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Inspecting Monetary Policy Rules in a Small Open Economy with Financial Frictions

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In this paper, we address how the monetary authority should react to financial market status and exchange rate movements in a small open economy New Keynesian model with financial frictions due to asymmetric information between savers and borrowers. We show that the small economy with financial frictions is more susceptible to the exogenous shocks under the fixed exchange rate regime than under the flexible exchange regime. The small economy experiences a more prolonged and deeper economic recession under the fixed exchange rate regime than under the flexible exchange rate regime. The small economy experiences a more prolonged and deeper economic recession under the fixed exchange rate regime than under the flexible exchange rate regime. The monetary policy taking into account external finance premium is better than the interest rate rule without considering the financial market status.

Keywords: Financial Frictions, Monetary Policy, Small Open Economy, Welfare Loss

JEL Classification: E52, F41

I. Introduction

The recent financial crises have raised questions on how the monetary authority should implement its policy rate not only for the advanced economies, but also for the emerging economies. Should the monetary authority take into account other macroeconomic variables such as international relative prices and financial market conditions, in addition to the domestic output gap stability and domestic price stability? To address the issue, many authors have suggested economic models with financial

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Yongseung Jung

market frictions as well as goods market frictions which are more useful in analyzing the propagation mechanism of monetary policy over the business cycles. There is a vast theoretical and empirical literature that has analyzed the causes of the recent financial crisis and the transmission and effects of monetary and fiscal policy on aggregate fluctuations. The development of a richer New Keynesian model has improved our understanding on aggregate fluctuations and monetary policy in the presence of incomplete markets and borrowing constraints.

Notwithstanding emerging market economies such as China and India are becoming prominent in the global economy, the international finance literature still focusses on the causes and effects of financial crisis in advanced countries. Taking into account the importance of the emerging economies in the world economy, a foremost important research direction to be followed is to explore the effect of monetary policy on aggregate fluctuations and welfare in emerging market economies by setting up appropriate economic models with goods and financial market frictions to compare welfare associated with alternative monetary policy rules.

Under the recent financial and economic turmoil, many policy makers in emerging economies who think that there exists a trade-off between inflation and output stability ask questions about the desirable form of the monetary policy. Even though many emerging economies have adopted flexible exchange rate regimes, there is still a big controversy over whether the monetary authority should consider the impact of exchange rate movements on domestic economy when it implements its monetary policy. Are the stability of financial markets and the stable exchange rate movements important when the domestic economy is augmented with financial frictions? If so, how should the monetary authority manipulate its policy rate to improve its own welfare?

Many papers such as Clarida et al. (2000), Lubik and Schorfheide (2007), and Svensson (2000) have explored the role of the international relative price stability in monetary policy formulation. Clarida et al. (2000) show that the optimal monetary policy problem in an open economy is isomorphic to that of a closed economy. However, the theoretical literature has not given a conclusive answer to this question. De Paoli (2009) argues that the exchange rate pegging policy can be desirable for a high degree of trade elasticity between home and foreign goods. Lubik and Schorfheide (2007) estimate the monetary policy rules in developed small open economies and find that the monetary authorities in the UK and Canada considered exchange rate movements whereas the monetary authorities in Australia and New Zealand did not. To address these questions in economies with financial frictions, we set up a small open economy New Keynesian model with financial frictions due to asymmetric information between savers and borrowers along the line of Bernanke et al. (1999). Considering the empirical fact that the financial frictions as well as the goods market frictions are important in our understanding about the effects of monetary policy on aggregate fluctuations in emerging economies as well as in advanced economies, we need set up an economic model which features the goods and financial market frictions with efficient and inefficient shocks. Then, we use the benchmark model to seek to understand the desirable simple monetary policy by studying the mechanism through which monetary policy affects on the aggregate fluctuations.

Specifically, we set up a multi-sector small open economy model with financial frictions to explore the effects of alternative monetary policy rules on the economy when the economic structure of small open economies is susceptible to the various kinds of shocks. To consider more seriously the financial frictions such as external finance premium, we also introduce a country risk premium in the international finance market by assuming that the international borrowing interest rate decreases with its own net foreign asset holdings. In particular, we will explore whether the monetary authorities should respond to other target variables, in addition to the typical target variables such as the output gap and domestic inflation when the economic structure of small open economies is susceptible to the internal and external shocks. We will also quantify the effect of monetary policy on the economy by comparing welfare and variations of key aggregate variables associated with alternative simple monetary policy rules. For this purpose, we will consider the general interest rate rules and analyze the role of the entrepreneur's net worth as well as the external risk premium which are critical in welfare as well as in the transmission of monetary policy rules.

The main findings of this paper can be summarized as follows.

First, the small economy with financial frictions is more susceptible to efficient and inefficient shocks such as the productivity and country risk premium shocks under the fixed or pegged exchange rate regime than under the flexible exchange regime. For example, the domestic monetary authority cannot implement an independent monetary policy by passively raising its interest rate substantially to match the exogenously increased foreign interest rate under the fixed exchange rate regime if the country premium shock hits the economy. Under this circumstance, the domestic economy has to experience a more prolonged and deeper economic recession under the fixed exchange rate regime than under the flexible exchange rate regime.¹

Second, domestic price stability is still desirable, while the exchange rate pegging is worst among the considered simple monetary policy rules in the small open economy New Keynesian model with financial frictions. Since domestic households own domestic firms whose dividends or profits move inversely with domestic relative price distortions, the monetary authority needs to maintain price stability which contributes to minimize domestic relative price distortions under the staggered price setting circumstances. There is no independent monetary policy to deal with inefficient resource allocations associated with relative goods distortions and undesirable international capital flows under the pegged exchange regime.

Finally, the interest rate rule that considers external finance premium is marginally better than the interest rate rule without any consideration of financial market conditions in welfare dimension. Since the external finance premium of domestic firms are closely interconnected with international capital markets, the monetary policy considering external finance premium is more successful in moderating international capital flows than the interest rate rule without any consideration of financial market status when capital control policy is not implemented to deal with excessive capital flows.

The paper is structured as follows. Section II describes a small open economy model with financial market frictions and risk premium shock. Section III derives equilibrium conditions, and section IV presents the quantitative results as well as welfare under alternative monetary policy rules. Section V concludes the paper.

II. The Model

This section sets up a variant of new Keynesian model with habit formation applied to open-economy. The world is composed of home (H) and foreign (F) country with population size n and 1-n, respectively. In this paper, the small open economy is characterized by assuming that the relative size of domestic economy is negligible relative to the rest of the world, i.e. by $n \rightarrow 0$ as in Faia and Monacelli (2008) and Galí and Monacelli (2005).

¹ It is desirable to address whether there still occurs the welfare reversal between the flexible exchange rate regime and the pegged exchange rate regime in the economy with inefficient risk premium shocks, in addition to markup shocks.

1. Households

Assume that a typical household of domestic economy maximizes one's utility function throughout lifetime subject to a sequence of budget constraints:

$$E_t[\sum_{k=0}^{\infty} \beta^k u(C_{t+k}, H_{t+k})], \quad 0 < \beta < 1$$
 (1)

where

 $u(C_{t+k}, H_{t+k}) = \frac{(C_{t+k} - b\tilde{C}_{t+k-1})^{1-\sigma} - 1}{1-\sigma} - \frac{H_{t+k}^{1+\upsilon}}{1+\upsilon} \quad \text{for} \quad \sigma \neq 1,$ and $u(C_{t+k}, H_{t+k}) = \ln(C_{t+k} - b\tilde{C}_{t+k-1}) - \frac{H_{t+k}^{1+\nu}}{1+\nu}$ for $\sigma = 1$. β is the household's time discount factor.

Here σ^{-1} is the intertemporal elasticity of substitution in consumption and v^{-1} is the elasticity of labor supply to real wage rate. β is the household's discount factor, and C_t , H_t represent the household's consumption for composite goods, work hours at time *t*, respectively, and $0 \le b \le 1$ denotes the degree of external habit persistence.

To make the discussion more concrete, a specific CES consumption index is assumed as follows:

$$C_{t} = \left[(1 - \gamma)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \qquad \eta > 0.$$
(2)

where $\gamma = (1 - n)\theta$ is the share of domestic consumption allocated to imported goods and $\eta > 0$ is the elasticity of substitution between home and foreign goods.

In similar, Foreign CES consumption index is assumed as

$$C_{t}^{*} = \left[(1 - \gamma^{*})^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} + \gamma^{*\frac{1}{\eta}} C_{H,t}^{*\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}},$$
(3)

where $\gamma_t^* = n\theta^*$.² To consider home bias in consumption, it is assumed that

$$(1 - \gamma) > \gamma^*. \tag{4}$$

² Foreign values of the corresponding domestic variables will be denoted by an asterisk (*).

Yongseung Jung

Here $C_{H,t}$ and $C_{F,t}$ are indices of consumption of domestic and foreign goods which are given by the following CES aggregators of the consumed amounts of each type of good:

$$C_{H,t} = \left[\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad C_{F,t} = \left[\int_0^1 C_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad \varepsilon > 1 \quad (5)$$

where ε measures the elasticity of substitution among goods within each category. In this context, the consumer price index is given by

$$P_t = [(1 - \gamma)P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta}]^{\frac{1}{1-\eta}}.$$
(6)

Here $P_{H,t}$ and $P_{F,t}$ denote the price of domestic goods and imported foreign goods in domestic currency unit in period *t*, given by

$$P_{H,t} = \left[\int_0^1 P_{H,t}(j)^{1-\varepsilon} dj\right]^{\frac{1}{1-\varepsilon}}, \quad P_{F,t} = \left[\int_0^1 P_{F,t}(j)^{1-\varepsilon} dj\right]^{\frac{1}{1-\varepsilon}}.$$
 (7)

Suppose that there exists incomplete asset market in the economy. Let $B_{H,t}$ and $B_{F,t}$ denote the outstanding amount of domestic-currency and foreign-currency debt held by the domestic residents in period *t*, and R_t and R_t^* be the corresponding nominal interest rate in period *t*. Then the household's wealth in the beginning of the period *t* is given by

$$P_t C_{H,t} + \frac{B_{H,t}}{R_t} + \frac{\mathcal{E}_t B_{F,t}}{R_t^* \Psi_t \mathcal{F}\left(\frac{\mathcal{E}_t B_{F,t}}{P_t}\right)} \le B_{H,t-1} + \mathcal{E}_t B_{F,t-1} + W_t (1 - \tau_t) H_t + P_t \Pi_t + P_t \Gamma_t$$

$$(8)$$

where W_t , Π_t , and Γ_t denote the domestic nominal wage rate, profits from firms, and lump-sum taxes (or transfers) in the domestic currency, respectively, in period *t*. $\mathcal{F}\left(\frac{\mathcal{E}_t B_{F,t}}{P_t}\right)$ represents the cost or the risk premium from international borrowings and \mathcal{E}_t denotes the nominal exchange rate at time *t*. The risk premium $\mathcal{F}(0)=1$ and it is increasing with the country's foreign debt, i.e. $\mathcal{F}'(.)<0$ around $\mathcal{B}_F = 0$. Following Farhi and Werning (2014), we introduce the risk premium shock Ψ_t to address the desirable monetary policy rule. We assume that the risk premium shock follows an AR(1) process as $\log \Psi_t = \rho_{\psi} \log \Psi_{t-1} + \xi_{\psi,t}, -1 < \rho_{\psi} < 1$, where $E[\xi_{\psi,t}] = 0$ and is i.i.d. over time. In the foreign country, households face an identical problem to the one outlined above except that they can lend or borrow at the risk-free interest nominal rate R_t^* . When it is assumed a small-country economy, a negligible weight is assigned to consumption goods produced in the small economy ($\theta_t^* = 1$). Therefore, $P_t^* = P_{F,t}^*$ and $C_t^* = C_{F,t}^*$ for all t in the small country case.

2. First Order Conditions

Consider the first order conditions for the household with external habit:

$$(C_t - bC_{t-1})^{-\sigma} = \Lambda_{t_s}^{3}$$
(9)

$$H_t^{\nu} = \Lambda_t (1 - \tau_t) w_t, \tag{10}$$

where Λ_t is the Lagrange multiplier of the budget constraint. Plugging (9) into (10), the labor supply function follows:

$$(C_t - bC_{t-1})^{\sigma} H_t^{\nu} = (1 - \tau_t) w_t, \tag{11}$$

where $w_t = W_t/P_t$ is the real wage in period *t*. (11) states that the marginal utility of leisure evaluated with the marginal utility of the consumption equals the tax-adjusted real wage rate, where the marginal utility of consumption represents the wealth effect on labor supply. Note that the households with external habit persistence in consumption work harder without taking into account their behavior on the economy, generating undesirable effects on the economy. Under this circumstance, they will experience a lower purchasing power and welfare, amplified by the excessive production due to envy.

³ For the marginal utility of consumption to be positive, $(1-b)(1+v) > \frac{\varepsilon-1}{\varepsilon(1-\tau)}$ must hold at the steady state.

Yongseung Jung

The optimization conditions of domestic and foreign yield

$$(C_t - bC_{t-1})^{-\sigma} = \beta E_t \left[(C_{t+1} - bC_t)^{-\sigma} R_t \frac{P_t}{P_{t+1}} \right], \tag{12}$$

$$(C_t - bC_{t-1})^{-\sigma} = \beta R_t^* \Psi_t \mathcal{F}(\frac{\mathcal{E}_t B_{F,t}}{P_t}) E_t \left[(C_{t+1} - bC_t)^{-\sigma} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \frac{P_t}{P_{t+1}} \right].$$
(13)

Equation (12) refers to the optimal choice of domestic currency denominated bonds, while equation (13) represents the optimal choice of foreign currency denominated bonds. Similarly, the foreign household's intertemporal decision of bond holdings is given by

$$(C_t^* - bC_{t-1}^*)^{-\sigma} = \beta E_t \left[(C_{t+1}^* - bC_t^*)^{-\sigma} R_t^* \frac{P_t^*}{P_{t+1}^*} \right].$$
(14)

(13) and (14) imply that the equilibrium real exchange rate Q_t is determined by

$$E_t \left[\left(\frac{C_{t+1}^* - bC_t^*}{C_t^* - bC_{t-1}^*} \right)^{-\sigma} \frac{P_t^*}{P_{t+1}^*} \right] = \Psi_t \mathcal{F}(\mathcal{E}_t \mathcal{B}_{F,t}) E_t \left[\left(\frac{C_{t+1} - bC_t}{C_t - bC_{t-1}} \right)^{-\sigma} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \frac{P_t}{P_{t+1}} \right], \quad (15)$$

where $Q_t \equiv \mathcal{E}_t P_t^* / P_t$ and $\mathcal{B}_{F,t} \equiv \mathcal{E}_t B_{F,t} / P_t$ represent the real exchange rate and the real net foreign asset holdings in period *t*. The log-linearization of (15) with (12) and (14) shows that the expected depreciation of the nominal exchange rate is determined by the net foreign asset as well as by the difference of the domestic and foreign interest rate:

$$E_t[\Delta lnQ_{t+1}] = (\tilde{r}_t - \tilde{r}_t^*) - \eta_F \mathcal{B}_{F,t}, \tag{16}$$

where \tilde{r}_t and \tilde{r}_t^* denote the domestic and foreign net real interest rate in period *t*, respectively and η_F is the sensitivity of intermediation cost or risk premium with respect to the net foreign asset positions. Next, note that the terms of trade defined as the price of foreign goods in terms of home goods is given by $S_t \equiv P_{F,t}/P_{H,t}$. Then, the real exchange rate Q_t can be written as

$$Q_t = \mathcal{S}_t \frac{P_{H,t}}{P_t}.$$
(17)

122

3. Manufacturing Firms

(1) Domestic firms

Labor and capital services are free to move between firms and factor prices are assumed to be fully flexible. Individual firms therefore have an identical cost function for producing output, so long as they have a constant return to scale technology. The production function of domestic firm *j* is given by

$$Y_t(j) = A_t K_t(j)^{\varphi} H_t(j)^{1-\varphi},$$
(18)

where A_t is the domestic transitory technology process in period t. $Y_t(j)$, $K_t(j)$ and $H_t(j)$ are the output, capital and labor input of the *j*th firm, respectively. We assume that the technology shock follows an AR(1) process:

 $\log A_t = \rho_A + \log A_{t-1} + \xi_{A,t}$, $-1 < \rho_A < 1$, where $E[\xi_{A,t}] = 0$ and $\xi_{A,t}$ is i.i.d. over time.

Demands for capital and labor are determined by a cost minimization

$$R_{k,t} = \varphi M C_t \frac{Y_t(j)}{K_t(j)},\tag{19}$$

$$w_t = (1 - \varphi) M C_t \frac{Y_t(j)}{H_t(j)},$$
(20)

where MC_t the nominal marginal cost and $R_{k,t}$ is the nominal rental rate of capital.

Next, consider a discrete time version of the Calvo (1983)-style staggered price setting rule with producer currency pricing. Suppose that firms set prices in the currency of the producer in both home and foreign markets. The monopolistically competitive firms in the domestic goods markets set their own price by maximizing the present discounted value of profits. Suppose that only the fraction $(1-\alpha)$ of the firms sets the new price, $\overline{P}_{H,t}$ to home consumers and the other fraction of firms, α , sets its current price at its previous price level. Let $Y_{t,t+k}(j)$ and $P_{Ht,t+k}$ denote the domestic demand in period t+k of firm j that set its price in period t and the price in period t+k that is predetermined in period t, respectively.

Since the probability that the firm sets its new price optimally is $(1-\alpha)$ in discrete time version of Calvo (1983) model, and this probability of setting new price level for

Yongseung Jung

each firm is independent of the time elapsed, the firm's maximization problem can be set up as follows:

$$max. E_t \Big[\sum_{k=0}^{\infty} \alpha^k \Xi_{t,t+k} [\bar{P}_{H,t} Y_{t,t+k}(j) - MC_{t+k} Y_{t,t+k}(j)] \Big], \qquad (21)$$

subject to

$$Y_{t,t+k}(j) = \left(\frac{\bar{P}_{H,t}}{P_{H,t+k}}\right)^{-\varepsilon} Y_{t+k},$$

where $P_{Ht,t+k} = \overline{P}_{H,t}$ with a probability of α^k , $\Xi_{t,t+k} \equiv \beta^k (\Lambda_{t+k} P_t) / (\Lambda_t P_{t+k})$, and Λ_{t+k} is the marginal utility of consumption in period t+k with $k=0,1,2,...,\infty$.

Finally, notice that the price level at period *t* under the Calvo-type staggered pricesetting can be expressed as

$$P_{H,t}^{1-\epsilon} = [(1-\alpha)\bar{P}_{H,t} + \alpha P_{H,t-1}]^{1-\epsilon}.$$
(22)

(2) Importing firms

In this section, we will consider the price-setting mechanism of the imported goods. Assume that the Law of One Price holds, the price of foreign good j in domestic currency $P_{F,t}(j)$ equals its price denominated in foreign currency $P_{F,t}^*(j)$ multiplied by the nominal exchange rate \mathcal{E}_t :

$$P_{F,t}(j) = \mathcal{E}_t P_{F,t}^*(j). \tag{23}$$

In the rest of the world, a representative household faces a problem identical to the one outlined above. Since the domestic economy is negligible in size, the weight to home produced consumption goods in the small economy equals zero, i.e. $\theta^* = 1$. Therefore, $P_t^* = P_{F,t}^*$ and $C_t^* = C_{F,t}^*$ for all *t*. The change in the exchange rate is perfectly reflected in the domestic price of the imported goods.

4. Financial Contract

In this paper, it is assumed that risk neutral entrepreneurs borrow to finance the capital used in the production process. The probability that an entrepreneur will survive until the next period is κ , so that the expected lifetime horizon equals $(1-\kappa)^{-1}$ as in Bernanke et al. (1999). This assumption is made to ensure that entrepreneurs' net wealth or the firm equity is not never enough to fully finance the new capital acquisition. Firms make debt contracts with financial intermediaries to finance their desired investment expenditure in excess of their net worth, N_t .

Entrepreneurs purchase capital K_{t+1} at the real price of $Q_{k,t}$ in the end of each period. The excess of their worth N_t is financed by issuing nominal bonds, B_{t+1} :

$$\frac{B_{t+1}}{P_t} = Q_{k,t} K_{t+1} - N_t.$$

The financial intermediaries obtain their funds from household's deposits and faces an opportunity cost of funds equal to the nominal riskless rate of return, R_t . The entrepreneurs' demand for capital is determined by the condition that the expected (real) marginal external financing cost $E_t[R_{t+1}^e]$ equals the marginal rate of return.

$$E_t[R_{t+1}^e] = E_t \left[\frac{\varphi_{K_t}^{\underline{Y}_t + (1 - \delta_k)Q_{k,t+1}}}{Q_{k,t}} \right],$$
(24)

where the right hand side represents the expected marginal return of capital.

Assume that there is an agency problem that makes external finance more expensive than internal finance. The borrowers can costless observe their output that is subject to random shocks, while the financial intermediaries incur a monitoring cost to observe the output. Only when the entrepreneurs default, the financial intermediaries monitor the loan and recover the project outcome, less auditing cost. Hence, the marginal external cost is equal to the sum of a gross premium for external funds and the riskless interest rate, the gross real opportunity cost. As Bernanke et al. (1999) show, the external finance premium varies inversely with the entrepreneur's net worth. That is, the external finance premium $\chi(.)$ can be expressed as an increasing function of the borrower's leverage ratio, $\frac{B_{t+1}/P_t}{N_t} = \frac{Q_{k,t}K_{t+1}}{N_t}$ -1. Therefore, the demand for capital

satisfies the following optimality condition:

$$E_t[R_{t+1}^e] = (1 + \chi_t) E_t[\frac{R_t P_{t+1}}{P_t}],$$
(25)

where $\chi_t = \chi\left(\frac{N_t}{Q_{k,t}K_{t+1}}\right)$, $\chi'(.) > 0, \chi(0) = 0$, and $\chi(\infty) = \infty$.

If the leverage ratio falls, the entrepreneurs rely on loans to a larger extent to finance the project. As the incentive to misreport the outcome of the project increases, the loan becomes riskier, increasing the loan rate higher. Due to the constant returns to scale production function and risk neutrality properties, all entrepreneurs choose the same leverage ratio, making the external finance premium to depend only on the aggregate leverage ratio. (25) represents the basis for the financial accelerator. If the price of capital $Q_{k,t}$ decreases, the leverage ratio increases, increasing the external finance premium.

The other key element of the financial accelerator is the evolution of entrepreneur's net worth, N_t . Assume that the exiting firms who go out of business make transfers T_t^e to new entering firms from their total worth. Denoting V_t the entrepreneur's capital net of borrowing cost carried over from the previous period, we can represent N_t as the weighted sum of V_t and T_t^e with the weights of surviving firms and newly entering firms, i.e. κ and 1- κ :

$$N_t = \kappa V_t + (1 - \kappa) T_t^e,$$

where

$$V_t = R_t^e Q_{k,t-1} K_t - (1 + \chi_t) \frac{R_{t-1}}{P_t / P_{t-1}} \frac{B_t}{P_{t-1}}$$

Since entrepreneurs going out of business in period t consume their remaining resources, the amount of the existing entrepreneurs consumption $C_t^e = (1 - \kappa)(V_t - T_t^e)$.

5. Capital Producers

Capital producers construct new capital combining the existing capital and new capital goods. Assume that there is no firm specific capital stock and firms incur an

adjustment cost in new capital stock installments as in Christiano et al. (2005). Each capital producer uses these inputs to produce new capital K_{t+1} employing the following production technology. Then the composite capital accumulation is given by

$$K_{t+1} = (1 - \delta_k)K_t + \Phi(I_t, I_{t-1}) = K_t + \left(1 - \frac{\gamma}{2} \left(\frac{I_t}{I_{t-1}}\right)^2\right)I_t, \quad (27)$$

where $\frac{Y}{2} \left(\frac{I_t}{I_{t-1}}\right)^2$ represents an adjustment cost in investment as in Christiano et al. (2005) and Schmitt-Grohéand Uribe (2006). I_t is the composite investment of the home resident at period *t*, and K_t is the composite capital stock of the home resident at period *t*. The capital producer chooses investment and capital stock to maximizes the expected discount value of profit:

$$\max E_t \left[\sum_{i=0}^{\infty} \beta^i \Lambda_{t+i} \left(Q_{k,t+i} K_{t+i} + \left(1 - \frac{\Upsilon}{2} \left(\frac{I_{t+i}}{I_{t+i-1}} \right)^2 \right) I_{t+i} \right) - Q_{k,t+i} I_{t+i} \right].$$

The optimal condition implies that

$$Q_{k,t}\Upsilon\left(\frac{l_t}{l_{t-1}}\right)\frac{l_t}{l_{t-1}} + \beta E_t\left[\frac{\Lambda_{t+1}}{\Lambda_t}Q_{k,t+1}\Upsilon\left(\frac{l_{t+1}}{l_t}\right)\frac{l_{t+1}}{l_t}\right] = 1.$$
(28)

6. Monetary Authority

There has been extensive debate over the most appropriate way to model monetary policy in the advanced economies as well as in the emerging economies. Recently, it is common to follow Taylor's recommendation of a simple interest rule or adopt a variant with an interest smoothing policy to evaluate the effect of the monetary policy.

In this paper, we employ various kinds of interest rate rules augmented with external finance premium to take into accounts financial market status as well as exchange rate movements to evaluate the effect of monetary policy on welfare and stability of key macroeconomic variables.

III. Equilibrium for the Small Open Economy

Aggregating individual output across firms yields

$$Y_t = \frac{A_t K_t^{\varphi} H_t^{1-\varphi}}{\Delta_{H,t}},\tag{29}$$

where $\Delta_{H,t} = \int_0^1 \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\varepsilon} di$ is the relative price dispersion in period *t*.

Assuming symmetric degree of home bias across countries with the negligible relative size of home country as in Faia and Monacelli (2008), goods market clearing in home and foreign countries requires that

$$P_{H,t}Y_t = P_t(C_t + I_t) + G_t,$$
(30)

where G_t is the demand for domestic consumption goods from the domestic government. The equilibrium condition for the foreign goods market is simply given by

$$Y_t^* = C_t^* + I_t^* + G_t^*. (31)$$

In the small open economy, net supply of bonds must satisfy

$$B_{H,t} = 0, \tag{32}$$

$$B_{F,t} + B_{F,t}^* = 0, (33)$$

where $B_{F,t}^*$ is the amount of outstanding debt in foreign currency held by the foreign residents.

IV. Quantitative Evaluation

1. Parameter Values

The computation of a numerical solution to the model requires assigning numbers

to parameters of the model. Specifically, parameters of the model are partitioned into two classes. For the first class of parameters, we simply choose their values in the small open economy literature. For example, we set $\sigma = 1$, v = 1 and $\alpha = 2/3$. Among the major parameters in this paper, the steady-state nominal interest rate and inflation rate are set by the average value of the data, and the time discount rate is set under the condition that nominal interest rate R_t equals in a steady state. The sensitivity of the country spread risk premium with respect to the net foreign asset, η_F , is set to 0.02 as in García-Cicco et al. (2010).

Values of other major parameters are taken from Gertler et al. (2007) and Elekdag et al. (2005) who calibrated or estimated them by applying the Bayesian method to Korean economy. National income distribution rate parameter φ is set to 0.37 and the steady state markup parameter is set to 11. The price elasticity of investment is set to 2.5, value that is used in the New Keynesian model, as in Christiano et al. (2005) and Schmitt-Grohé and Uribe (2006). The other parameter values are specified in Table 1.

Parameter	Values	Description and definitions
b	0.5	Degree of external habit persistence
3	11	Elasticity of demand for a good with respect to its own price
σ	1	Relative risk aversion parameter
α	3/4	Fraction of firms that do not change their prices in a given period
η	1	Elasticity of substitution between home and foreign goods
ν	1	Inverse of elasticity of labor supply
θ	0.4	Degree of openness
η_F	0.02	Elasticity of the country spread to net foreign asset
1 - κ	0.0272	Entrepreneur's death rate
N_{ss}/K_{ss}	1.2	Leverage ratio
rp	0.0035	Risk spread or External finance spread
Υ	2.5	Parameter governing investment adjustment costs
$ ilde{r}$	0.016	Steady state real interest rate
$ ho_a$	0.9	Serial correlation of domestic productivity shock
$ ho_{a^*}$	0.9	Serial correlation of foreign productivity shock
$ ho_g$	0.9	Serial correlation of domestic government spending shock
$ ho_\psi$	0.5, 0.7	Serial correlation of risk premium shock
σ_a	0.0064	Standard deviation of domestic productivity shock
σ_{a^*}	0.0064	Standard deviation of foreign productivity shock
σ_g	0.0064	Standard deviation of domestic government spending shock
$\sigma_{oldsymbol{\psi}}$	0.0064	Standard deviation of risk premium shock

Table 1. Calibrated Parameters

Since the implementable general monetary policy rules can be represented in terms of the interest rate rule, we will use this form of monetary policy rule to discuss the effect of monetary policy on aggregate fluctuations and welfare. The interest rate rule can express monetary policy in various ways depending on the criterion of an inflation targeting: Criterion can be either domestic price index (DPI) or the consumer price index (CPI). We will specify an interest rate rule such that the monetary authority also respond to the exchange rate fluctuations as the external finance premium gap, i.e. the difference between the risky interest rate and the riskless interest rate as in Cúrida and Woodford (2009), McCulley and Toloui (2008), and Taylor (2008) as follows:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_r} \left(\left(\frac{1+\pi_t}{1+\pi}\right)^{b_\pi} \left(\frac{Y_t}{Y}\right)^{a_y} \left(\frac{\mathcal{E}_t}{\mathcal{E}}\right)^{a_e} \left(\frac{RP_t}{RP}\right)^{a_{rp}} \right)^{1-\rho_r},\tag{34}$$

where $RP_t \equiv E_t \left[\frac{R_{t+1}^e}{R_t}\right]$ denotes the external finance premium. When there is the perfect floating exchange rate system (when monetary authority is indifferent to the change in the exchange rate), the monetary authority does not react to the fluctuation of the exchange rate, i.e. $a_e = 0$. If the monetary authority taking into consideration the financial market fluctuations adjusts its policy rate to an increase of external finance premium, then $a_{rp} \neq 0$. The rule with $a_{rp} < 0$ reflects the idea that the monetary authority should lower the interest rate when credit spreads increase, so as to prevent the increase in spreads from effectively tightening monetary conditions in the absence of any sign of positive inflation or output gap.

When the central banks control the exchange rate taking into account the country's economic situations and the balance of trade, this is the case of managed floating exchange rate system. In the above equation, monetary authority can use either consumer price inflation or domestic price inflation rate as its target variable. In this paper, we will inspect the effect of monetary policy on welfare and stability of key macroeconomic variables when domestic monetary authority implements either a typical interest rate rule or a general interest rate rule augmented with external risk premium and exchange rate targets.

While Taylor (1993) suggested a simple interest rate rule with $a_e = a_{rp} = 0$ in the closed economy where the policy rate responds to output gap and inflation, Clarida et al. (2000) and Lubik and Schorfheide (2007) estimate that many advanced countries have adopted a general form of the interest rate rule: The monetary authorities have

targeted not only domestic output gap and inflation, but also the nominal exchange rate in their interest rate rule. In this paper, we adopt a general form of the interest rate rule by including external finance premium as well as the exchange rate stability and discuss the welfare ranking of alternative interest rate rules by setting non-zero weights on a_e and a_{rp} with b_{π} and ρ_r equal to [3, 10] and 0.65 with in Clarida et al. (2000) and Schmitt-Grohé and Uribe (2006).

Finally, there are four exogenous driving process. The (log) domestic and foreign productivity, $a_t \equiv logA_t$ and $a_t^* \equiv logA_t^*$ are assumed to follow an AR(1) as in De Paoli (2009), Faia and Monacelli (2008), and Galí and Monacelli (2005).

$$a_t = 0.9a_{t-1} + \xi_{a,t}, \quad \sigma_a^2 = 0.0064, \\ a_t^* = 0.9a_{t-1}^* + \xi_{a^*,t}, \quad \sigma_{a^*}^2 = 0.0064.$$

The (log) domestic government spending shock also follows an AR (1) process with serial correlation 0.9 and standard deviation 0.064 as in Schmitt-Grohe and Uribe (2006). The (log) risk premium shock Ψ_t follows an AR (1) process with serial correlation 0.7, 0.5 and standard deviation 0.0064 as in Farhi and Werning (2014).

2. External Credit Shock under Fixed Exchange Rate versus Flexible Exchange Rate Regime

In this section, we will numerically inspect the effects of the internal and external shocks on aggregate variables under different exchange rate regimes. In particular, we will explore the reaction of the selected real and nominal variables to domestic productivity and risk premium shocks under alternative exchange regime.

Consider an unanticipated increase in the country risk premium Ψ_t , which is assumed to follow an AR(1) process with a persistence rate of 0.7 per quarter as in Farhi and Werning (2014). Figure 1 shows the response of selected variables to the risk premium shock under the fixed exchange rate regime (long-dashed lines), and the flexible exchange rate regimes with the DPI rule (circle lines) and a simple interest rate rule (star lines).

Under the fixed exchange rate regime, the domestic interest rate must rise to countervail the effect of risk premium shock on the exchange rate. Since prices of domestic goods are sticky, the nominal interest rate increase entails an increase in the real interest rate, resulting in a severe contraction of domestic output. The increase of the real interest rate depresses asset prices, pushing up the leverage ratio and external finance premium under the specified financial frictions. The financial friction magnifies the drop of investment, consumption and output. The contraction in goods market pushes down price. Therefore, the small country with financial frictions that is hit by the risk premium shock experiences a serious economic downturn under the fixed exchange rate regime.

Next, consider the response of the economy to the risk premium shock under the flexible exchange rate regime. There occurs a depreciation of the domestic currency, inducing a strong trade surplus with a substantial inflation. Domestic output marginally expands to the risk premium shock with an increase of exports. The monetary authority raises the policy rate to stabilize domestic price, which induces a fall in domestic consumption and investment under the flexible exchange rate regime as in Figure 1.



Figure 1. Impulse Response Function to Risk Premium Shock

133

Figure 1 shows that the DPI rule is more successful in moderating the negative effect of the risk premium shock on domestic economy than a simple Taylor rule. The financial friction greatly magnifies the effect of (sovereign) risk premium shock on the economy under the fixed exchange rate regime than under the flexible exchange rate regime.

3. Impulse Response Function under Alternative Monetary Policy Rules

In this section, we will discuss the dynamic effects of exogenous shocks on the economy, when the monetary authority implements a general the interest rate rule, taking into account the change in the exchange rate as well as the external finance premium.

Figure 2 presents the effect of a domestic productivity shock on some selected economic variables, when monetary authority implements different kinds of interest rate rules. Star lines represent the response of the economy associated with the simple interest rate rule economy like Clarida et al. (2002), which targets only the domestic product gap and the consumer price index, while circle lines show the response of the economy under a more general interest rate rule, targeting the financial market status as well as the domestic product gap and the consumer price index. Solid lines represent the response of some selected variables to the shock when the monetary authority implements the interest rate rule responding to the exchange rate fluctuations as well as the domestic product gap and the consumer price index, while long-dashed lines represent the response of macroeconomic variables to the shock when the monetary authority implements the interest rate rule, reacting to the financial market conditions and exchange rate fluctuations, in addition to the domestic product gap and the consumer price index. These last two interest rates rules correspond to a kind of managed floating exchange rate regime.

There are only marginal differences in the responses of selected variables to the domestic productivity shock whether the monetary authority implements an interest rate rule responding to the financial market status and the exchange rate stability or not. The interest rate rule responding to an external finance premium is mildly better in offsetting the effect of the shock on the external finance premium and the leverage ratio than the typical interest rate rule. Except these mild differences, there does not exist any noticeable difference in the impulse response functions under the corresponding monetary policy regimes.



Figure 2. Impulse Response Function to Domestic Productivity Shock

Next, consider the responses of the macroeconomic variables to the shock under the interest rate rules responding to the exchange rate fluctuations. There also exist marginal differences in the responses of major macroeconomic variables to the shock whether the monetary authority implements either an interest rate rule responding to both the financial market status and the exchange rate fluctuations or an interest rate rule responding to both an external finance premium change and the exchange rate fluctuations is mildly better in offsetting the effect of the shock on the external premium and the leverage ratio than the interest rate rule responding to only the exchange rate fluctuations. Except these mild differences, there is not any noticeable difference in the impulse response functions under the corresponding monetary policy regimes.



Figure 3. Impulse Response Function to Risk Premium Shock

Figure 3 displays the effect of a (sovereign) risk premium shock on some selected variables, conditional on alternative interest rate rules. The risk premium shock generates a substantial contraction of domestic output and a terms of trade depreciation. The monetary authority has to raise its policy interest rate to minimize capital outflows associated with the sovereign risk premium shock. Domestic economy experiences a severe contraction in investment, consumption, and output as in Figure 3. There occurs a substantial increase of external finance premium with a drop in net worth as it is more difficult for domestic firms to finance necessary funds from abroad. The impulse response functions of relevant variables to the risk premium shock under alternative interest rate rules are also indistinguishable as the responses of economy to the favorable domestic productivity shock.

Yongseung Jung

However, there occurs a substantial difference in impulse response functions of selected variables to exogenous shocks, depending on the stance of monetary authority on price stability as in Figure 4 and Figure 5. Figure 4 and Figure 5 present the impulse response to the domestic productivity and risk premium shock, respectively when the monetary authority implements either an aggressive ($b_{\pi} = 10$) or mild interest rate ($b_{\pi} = 2$) rule to stabilize either domestic product price or consumer price,⁴ respectively.



Figure 4. Impulse Response Function to Domestic Productivity Shock

⁴ In the specified interest rate rule (34), we set ρ_r , a_y , a_e , a_{rp} to 0.65, 0, 0.01, 0.01 and $b_{\pi} = 10$ or $b_{\pi} = 2$, depending on the aggressive or mild interest rate rule.



Figure 5. Impulse Response Function to Risk Premium Shock

Star lines represent the response of the small open economy associated with an aggressive interest rate rule ($b_{\pi} = 10$) to the domestic price index inflation gap, while circle lines show response of the small open economy associated with an aggressive interest rate rule to the consumer price index inflation gap. The long-dashed lines represent the response of some selected variables to the shock when the monetary authority implements a mild interest rate rule that responds to the exchange rate fluctuations as well as the domestic product price index, and the short-dotted lines represent the response of macroeconomic variables to the shock when the monetary authority implements a typical interest rate rule that responds to the exchange rate fluctuations as well as the consumer price index. Figure 4 and Figure 5 show that the interest rate rule responding to the DPI is more successful in utilizing the efficient shock and moderating the negative effect of inefficient shock on the economy than the

interest rate rule reacting to the CPI. Figure 4 and Figure 5 also show that the higher weights on price stability, the more volatile the relevant variables except the targeting inflation variable in the economy with financial frictions.

4. Welfare under Alternative Monetary Policy Rules

The linear-quadratic framework that has been extensively utilized in the literature (Galí and Monacelli, 2005; Woodford, 2003) is difficult to apply in the small open economy with financial frictions, since the conventional linear quadratic framework entails a linear term which yields a spurious welfare implication. To obtain a correct quadratic objective which can be evaluated to second order using a solution for the endogenous variables accurate to first order, it is necessary to replace the linear terms in the welfare function in (1) using a second order approximation of the model's equilibrium conditions à la Benigno and Woodford (2012) and Levine et al. (2008). Taking into account that it is very complicated to use Benigno and Woodford (2012) and Levine et al. (2008) to obtain a correct quadratic welfare function, we will utilize the numerical method of Schmitt-Grohé and Uribe (2006) by computing a second-order approximation of equilibrium conditions associated with monetary policy rules around the Ramsey deterministic steady state, assuming that economies are subject to stationary distribution of various shocks.

We measure the level of utility associated with a particular monetary policy specification as follows. Let the equilibrium processes for consumption and hours associated with a particular policy regime be denoted by $\{C_t, H_t\}$. Then we measure welfare as the conditional expectation of lifetime utility as of time zero evaluated at $\{C_t, H_t\}$. We denote this welfare measure by V, given by

$$\mathbf{V} = \sum_{t=0}^{\infty} E_t \left[\ln \left(C_t - b \tilde{C}_{t-1} \right) - \frac{H_t^{1+\nu}}{1+\nu} \right]$$
(35)

The statistics reported in Table 2–4 present the conditional welfare measured by (35), and second moments of some key macroeconomic variables, employing the Matlab code compiled by Schmitt-Grohé and Uribe (2006). The numbers in λ_c display the welfare cost in the steady-state consumption unit relative to the DPI rule for Table 2 and Table 3. λ_c in Table 4 represents the welfare cost relative to the interest rate rule taking into account only inflation and risk premium. Table 2 and Table

3 present the second moments of the selected variables and welfare associated with various simple monetary policy rules when the half-life of the risk premium shock equals 0.5 year as in Farhi and Werning (2014), while Table 4 presents the second moments of the selected variables and welfare cost associated with simple monetary policy rules when the serial correlation of the risk premium shock is weak, i.e. for $\rho_{\psi} = 0.5$.

	$(a_e = a_{rp} = 0)$	$(a_e = 0, a_{rp} = 0.01)$	$(a_e = 0.01, a_{rp} = 0)$	$(a_e = a_{rp} = 0.01)$
y_t	3.3434	3.4471	3.3859	3.4471
π_t	0.6667	0.6593	0.6660	0.6593
$\pi_{H,t}$	0.3024	0.2945	0.2980	0.2945
R_t	0.7691	0.7583	0.7647	0.7583
R_t^e	9.3104	9.6510	9.4563	9.6510
V	-88.9516	-88.9507	-88.9513	-88.9507
λ_c	0.0154%	0.0149%	0.0152%	0.0149%

Table 2. Volatility and Welfare Cost with Alternative DTR Rules ($\rho_{\varphi} = 0.7$)

Notes: λ_c denotes the welfare cost of adopting the relevant monetary policy instead of the DPI rule conditional on a particular state in period 0. DTR rules stands for the interest rate rule targeting the domestic price index inflation.

Table 3. Volatility and Welfare Cost with Alternative Monetary Policy Rules ($\rho_{\varphi} = 0.7$)

	DPI	PEG	DTR with $b_{\pi} = 10$	CTR with $b_{\pi} = 10$
y_t	3.8096	10.6470	3.0096	5.9959
π_t	0.9401	0.5437	1.0881	0.2855
$\pi_{H,t}$	0.0000	1.0875	0.0829	0.4292
R_t	0.6293	1.1486	0.3661	1.0384
R_t^e	9.7608	32.8040	6.6857	17.9831
V	-88.9209	-89.1390	-88.9418	-88.9460
λ_c	0	0.109%	0.0105%	0.0125%

Notes: λ_c denotes the welfare cost of adopting the relevant monetary policy instead of the DPI rule conditional on a particular state in period 0. DTR and CTR denote the Taylor rule (interest rate rule), targeting the domestic price index inflation, and the consumer price index inflation, respectively.

	$(a_e = a_{rp} = 0)$	$(a_e = 0, a_{rp} = 0.01)$	$(a_e = 0.01, a_{rp} = 0)$	$(a_e = a_{rp} = 0.01)$
y_t	2.6406	2.6829	2.6705	2.7124
π_t	0.5960	0.5922	0.5913	0.5896
$\pi_{H,t}$	0.2780	0.2804	0.2755	0.2746
R_t	0.6158	0.6121	0.6134	0.6096
R_t^e	6.7299	6.8703	6.8443	6.9846
V	-88.9706	-88.9704	-88.9706	-88.9705
λ_c	10-40%	0	10 ⁻⁴⁰ ⁄0	5×10 ⁻⁵⁰ / ₀

Table 4. Volatility and Welfare Cost with Alternative DTR Rules ($\rho_{\varphi} = 0.5$)

Note: λ_c denotes the welfare cost of adopting the relevant monetary policy instead of the DTR rule with $a_e = 0, a_{rp} = 0.01$ conditional on a particular state in period 0.

Three facts are of foremost importance in Table 2-4.

First, the strict DPI rule is best, while the PEG rule is worst among the considered simple interest rate rules in the small open economy New Keynesian model with financial frictions. In the small open economy with financial frictions and risk premium shock, it is necessary for the monetary authority to implement an independent monetary policy rule to stabilize undesirable capital fluctuations across borders if there are no capital controls to moderate excessive international capital movements. Since an independent monetary policy is not available under the fixed exchange rate regime, the welfare under the regime is lowest among the available simple rules. Though the monetary policy of domestic price stability is not optimal in the small open economy with financial frictions (Farhi and Werning, 2014), it is still desirable to maintain stable price and better than other simple rules. Table 3 shows that the DPI rule is best among the simple monetary policy rules in the small open economy with incomplete markets as in De Paoli (2009).

Second, the higher the weights to price stability in the interest rate rule, the higher the welfare associated with the monetary policy rule. Notice that the second-order approximation of welfare shows that households put higher weights to domestic price stability than any other macroeconomic variables. Keeping in mind that households own whole share of dividends in the representative agent model and dividends or profits accruing to households move inversely with relative price distortions which are closely related with price stability, it is highly desirable to maintain price stability in staggered price models. Hence, the interest rate rule with higher weights on domestic price stability dominates the interest rate rules with smaller weights on domestic price stability as in Table 3.

Finally, the interest rate rule considering the external finance premium is marginally better than the interest rate rule not responding to the external finance premium in the small open economy with financial frictions and risk premium shocks. Furthermore, the interest rate rule considering the domestic price stability is marginally better than the interest rate rule reacting the consumer price stability. This marginal difference reflects that domestic households own domestic firms whose profits are more critically dependent on the domestic relative price distortions.

V. Conclusion

We set up a fully-fledged multi-sector small open economy with financial frictions to explore the vulnerability of the economy to the risk premium shock. We have found that the small economy with financial frictions is more susceptible to the exogenous shocks such as the risk premium shock under the fixed exchange rate regime than under the flexible exchange regime. The small economy experiences a more prolonged and deeper economic recession under the fixed exchange rate regime than under the flexible exchange rate regime. Domestic price stability is still desirable in the economy with financial frictions and risk premium shock. Since the interest rate rule considering external finance premium of domestic firms can moderate undesirable excessive capital flows across borders, it is marginally better than other interest rate rules without considering financial market conditions in the small open economy.

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