be understood as the difference between the short-term rate and the bank loan rate.

where $\lambda' \equiv \lambda b(2+\lambda b)/(1+\lambda b)$ and b is the steady state value of b_t. To understand the meaning of $\hat{w}_t$, let

$$\hat{F}_t = E_t \hat{S}_{t+1} + \hat{w}_t$$

and substitute it into the following covered interest rate parity condition,

$$\hat{R}_t + \hat{u}_t = \hat{R}_t^* + \hat{F}_t - \hat{S}_t - \lambda' \hat{b}_t$$

where F_t is the forward rate. Then we have the same equation as the above, which means that $\hat{w}_t$ can be regarded as the risk premium in the foreign exchange market. We assume that interest arbitrage, which envolves buying domestic bonds, occurs when the risk premium shock, $\hat{w}_t$, is negative. However, that is not enough to generate interest arbitrage because the net foreign asset, $\hat{b}_t$, will be negative and, as a result, the risk premium, $-\lambda'\hat{b}_t$, positive when $\hat{w}_t$ is negative. Therefore, we are going to see whether $\hat{u}_t$ decreases when $\hat{w}_t - \lambda'\hat{b}_t$ falls to show that interest arbitrage lowered long-term rates.

The Phillips curve in the economy is given by

$$\hat{\pi}_{c,t} = \beta E_t \hat{\pi}_{c,t+1} + \theta \kappa_H \widehat{mc}_{H,t} + (1-\theta)\kappa_F \hat{\zeta}_t \tag{42}$$

where

$$\kappa_H \equiv \frac{(1-\omega_H)(1-\beta\omega_H)}{\omega_H}$$

$$\kappa_F \equiv \frac{(1-\omega_F)(1-\beta\omega_F)}{\omega_F}$$

$$\widehat{mc}_{H,t} = \omega_{cc}\hat{c}_t + \omega_{ch}\hat{v}_t + \frac{1-\theta}{\theta}(\hat{\xi}_t - \hat{\zeta}_t) - \hat{z}_t.$$

The equation for the law-of-one-price gap is

$$\begin{aligned}(1+\beta+\kappa_F)\hat{\zeta}_t &= \beta E_t\hat{\zeta}_{t+1}+\hat{\zeta}_{t-1}+\hat{\pi}_{c,t}-\beta E_t\pi_{c,\hat{t}+1} \\ &\quad +(1+\beta)\hat{\xi}_t-\beta E_t\hat{\xi}_{t+1}-\hat{\xi}_{t-1}. \end{aligned} \tag{43}$$

The monetary policy can be described as

$$\hat{R}_t=\alpha_r\hat{R}_{t-1}+\alpha_y\hat{y}_t+\alpha_\pi\hat{\pi}_{c,t}+\epsilon_{r,t}. \tag{44}$$

For the foreign variables, we assumed that

$$\hat{y}_t^* = \rho_{y^*}\hat{y}_{t-1}^*+\epsilon_{y^*,t} \tag{45}$$

$$\hat{\pi}_t^* = \rho_{\pi^*}\hat{\pi}_{t-1}^*+\epsilon_{\pi^*,t} \tag{46}$$

$$\hat{R}_t^* = \rho_{r^*}\hat{R}_{t-1}^*+\epsilon_{r^*,t}. \tag{47}$$

Finally, from goods market equilibrium, we have

$$\hat{y}_t = \theta\hat{c}_t+\psi\frac{(1-\theta^2)}{\theta}(\hat{\xi}_t-\hat{\zeta}_t)+\psi(1-\theta)\hat{\zeta}_t+(1-\theta)\hat{y}_t^*+\hat{a}_t. \tag{48}$$

3 Empirical Analysis

3.1 Data and Estimation Method

For the domestic variables, we used Korea's GDP, consumption, CPI, House Prices Index by Kookmin Bank, the 91-day CD rate, Lf(or M3), and the Won/Dollar exchange rate. For the foreign variables, America's GDP, CPI, and the 3-month Treasury bill rate were chosen. The samples run from 1991:Q1 to 2007:Q3. All series were detrended using the HP filter.

Before estimation, some parameters were calibrated: $\beta = 0.99$ as many papers did, $\alpha = 0.85$ based on the ratio of contruction to GDP, and $\theta = 0.6$ considering the ratio of imports to GDP. The parameters for the foreign variables were estimated by OLS. For the other parameters were estimated by Bayesian methods and the priors were chosen as in Table 1 and 2. The posterior distributions were obtained by Markov Chain Monte Carlo (MCMC) methods.

3.2 Estimation Results

To see whether interest arbitrage lowered long-run interest rates, we decompose the external finance premium shock, $\hat{u}_t$, into

$$\hat{u}_t = \hat{\nu}_t + \gamma(\hat{w}_t - \lambda'\hat{b}_t) \tag{49}$$

where

$$\ln(\nu_t) \quad = \quad \rho_\nu \ln(\nu_{t-1}) + \epsilon_{\nu,t}$$

and $\epsilon_{\nu,t}$ is an i.i.d innovation which is normally distributed with the standard deviation σ_ν.

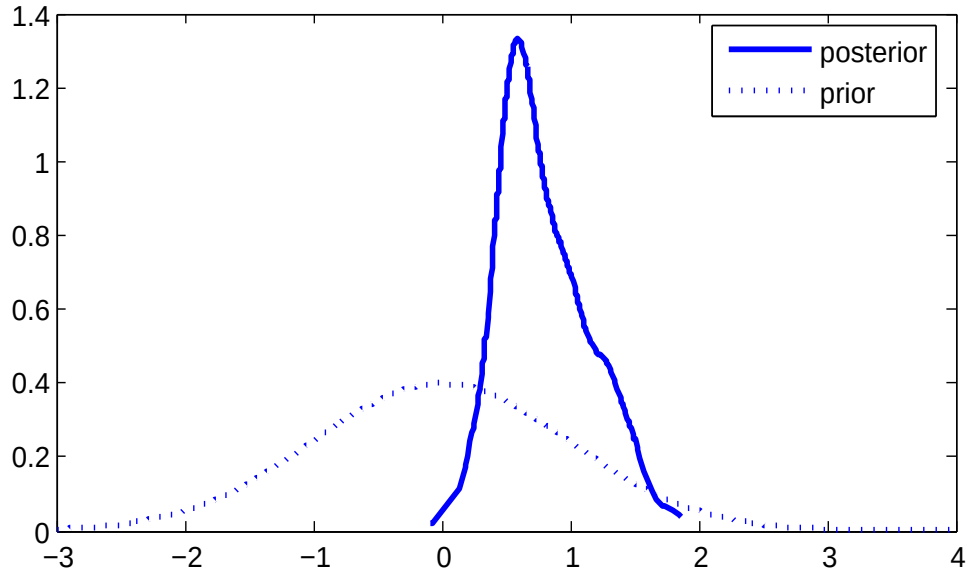
A significantly positive γ would mean that when the risk premium, $\widehat{rp}_t \equiv \hat{w}_t - \lambda'\hat{b}_t$, is negative and, as a result, interest arbitrage occurs, long-run interest rates also decrease.

Table 1 and 2 show that all the estimates look reasonable and consistent to other studies. γ, the key parameter in this paper, is estimated to be

significantly positive, as shown in Figure 3. Therefore, we can conclude that interest arbitrage lowered long-run interest rates.

Figure 4 graphs the estimated $\hat{u}_t$ and $\widehat{rp}_t$ to show that how much the two elements are related. Before the Asian financial crisis, the external finance premium shock and the risk premium showed little relationship. However, since 1999, two process have moved very closely. Especially in 2006, almost all the variations in long-term rates can be accounted for the changes in the risk premium.

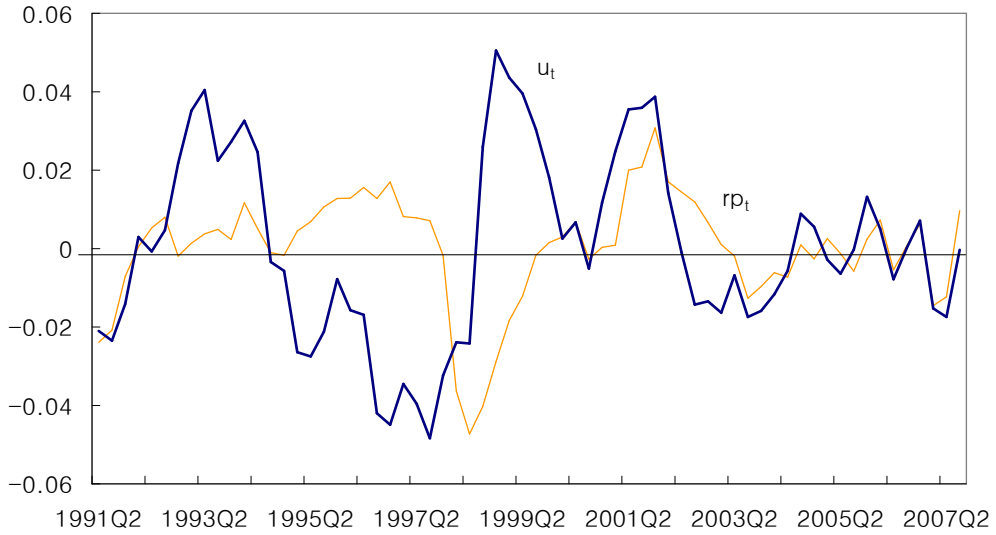
Figure 3: Posterior for γ



4 Conclusion

When a central bank raises its policy rate and long-term interest rates do not increase, the effect of monetary policy on the economy would be limited. The

Figure 4: External Finance Premium and Risk Premium



Note: The external finance premium shock is $\hat{u}_t = \hat{\nu}_t + \gamma \widehat{rp}_t$ and the risk premium is $\widehat{rp}_t \equiv \hat{w}_t - \lambda' \hat{b}_t$.

Bank of Korea has witnessed the phenomenon from mid-2005 to 2007 and one of the suspected reasons was interest arbitrage which involved buying Korean bonds.

We set up a small open dynamic stochastic general equilibrium (DSGE) model and estimated it with Korean data using Bayesian methods. The main result of this paper is that the interest arbitrage was significantly associated with the decrease in long-term interest rates. This means that shocks in foreign exchange markets hindered long-term rates from increasing even when the Bank of Korea raised short-term interest rates.

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Table 1: Estimation Results 1

	Prior			Posterior	
	Distr	Para(1)	Para(2)	mean	95% HPDI
ω_c	Gamma	6	0.4	0.2937	[0.1190 , 0.4950]
$1/\omega_m$	Gamma	2	0.4	0.0055	[0.0001 , 0.0121]
η	Gamma	2	0.4	0.8414	[0.5265 , 1.2789]
ψ	Gamma	6	0.4	1.0267	[0.7017 , 1.3575]
ω_H	Beta	8	4	0.7072	[0.5681 , 0.8260]
ω_F	Beta	8	4	0.5080	[0.1165 , 0.8722]
α_r	Beta	10	2	0.7738	[0.6028 , 0.9386]
α_π	Gamma	2	0.4	0.3166	[0.2213 , 0.4106]
α_y	Gamma	2	0.4	1.0907	[0.7819 , 1.4266]
λ	Gamma	2	0.4	0.1203	[0.1155 , 0.1242]
γ	Normal	0	1	0.7998	[0.2246 , 1.5018]

Note: Para(1) and Para(2) respectively indicate the mean and the standard deviation of a normal distribution and α and β of $p_G(x|\alpha,\beta) \propto x^{\alpha-1}e^{-x/\beta}$ in case of a gamma distribution, of $p_B(x|\alpha,\beta) \propto x^{\alpha-1}(1-x)^{\beta-1}$ in case of a beta distribution, of $p_{IG}(x|\alpha,\beta) \propto x^{-\alpha-1}(1-x)^{\beta-1}$ in case of a inverted gamma distribution.

Table 2: Estimation Results 2

	Prior			Posterior	
	Distr	Para(1)	Para(2)	mean	95% HPDI
ρ_a	Beta	10	2	0.5697	[0.3973 , 0.7465]
ρ_v	Beta	10	2	0.7114	[0.5937 , 0.8216]
ρ_e	Beta	10	2	0.8989	[0.8197 , 0.9783]
ρ_w	Beta	10	2	0.9033	[0.8343 , 0.9766]
ρ_z	Beta	10	2	0.2589	[0.1757 , 0.3472]
ρ_ν	Beta	10	2	0.8521	[0.7576 , 0.9518]
σ_a	Inverted Gamma	3	5000	0.0240	[0.0190 , 0.0289]
σ_v	Inverted Gamma	3	5000	0.2106	[0.1105 , 0.3479]
σ_e	Inverted Gamma	3	500000	0.0064	[0.0054 , 0.0075]
σ_w	Inverted Gamma	3	500000	0.0094	[0.0038 , 0.0167]
σ_z	Inverted Gamma	3	5000	0.8337	[0.2253 , 1.5802]
σ_ν	Inverted Gamma	3	5000	0.0124	[0.0097 , 0.0156]
σ_r	Inverted Gamma	3	5000	0.0159	[0.0121 , 0.0205]

Note: Para(1) and Para(2) respectively indicate α and β of $p_G(x|\alpha,\beta) \propto x^{\alpha-1}e^{-x/\beta}$ in case of a gamma distribution, of $p_B(x|\alpha,\beta) \propto x^{\alpha-1}(1-x)^{\beta-1}$ in case of a beta distribution, of $p_{IG}(x|\alpha,\beta) \propto x^{-\alpha-1}(1-x)^{\beta-1}$ in case of a inverted gamma distribution.