行政院國家科學委員會專題研究計畫 成果報告

貨幣政策法則與匯率波動程度於大小型開放性經濟體系之差異：福利與景氣循環的數量分析

研究成果報告(精簡版)

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計畫主持人： 黃俞寧

計畫參與人員： 碩士班研究生-兼任助理人員：何佩螢
碩士班研究生-兼任助理人員：吳信毅
碩士班研究生-兼任助理人員：黃柏鈞
碩士班研究生-兼任助理人員：楊馥珉
碩士班研究生-兼任助理人員：陳建璋
碩士班研究生-兼任助理人員：賴建男
博士班研究生-兼任助理人員：陳冠璋

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附件一

行政院國家科學委員會補助專題研究計畫 ■ 成果報告 □期中進度報告

（計畫名稱）

貨幣政策法則與匯率波動程度於大小型開放性經濟體系之差異：
福利與景氣循環的數量分析

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執行單位：政治大學經濟學系

中 華 民 國 98 年 10 月 31 日

貨幣政策法則與匯率波動程度於大小型開放性經濟體系之差異：福利與景氣循環的數量分析

摘要

本研究採取一不對稱之兩國模型，針對國家規模對於最適貨幣政策法則與匯率波動性的影響以模擬進行數量化分析。模擬結果顯示，對於一由兩對稱國家組成之經濟體系而言，維持匯率穩定是較佳的；相反的，若兩國國家規模大小不同，則以通膨穩定爲目標之利率法則，並維持彈性匯率爲最適。而不論在何種政策之下，小國難以避免地要承受較大的經濟波動。

中文關鍵字：貨幣政策、匯率制度、匯率波動性、泰勒法則、國家規模

The Implications of the Country Size on Optimal Monetary Policy Rule and Exchange Rate Flexibility: a Quantitative Assessment of Welfare and Business Cycles

Yu-Ning Hwang[1]

Department of Economics
National Chengchi University

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Abstract

This study calibrates a model with asymmetrically-sized countries to investigate numerically the impacts of the country size on the optimal monetary policy rule, exchange rate flexibility and welfare. The calibration results demonstrate that an economy composed of two countries with equal size merits exchange rate stability, while the flexible exchange rate is more desirable when the country sizes diverge. Moreover, the smaller country unavoidably suffers from drastic rises in economic fluctuations under all policies.

Keywords: monetary policy, exchange rate regime, exchange rate flexibility, Taylor rule, country size

[1] Department of Economics, National Chengchi University, 64, Sec. 2, Tz-nan Rd., Wenshan, Taipei 116, Taiwan. Tel.: 886-2-29393091 ext. 51041. Email: yuning@nccu.edu.tw.

1. Introduction

The objective of this study is to investigate whether and how the optimal monetary policy rules, the exchange rate volatilities as well as macroeconomic fluctuations would differ with the country size. This study examines these issues quantitatively by calibrating a two-country dynamic stochastic general equilibrium model, composed of countries with different population sizes.

In the past decade, most of the researches on exchange rate regimes are conducted under the open-economy dynamic stochastic general equilibrium (DSGE) framework with nominal rigidity and monopolistic competition such as Bacchetta and van Wincoop (2000), Obstfeld and Rogoff (2000) and Corsetti and Pesenti (2001)). Equipped with microfoundation, this model has served as a good platform for the welfare assessment of policies. Among the calibrated works on monetary policy and exchange rate flexibility, many of them reach the same conclusion that the inflation stabilizing rule is the optimal policy, letting exchange rates fluctuate (Kollmann (2002) and Bergin, Shin and Templeton (2007)).

While the conclusion from quantitative studies is derived from models using a small open economy or two equally-sized countries, the effects that the country size may have on the policies and exchange rate fluctuations are neglected. Here comes the main reason that we conduct the research in a numerical way: although the effects of the country size on the business-cycle volatilities and exchange rate fluctuations have been shown significant by analytical and empirical studies (see Furceri and Karras (2007) and Sutherland (2005)), these issues that the magnitudes of these effects on the economy, and the implications of the relative size on the exchange rate and monetary policy have not been evaluated quantitatively by calibrations. Therefore, this research wants to fill in the gap between the quantitative examinations of optimal exchange rate flexibilities in a small open economy and two equally-large countries to examine the "size" effect on the macroeconomy and welfares.

Whether the country size matters is an issue that has been widely discussed in the literature of economic growth, particularly.[2] It is known as the "scale effect", which essentially states that a country of greater population size grows faster than a smaller country. There have been various debates over the presence of the scale effect in the literature. While the scale effects have been carefully examined in the economic growth literature, relatively few researches have examined the effect of the country size on business cycles. The empirical studies, such as Zimmermann (1997), Martin (1998), Furceri and Karras (2007) and Duarte and Wolman (2002)[3], demonstrate the

[2] For example, Rose (2006) reviews the literature and documents that this scale is significant in a number of studies, though not in the "social phenomenon" of his study.

[3] The empirical study in Furceri and Karras (2007) demonstrates a negative relationship between the

significant relationship between the country size and cyclical economic fluctuations.

Among all, Sutherland (2005) is the one that is closest to this research. He finds that the degree of pass-through, the country size and openness as well as other factors in production sectors are primary determinants of the optimal exchange rate volatility. While his research is conducted analytically subject to a great degree of simplifications, we follow the model setup of Bergin et al. (2007) and Bergin (2006) and run calibrations to numerically assess the optimal monetary policy, the cyclical behavior of the macroeconomic fundamentals, exchange rate fluctuations and the welfare that the policy entails. Whether and how these aspects vary with the size of a country is the focus of this study. By taking advantage of calibrations, the model in this research allows more realistic and general specifications such as the Calvo-type staggered pricing to capture the dynamics of macroeconomic variables.

The remainder of this paper is structured as follows. We present the specifications of the model in Section 2. Section 3 describes the model's parameterization and Section 4 discusses the calibration results. Section 5 concludes.

2. The model

2.1 Production and price setting

There are two countries, Home and Foreign, each of which produces final goods and the intermediate goods for final goods production. The final goods are sold domestically and perfectly competitive, while the intermediate goods are produced on monopolistically competitive markets and traded internationally within the range $\left[0,1\right]$. The production of final goods follows:

$$Q_t = \left[\alpha^{\frac{1}{\sigma}} X_{H,t}^{\frac{\sigma-1}{\sigma}} + \left(1-\alpha\right)^{\frac{1}{\sigma}} X_{F,t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \qquad (1)$$

$X_{H,t}$ and $X_{F,t}$ are the home and foreign intermediate products, which are composed of differentiated goods:

$$X_{H,t} = \left[\int_0^1 x_{H,t}\left(i\right)^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} \quad , \quad X_{F,t} = \left[\int_0^1 x_{F,t}\left(i\right)^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} \qquad (2)$$

Based on the composite product indexes, the price indexes can be defined as:

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country size and cyclical economic fluctuations. Moreover, Martin (1998) finds that exchange rate volatility is a hump-shaped function of country size which holds both analytically and empirically in his study.[3] Other studies showing that smaller countries are more sensitive to shocks include Zimmermann (1997) and Duarte and Wolman (2002).

$$P_t = \left[\alpha P_{H,t}^{\ 1-\sigma} + (1-\alpha) P_{F,t}^{\ 1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{3}$$

where $P_{H,t} = \left[\int_0^1 p_{H,t}(i)^{1-\eta} \, di \right]^{\frac{1}{1-\eta}}$ and $P_{F,t} = \left[\int_0^1 p_{F,t}(i)^{1-\eta} \, di \right]^{\frac{1}{1-\eta}}$.

σ and η are the elasticities of substitution between the home and foreign goods and a variety of goods. α is the share of the expenditure on tradable goods in the total consumption spending and thus is the measure of the trade openness in this model. Given the goods and price indexes, the demand for each type of goods can be obtained:

$$X_{H,t} = \alpha \left(\frac{P_{H,t}}{P_t} \right)^{-\sigma} Q_t, \quad X_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\eta} X_{H,t}, \tag{4}$$

$$X_{F,t} = \alpha \left(\frac{P_{F,t}}{P_t} \right)^{-\sigma} Q_t, \ X_{F,t}(i) = \left(\frac{P_{F,t}(i)}{P_{F,t}} \right)^{-\eta} X_{F,t}.$$

The foreign country follows the analogous forms which are indicated by asterisks. The population sizes of the home and foreign countries are n and $1-n$ respectively.

2.2 Intermediate goods

The intermediate goods markets are monopolistically competitive. Each of the firms produce goods by using the Cobb-Douglas technology by using capital and labor supply, K_t and L_t. The production function for a firm i is specified as follows:

$$y_t(i) = A_t K_t(i)^{\gamma} L_t(i)^{1-\gamma}, \ 0 < \gamma < 1. \tag{5}$$

where A_t is the total factor productivity, subject to a stochastic process:

$$a_t = \bar{a} + (1-\rho_a) a_{t-1} + \varepsilon_t \tag{6}$$

Here, $a_t = \log A_t$. The clearing condition for the good should hold as $y_t(i) = x_{H,t}(i) + ((1-n)/n) x_{H,t}^{*}(i)$. All the firms take the producer-currency pricing (PCP), following the Calvo-type staggered pricing strategies. Each of the intermediate goods producers maximizes its profit:

$$Max \quad E_0 \sum_{t=0}^{\infty} \xi_{t,t+h} \Pi_{H,t}(i) \tag{7}$$

Where $\xi_{t,t+h} = \beta^n \left(U'_{c,t+h} / P_{t+h} \right) / \left(U'_{c,t} / P_t \right)$. The profit $\Pi_{H,t}(i)$ can be stated as below:

$$\Pi_{H,t}(i) = \left[P_{H,t}(i) - MC_t(i) - AC_{P,t}(i)\right]\left[x_{H,t}(i) + \frac{1-n}{n} x^*_{H,t}(i)\right] \quad (8)$$

The adjustment and marginal costs are defined as:

$$AC_{P,t}(i) = \frac{\phi_P}{2} . \frac{\left[P_{H,t}(i) - P_{H,t-1}(i)\right]^2}{P_{H,t-1}(i)}, \quad (9)$$

$$MC_t = \frac{(r_t P_t)^{\alpha} W_t^{1-\alpha}}{\theta_t \alpha^{\alpha} (1-\alpha)^{(1-\alpha)}} \quad (10)$$

where ϕ_P characterizes the stickiness of price adjustments. r_t is the rental rate on capital and W_t denotes the wage.

The optimal pricing strategy for each individual intermediate goods producer is:

$$\begin{aligned} P_{H,t}(i) &= \frac{\bar{\lambda}}{\bar{\lambda}-1}\left(MC_t + AC_{P,t}\right) + \frac{\phi_P}{\bar{\lambda}-1} P_{H,t}(i) . \left(1 - \frac{P_{H,t}(i)}{P_{H,t-1}(i)}\right) \\ &+ \frac{1}{\alpha}\frac{\phi_P}{\bar{\lambda}-1} P_{H,t}(i) . E_t\left[\xi_{t,t+1}\left(\frac{P^2_{H,t+1}(i)}{P^2_{H,t}(i)} - 1\right)\left(\frac{y_{t+1}(i)}{y_t(i)}\right)\right] \end{aligned} \quad (11)$$

where $\bar{\lambda} = -\left(\partial y_t(i)/y_t(i)\right)/\left(\partial P/P\right)$.

2.3 Consumers

The optimization problem faced by each consumer is as follows:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U\left[C_t, \frac{M_t}{P_t}, L_t\right] = \frac{1}{1-\rho} C_t^{1-\rho} - \frac{\omega}{1-\psi}\left(\frac{M_t}{P_t}\right)^{1-\psi} - \frac{\chi}{1+\varepsilon}\left(H_t\right)^{1+\varepsilon} \quad (12)$$

s.t.

$$\begin{aligned} & P_t C_t + P_t I_t + P_t AC_{I,t} + M_t + B_{H,t+1} + e_t B_{F,t+1} \\ & = \left(1+i_{t-1}\right) B_{H,t} + e_t\left(1+i^f_{t-1}\right) B_{F,t} + M_{t-1} + W_t L_t + P_t R_t K_t + \int_0^1 \pi_t(j)\, dj + T_t \end{aligned} \quad (13)$$

where L_t is the labor supply with W_t as the wage. β denotes the subjective time preference, ω characterizes the utility from the money demand and χ is the disutility from the labor supply, ρ and ψ are the curvatures of the utility functions associated with consumption and labor supplied respectively.

In the budget constraint, K_t is the capital that are used in the production of intermediate goods with the rental rate R_t. I_t is the investment, which is subject to convex adjustment costs, defined as $K_{t+1} + \phi\left(K_{t+1}, K_t\right) = K_t\left(1-\delta\right) + I_t$ where

$\phi(K_{t+1},K_t)=1/2\,\phi_I\{K_{t+1}-K_t\}^2/K_t$. The asset market is assumed incomplete.[4] $B_{H,t}$ and $B_{F,t}$ are two types of bonds which are denominated in the home currency and in the foreign currency with the interest rates i_t and i_t^f respectively. π_t is the profit of the firm. e_t denotes the nominal exchange rate, defined as the home-currency price of one foreign currency.

The first-order conditions associated with the maximization problem of households are:

$$\frac{W_t}{P_t C_t^{\rho}}=H_t^{\phi}, \tag{14}$$

$$\frac{M_t}{P_t}=\frac{\chi_t^{1/\varepsilon} C_t^{\rho/\varepsilon}}{(1-d_t)^{1/\varepsilon}} \tag{15}$$

where $d_t=1/(1+i_t)$.

2.4 Market Clearing Conditions

All the market should clear. Total demands for the home and foreign intermediate goods should equal to the supplies:

$$X_{H,t}+\frac{1-n}{n}X_{H,t}^{*}=Y_t, \tag{16}$$

$$\frac{n}{1-n}X_{F,t}+X_{F,t}^{*}=Y_t^{*} \tag{17}$$

Similarly, the final goods should clear when demand and supply are equal:

$$Q_t=C_t+\left[K_{t+1}-(1-\delta)K_t\right]+AC_{I,t}+\frac{AC_{B,t}}{P_t}+Y_t.\frac{AC_{P,t}}{P_t} \tag{18}$$

$$Q_t^{*}=C_t^{*}+\left[K_{t+1}^{*}-(1-\delta)K_t^{*}\right]+AC_{I,t}^{*}+\frac{AC_{B,t}^{*}}{P_t^{*}}+Y_t^{*}.\frac{AC_{P,t}^{*}}{P_t^{*}} \tag{19}$$

The sum of the bonds should equal zero:

$$B_{H,t}+\frac{1-n}{n}B_{H,t}^{*}=0 \tag{20}$$

[4] Obstfeld and Rogoff (2000) address that the incomplete asset market is a more reasonable assumption given that two market frictions exist in the goods markets: monopolistic competition and nominal rigidity.

$$\frac{n}{1-n} B_{F,t} + B^{*}_{F,t} = 0 \qquad (21)$$

Therefore, the home balance of payments can be written as:

$$\left(B_{H,t} - B_{H,t-1}\right) + S_t\left(B_{F,t} - B_{F,t-1}\right) = P_{H,t}Y_t + i_{t-1}B_{H,t-1} + S_t i^{*}_{t-1} B_{F,t-1} - P_t F_t \quad (22)$$

2.5 Monetary Policies

The monetary authorities adopt two types of monetary policies: the exchange rate peg and the Taylor rules as specified below. Under the fixed exchange rate regime, the exchange rate is fixed at a predetermined level:

$$e_t = \overline{e} \qquad (23)$$

The monetary authorities in these two countries should cooperate to maintain the fixed exchange rate.

Under the Taylor rule, the interest rate reacts to the domestic inflation rate, the output gap and the percentage change in the nominal exchange rate:

$$i_t = \overline{i} + \Lambda_{\pi}\pi_t + \Lambda_Y \hat{Y}_t + \Lambda_e \Delta e_t \qquad (24)$$

where $\overline{i}$ is the steady state interest rate, π_t is the domestic inflation rate, $\hat{Y}_t = \left(Y_t - \overline{Y}\right)/\overline{Y}$ denotes the output gap (the output deviation from its steady state level) and Δe_t is the percentage change in the nominal exchange rate. Λ_{π}, Λ_Y and Λ_e are the policy parameters that govern the reactions of the monetary policy to the domestic inflation rate, output gap and the percentage change in the nominal exchange rate respectively. Note that, Λ_e measures the attempt of the central bank to control the exchange rate variability. Exchange rates are flexible, allowed to fluctuate if $\Lambda_e = 0$. On the other hand, this policy turns to fix the exchange rate if Λ_e is large.

2.5 Welfare criteria

The welfare measure of the representative agent is given by the conditional expected lifetime utility function at time zero:

$$V_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{1}{1-\rho} C_t^{1\text{-}\rho} - \frac{\chi}{1+\varepsilon}\left(H_t\right)^{1+\varepsilon} \right) \qquad (25)$$

Following Obstfeld and Rogoff (1998, 2000), the utility from the real money holding can be negligible. The initial state is specified as the deterministic steady state, according to Schmitt-Grohe and Uribe (2007). For a policy r, the welfare cost can be measured by the fraction u_c of the steady-state consumption which the households are willing to give up to be as well off as under the policy r. The welfare cost u_c of the policy r can be written as:

$$\sum_{t=0}^{\infty}\beta^t\left(\frac{1}{1-\rho}\left(\left(1-u_c\right)C_t\right)^{1-\rho}-\frac{\chi}{1+\varepsilon}\left(H_t\right)^{1+\varepsilon}\right)=V_0^r \tag{26}$$

Higher value of u_c indicates greater welfare loss that the policy entails.

3. Parameterization

The calibration is conducted by using the Dynare for Matlab. We take the second-order Taylor expansion around the deterministic steady state where the inflation and shocks are absent. We assess three monetary policies as discussed above and rank their welfare implications with the welfare costs that each of them incurs. The model parameter values are calibrated as below, primarily following the specification of Bergin et al. (2007). Each period is identified as a quarter. First, following conventional settings, we set the quarterly discount factor β as 0.99, and $\delta = 0.025$ for the quarterly depreciation rate. ε is specified as 1 to characterize the unity elasticity of labor supply. Both ρ and ψ are set at 4. $\alpha = 0.8$ to reflect the 20% of import in the aggregate goods for G7 countries during the 90's. The elasticity of individual goods is specified as 7 such that the market up of the goods is equal to 16%. The elasticity between home and imported goods is set at 5. The adjustment cost of investment is specified as $\phi_I = \phi_I^* = 4$. $\phi_B = \phi_B^* = 4\times10^{-6}$ to characterize the friction on the international asset market, while $\phi_P = 50$ implying 95% of prices adjust four periods after a monetary shock. Technology shocks take the persistence $\rho_1 = \rho_1^* = 0.9$ with the volatility $\mathrm{var}\left(\varepsilon_1\right) = \mathrm{var}\left(\varepsilon_1^*\right) = 0.01$.

4. Calibration Results

Calibrations are conducted for two cases: the baseline model is the equally-sized countries with $n = 0.5$ and the scenario with $n = 0.3$. In the latter case, the home country is the country with smaller size for the discussion which centers on the optimal monetary policy of a small economy.[5] Three policies are examined. Firstly,

[5] Instead of setting up a small open economy as in Kollmann (2002) or Sutherland (2005), we vary the value of n under the same framework.

we study the fixed exchange rate policy. The implementation of the fixed exchange rate is achieved by the small (home) country which abandons its freedom to adjust the interest rate, but adjusts with the monetary policy of the large (foreign) country to maintain the nominal exchange rate at one. That both countries conduct the Taylor rule, leaving the exchange rate flexible, is the second case. We borrow the optimal inflation targeting rule from Bergin et al. (2007).[6] While the countries seem to benefit from the exchange rate stability, as shown below, we try another scenario where the home country implements the exchange rate stabilization policy.

Calibration results are listed in Table 1 and 2. In Table 1, we can see that the policies with exchange rate stabilization outperform the optimal Taylor rule under flexible exchange rates. There are significant welfare gains when moving from policy 2 to 3 for both countries. In particular, under policy 3, while the home country engages in the stabilization of exchange rate, the foreign country reaps the benefit by having greater output without experiencing significant rise in output fluctuations and the exchange rate fluctuation is lowered significantly. The welfare fain of the foreign country is 0.0045%. The gain from the exchange rate stabilization can be even more significant when the interest rate rule of the home country targets that of the foreign country.

Table 2 shows the opposite results while the foreign country gets larger. The optimal Taylor rule is optimal for both countries with the lower welfare cost equals 0.029% for the home and -0.1124% for the foreign respectively. The small (home) country's reaction coefficient to the exchange rate depreciation, which is equal to 5, seems ineffective to prevent itself from economic fluctuations.

The comparison of the standard deviation of macroeconomic variables in Table 1 and 2 further demonstrates the effects of the country size on the economy. Under all three policies, the home country suffers from significant rises in the fluctuations of consumption, output and investment when it is downsized. The foreign country, on the contrary, experiences relatively mild, or even lower, fluctuations of the macroeconomic variables.

In sum, the results show that the fluctuations of the economy are higher for the small country, but lower for the large country under same shocks. Exchange rate stabilizations seem to be more desirable in the environment with two equally-sized countries, but exchange rate flexibility is welfare superior when the country size diverges. This result is consistent with the finding by Sutherland (2005). He shows that the monetary policy rule of a larger country should place smaller weight on the exchange rate fluctuation.

[6] The optimal monetary policy rule in Bergin et al. (2007) is $i_t = \bar{i} + 5.0\pi_t$.

5. Conclusion

In this study, we use a two-country model to examine the effects of country size on the optimal monetary policy, the exchange rate and macroeconomic fluctuations. Three monetary policies are examined: the fixed exchange rate regime, the Taylor rule and the exchange rate stabilizing policy rule. The calibration results show that the baseline case with two equally-sized countries may prefer exchange rate stability to the flexible exchange rate, while the exchange rate flexibility may be desirable for an economy composed of two unequally-sized countries. For all these policies, the smaller economy encounters greater macroeconomic fluctuations.

There are a number of issues that could be examined further in future studies. In this study, we have assumed that all the goods can be traded internationally. However, Sutherland (2005) finds that the economic openness may influence the exchange rate variability significantly. We may further use this model to analyze business cycles.

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Table 1: Baseline model: $n = 0.5$

	Policy 1	Policy 2	Policy 3
mean			
consumption (home)	1.381497	1.359316	1.380172
consumption (foreign)	1.373544	1.392631	1.365992
output (home)	1.749299	1.827900	1.722975
output (foreign)	1.783252	1.699013	1.806013
investment (home)	0.385595	0.400008	0.380172
investment (foreign)	0.391916	0.374959	0.395901
exchange rate depreciation	0.000000	0.000013	-0.000000
standard deviation			
consumption (home)	0.012861	0.013102	0.014242
consumption (foreign)	0.013812	0.012420	0.015277
output (home)	0.057675	0.056748	0.066142
output (foreign)	0.059010	0.058856	0.063487
investment (home)	0.026492	0.026979	0.026925
investment (foreign)	0.027957	0.027490	0.027221
exchange rate depreciation	0.000000	0.001924	-0.000634
conditional welfare effects (in %)			
u (home)	0.0108	0.0108	-0.0058
u (foreign)	-0.0061	-0.0013	-0.0058

Note: Policy 1: fixed exchange rate policy; Policy 2: flexible exchange rate under the Taylor rule $i_t = \bar{i} + 5.0\pi_t$; Policy 3: The home country conducts the exchange rate stabilizing rule: $i_t = \bar{i} + 3.0\pi_t + 5.0\Delta e_t$ while the foreign country implements the inflation-stabilizing rule: $i_t = \bar{i} + 5.0\pi_t$.

Table 2: Unequally-sized countries: $n = 0.3$

	Policy 1	**Policy 2**	**Policy 3**
mean			
consumption (home)	1.286448	1.348407	1.314452
consumption (foreign)	1.427746	1.384743	1.407269
output (home)	2.310929	1.967429	2.150858
output (foreign)	1.548737	1.671860	1.604213
investment (home)	0.509015	0.437986	0.475278
investment (foreign)	0.341979	0.364336	0.351585
exchange rate depreciation	0.000000	-0.000032	-0.000008
standard deviation			
consumption (home)	0.019025	0.023408	0.014213
consumption (foreign)	0.014889	0.014966	0.014082
output (home)	0.102160	0.127127	0.092118
output (foreign)	0.053146	0.064833	0.049740
investment (home)	0.035989	0.039105	0.035833
investment (foreign)	0.026189	0.026332	0.025328
exchange rate depreciation	0.000000	0.001863	0.000622
conditional welfare effects (in %)			
u (home)	0.1780	0.0290	0.0732
u (foreign)	-0.1047	-0.1124	0.0584

計畫成果自評

1．研究內容與原計畫相符程度：

本研究內容與原計畫主題相符。除了結案報告中所討論之國家規模對於貨幣政策造成之影響外，本人亦正與學生在不對稱兩國之模型架構下，研究國際通貨對於貨幣政策之影響，後者將涉及匯率轉嫁程度的探討。因此本計畫大致維持原計畫案中所提出之想法逐步進行相關研究。

2．達成預期目標情況：

本研究約達成原計畫預計目標之 90%

3．研究成果之學術或應用價值：

本研究是以一兩國模型架構，探討國家規模對於最適貨幣政策、匯率與總體經濟波動性之影響爲何。過往匯率相關研究普遍是在一小型開放經濟體系或是兩規模相等之大國的模型架構下進行探討，因此可能忽略了國家規模對於最適貨幣政策與其效果之影響，此爲本研究主要之學術貢獻。本研究成果可作爲政府單位制定貨幣政策之參考。

4．是否適合在學術期刊發表或申請專利：

本人亦在此兩規模大小不同之國家的模型架構下進行國際通貨（international currency）之研究。本計畫預計於國際期刊上發表 1-2 篇文章。

5．主要發現或其他有關價值等：

模擬結果顯示，對於一由兩對稱國家組成之經濟體系而言，維持匯率穩定是較佳的；相反的，若兩國國家規模大小不同，則以通膨穩定爲目標之利率法則，並維持彈性匯率爲最適。而不論在何種政策之下，小國難以避免地要承受較大的經濟波動。

出席國際學術會議心得報告

計畫編號	NSC 97 －2410 －H－004－014－
計畫名稱	貨幣政策法則與匯率波動程度於大小型開放性經濟體系之差異：福利與景氣循環的數量分析
出國人員姓名 服務機關及職稱	黃俞寧　國立政治大學經濟學系助理教授
會議時間地點	2009 年 7 月 15 日~7 月 17 日　澳洲雪梨
會議名稱	The 15th International Conference on Computing in Economics and Finance
發表論文題目	The Credit Channel of Monetary Policy and Exchange Rate Flexibility in a Small Open Economy

一、參加會議經過

7 月 13 日晚間與本系陳樹衡老師與國貿系山本童市老師同時抵達雪梨。於 7 月 15 日下午發表”The Credit Channel of Monetary Policy and Exchange Rate Flexibility in a Small Open Economy”一文。13 日晚間參與歡迎茶會, 遇見多位共同參加會議的台灣老師與學生, 並得與一知名的經濟學家, Michel Juillard (爲目前廣爲 computational economics 學界使用的套裝軟體 Dynare 之主要作者) 相識。16 日晚間在會議安排下前往雪梨歌劇院觀賞歌劇, 並於 17 日晚間參加會議晚宴, 與多位知名經濟學家同席, 交換許多對於當今金融海嘯的看法。18 日上午即啓程返回台灣。

二、與會心得

參與此次會議使我獲益良多, 除了遇見國際經濟學界之知名教授之外, 還得以與多位各國央行的研究員進行學術與實務上的討論。其中一位是德國央行的 Felix Hammermann, 他與我在相同的模型架構下進行不同主題的研究; 另一位則是加拿大央行的 Ali Dib, 他以另一模型進行信用傳遞管道的相關研究。我與他們除了在會議與晚宴中很快地針對彼此的研究交換意見之外, 於會議結束後並彼此以 email 聯繫, 交換論文與相關意見。此外, 並與舊金山聯準會的 Kevin Lansing (他爲 UC Riverside 郭建廷老師長期以來的合作者) 交換了許多對於當今金融海嘯的看法。整體來説，因此一會議與我的研究有高度相關, 參與此一會議，不論是對於目前的學術研究或是未來的研究規劃，皆有相當的助益。而對於此次在研討會上所認識的國際學者，更期能與其有更進一步的交流與討論，以在學術研究上有更深更廣的發展。

The Credit Channel of Monetary Policy and Exchange Rate Flexibility in a Small Open Economy

Yu-Ning Hwang[a] Fu-Min Yang[b]

Department of Economics
National Chengchi University

Abstract

The objective of this study is to highlight the role of the banking sector in a small open economy. By including the banking sector in a dynamic stochastic general equilibrium (DSGE) model with the small-open-economy setting, this study examines the significance of the banking sector in a small open economy and the implication of economic openness for the credit market. The steady state analyses show that the inefficiency of the banking sector in a small open economy drives substantial movements of the EFP, same as its role in a closed economy, but higher openness raises the EFP. Furthermore, in line with the current worldwide financial crisis, this study stresses the shock to the collateral effectiveness for the loan services. In face of the financial shock, consumption and output drop as they do in a closed economy, accompanied by the appreciation of the home currency. Thereby the home currency appreciation results in lower export as well as production, and thus exacerbates the impacts of shocks on the economy.

Keyword : Credit Channel; External Financial Premium; Flexible Exchange Rate; Financial Crisis

JEL Classifications: F31; F41; F51

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[a] Department of Economics at National Chengchi University, 64, SEC. 2, Tz-nan Rd., Wenshan, Taipei 116,Taiwan. Tel.: 886-2-29393091 ext. 51641. Email: yuning@nccu.edu.tw.
[b] Department of Economics at National Chengchi University, 64, SEC. 2, Tz-nan Rd., Wenshan, Taipei 116,Taiwan. Tel.: 886-2-29393091 ext. 51641. Email: 96258015@nccu.edu.tw.

1. Introduction

In the past decade, there are considerable quantities of studies on the monetary policy under open economies, particularly using the DSGE framework. However, most of these studies neglect the banking sector whose importance has been well recognized in a closed economy. On the other hand, although the role of the banking sector in an economy has been examined extensively, these studies are conducted under a closed economy framework. Nevertheless, the ongoing worldwide financial crisis which originated from dysfunctional credit markets in the US has demonstrated how easily the credit market shocks can be spread to other countries under globalization of goods and capital markets. The crisis has cast strong doubt for globalization.

Therefore, it is crucial to investigate the role of the banking sector in an open economy. The objective of this study is to establish a small-open-economy DSGE model with money and banking to examine whether the openness of goods and asset markets alters the role of the credit market and helps dampen the macroeconomic impacts of the financial distress that originates from the credit market. Intuitively, globalization may not affect the role of the banking sector qualitatively, but exchange rate movements driven by the interest rate disparity on the global asset market due to financial shocks may influence the international trades, and thus may alter the impacts of shocks on the production and consumption in an economy quantitatively. By using the model in Goodfriend and McCallum (2007), we will conduct calibrations to examine the role of banking sector numerically. Equipped with the loan market, this study can also have some implications for the current global financial crisis.

The literature on credit channel such as Bernanke and Blinder (1988) and Bernanke and Gertler (1995), followed by many other studies places an emphasis on the implication of the banking sector for monetary policy transmission. Instead of lumping up all the interest rates, they distinguish various interest rates on the market and show that the external finance premium (EFP), which is the spread between the loan and deposit rates, can be countercyclical and plays the role of the "financial accelerator" of monetary policy. The lower interest rates caused by expansionary monetary policy help improve the balance sheets of firms and thus firms can acquire more funds at lower loan rates. This will reduce the EFP and reinforces the effects of monetary policy on production. The credit channel has been examined extensively by Edwards and Vegh (1997), Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997), Kocherlakota (2000) and others.

However, studies listed above neglect the role of money in the economy with banking sector. Goodfriend and McCallum (2007, henceforth GM (2007)) includes the banking sector in a prevailing DSGE model. They emphasize the quantitative importance of money for an economy with credit market instead, and show that money will be the "financial attenuator" of monetary policy, counteracting the effects of the financial accelerator. The rising demand for deposits which is driven by an expansionary monetary policy raises the EFP. Moreover, by including the loan production process in the model, they can discuss the financial distress that originates from the credit market.

While these studies discussed above are conduced under closed economy frameworks and the examination of the credit channel under an open economy is absent, it is crucial to study this issue under a small open economy setting. Moreover, since the exchange rate movements may alter the effects of the credit channel, we have to include money in the model. Therefore, we extend the model with money and banking in GM (2007) by opening up the good and asset markets. All the goods are tradable across countries under a monopolistically competitive market structure. In addition to the home bond issued by the government and held by domestic households only, there is the foreign bond that can be traded internationally. Following the specification of GM (2007), the loan production requires collaterals and monitoring. The collaterals consist of the home bonds and real capitals. The foreign bonds, however, can not serve as the collateral. Thus, the foreign bonds require a "liquidity premium" to compensate for the lack of the liquidity services that the home bonds can offer. Moreover, the loan process is subject to two shocks: the shock to the value of real capital as collateral for loans and to the monitoring. The credit shocks can characterize the current financial crisis starting from the credit market.

By using this framework, we can see that the banking sector does matter in an open economy and will play an additional role for monetary policy transmission, as the credit channel literature suggests. More efficient loan production does help reduce the EFP in the steady state analysis. On the other hand, in the dynamics, a positive unit shock to productivity causes the EFP to rise, which serves as the financial attenuator as in GM (2007) due to the presence of money. The financial shocks also drive the EFP movements. Furthermore, the calibration results show that higher degree of openness in the good markets raises the EFP in the steady state by inducing greater transactions in bonds, and exacerbates the impacts of the financial shock in dynamics.

The remainder of this paper is structured as follows. In Section 2, we present the specifications of the model and the endogenous determination of interest rates is listed in Section 3. The results of the steady state are listed in Section 4 to examine the quantitative importance of money and banking as well as the economic openness to the economy. In Section 5, we conduct the dynamic analyses to examine how the EFP may behave differently upon shocks in a small open economy, and how the openness may reinforce or dampen the impacts of shocks through exchange rate movements. Section 6 concludes.

2. The model

2.1 The model

2.1.1 The goods market

Consider a small open economy operates under floating exchange rates and perfect capital mobility in a DSGE structure. There are households, firms, banks, and government. The typical household owns a monopolistically competitive firm and a perfectly competitive bank. All the goods are traded across countries by using capital and labor as inputs which are immobile across countries. The consumption bundle of the countries includes the domestic goods and imports.

The consumption bundle in the country consists of the domestic and imported goods:

$$c_t = \left[\left(\alpha^d\right)^{1-\nu} \left(c_t^d\right)^{\frac{(\nu-1)}{\nu}} + \left(\alpha^m\right)^{1-\nu} \left(c_t^m\right)^{\frac{(\nu-1)}{\nu}} \right]^{\frac{\nu}{(\nu-1)}}$$

The associated price index of the composite goods, and the associated demands for each type of goods are shown below:

$$P_t^i = \left[\int_0^1 P_t^i(s)^{1-\nu}\, ds \right]^{\frac{1}{1-\nu}} \quad i = d, m, \qquad P_t = \left[\alpha^d \left(P_t^d\right)^{1-\nu} + \alpha^m \left(P_t^m\right)^{1-\nu} \right]^{\frac{1}{1-\nu}},$$

$$c_t^i = \alpha^i \left(P_t^i / P_t\right)^{-\theta} c_t, \quad i = d, m \tag{1}$$

where $\alpha^d \left(\alpha^m\right)$ are the percentage of the domestic (import) good in c_t, with $\alpha^d, \alpha^m \geq 0$, $\alpha^d + \alpha^m = 1$. ν and θ are the price elasticity of each individual goods and each type of goods in the aggregate consumption. P_t^i is the price of goods associated with the firms of the country. The goods of type d and m present the domestic goods and imported goods respectively.

The consumption demand and the price index in the rest of the world follow the similar fashion:

$$c_t^x(s) = \left(P_t^x(s)/P_t^x\right)^{-\nu} c_t^*, \qquad \text{with } c_t^* = \left(P_t^x / P_t^*\right)^{-\mu} \tag{1}$$

where

$$c_t^x = \left[\int_0^1 c_t^x(s)^{(\nu-1)/\nu} ds\right]^{\nu/(\nu-1)} \quad \text{and} \quad P_t^x = \left[\int_0^1 P_t^x(s)^{1-\nu} ds\right]^{1/(1-\nu)}$$

Here, P_t^x is the home country's export price index denominated in the foreign currency and P_t^* is the aggregate price index for the rest of the world. We assume that the law of one price holds for the home goods and thus $P_t^d = P_t^x e_t$ where e_t is the nominal exchange rate.

2.1.2 The representative household

The typical household's preference is described by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\psi \log(c_t) + (1-\psi)\log(1 - l_t^s - n_t^s)\right] \tag{2}$$

where $\beta \in (0,1)$ is the subjective discount rate , and c_t is the period t consumption bundle.[a] The time that the typical household own is normalized to one, l_t^s and n_t^s are the labor supplied in the good production and banking sector separately. ψ characterizes the importance of the utility generated by consumption .

The typical household obtains income from the salary of working, revenue from production, receipt of financial assets, and net sales of capital goods. So the budget constraint can be written as

[a] It is a Dixit-Stiglitz consumption bundle, in advance for always lending to consume.

$$q_t\left(1-\delta\right)K_t+\frac{M_{t-1}}{P_t}+\frac{e_tB_t^*}{P_t}+\frac{B_t}{P_t}+w_t(l_t^s+n_t^s)+\alpha^d\left(\frac{P_t^d\left(s\right)}{P_t^d}\right)^{1-\nu}\left(\frac{P_t^d}{P_t}\right)^{1-\theta}c_t^A+$$
$$\left(\frac{e_tP_t^x\left(s\right)}{P_t}\right)\left(\frac{e_tP_t^x\left(s\right)}{P_t^x}\right)^{-\nu}\left(\frac{P_t^x}{P_t^*}\right)^{-\mu}-w_t(l_t+n_t)-q_tK_{t+1}-\frac{M_t}{P_t}-T_t \tag{3}$$
$$-\frac{e_tB_{t+1}^*}{P_t(1+R_t^{B^*})}-\frac{B_t}{P_t\left(1+R_t^B\right)}-c_t=0$$

Here, q_t is the value of the capital in terms of consumption goods, δ denotes the depreciation rate of capital, K_t represents the capital stock in the period t. w_t is the real wage rate and is identical across sectors. l_t is the labor demanded by firms in the production sector, while n_t is the labor demand of banks. M_t is nominal holdings of high-powered money at the end of t. T_t stands for the real lump-sum tax payment in the period t.

B_{t+1} is the bonds issued by the home government and R_t^B denotes the associated interest rate. We assume that the home bonds are circulated within the country only. On the world asset market, there is one internationally tradable bonds, B_{t+1}^*, with the interest rate $R_t^{B^*}$. Following the specification in Kollmann (2002), we assume there is a world interest rate that prevails on the global asset market and the relationship between the world interest rate and the bond rate paid by the individuals in the small open economy is stated as below:

$$\left(1+R_t^{B^*}\right)=\left(1+R_t^*\right)\text{-}\varphi\left(B_{t+1}^*/P_t^*\right)/\chi \tag{4}$$

Eq. (5) captures the friction in the global financial market with φ as the degree of capital mobility. Higher φ represents lower capital mobility and thus the bond rate faced by the home individual will be lower, closer to the world bond rate. χ is the steady-state value of exports $\left(P_t^x/P_t^*\right)^{-\mu}$.

2.1.2 The goods market clearing condition

Goods are sold in the domestic market or are exported to the rest of the world. Under monopolistically competitive markets, output is determined by the demand. Therefore, the market clearing condition holds as follows:

$$K_t^{\eta}\left(A_t^l l_t\right)^{1-\eta}-\alpha^d\left(\frac{P_t^d(s)}{P_t^d}\right)^{-\nu}\left(\frac{P_t^d}{P_t}\right)^{-\theta}c_t^A-\left(\frac{P_t^x(s)}{P_t^x}\right)^{-\nu}\left(\frac{P_t^x}{P_t^*}\right)^{-\mu}=0 \quad (5)$$

where $c_t^A=c_t+\delta q_t K_t$ and A_t^l is the technology shock to the goods production.

To simplify the model, we will assume that the capital remains at its steady-state level all the time, following GM (2007). Therefore, in the following calibrations, the investment expenditure is completely reflected by the movements of the capital value, q_t.

2.1.3 Banks

Aside from the real sector, there is a banking sector in the economy to supply the liquidity services, including deposits and loans, to the market. If the typical household wants to consume goods, they need to hold money in the period t for the payment. Therefore, the consumption is subject to the credit-in-advance constraint as follows:

$$c_t=\frac{VD_t}{P_t} \quad (6)$$

where D_t is the nominal deposits, and V stands for the velocity of deposits.[a]

The bank as the financial intermediary receives deposits and creates loans. Thus the bank's asset is composed of the total reserves M_t and loans L_t, while the liability

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[a] The concept comes from the equation of exchange $\left(MV=PY\right)$, similar to the turnover rate of money per year.

consists of the demand deposit D_t. The balance sheet is shown below:

$$M_t + L_t = D_t \tag{7}$$

where $M_t = \tau D_t$ with τ as the bank's reserve ratio[a].

To offer loans, the bank has to hire labor for the loan management (such as evaluating customers, monitoring loan repayments, and so on), as well as the acquisition of capital and the home government bonds as the collateral. The internationally traded bonds are not effective to serve as the collateral for loans. The loan production is assumed to follow the Cobb-Douglas form:

$$\frac{L_t}{P_t} = Z\left(b_{t+1} + A_t^k \Theta q_t K_{t+1}\right)^{\alpha}\left(A_t^n n_t\right)^{1-\alpha} \qquad 0<\alpha<1 \tag{8}$$

where Z is the constant measure of the loan production efficiency. $\left(b_{t+1} + A_t^k \rho q_t K_{t+1}\right)$ is the collateral with $b_{t+1} = B_{t+1} / P_t\left(1 + R_t^B\right)$. A_t^k and A_t^n are shocks to the efficiency of capital as the collateral and the effectiveness of monitoring respectively. The financial distress that originates from the credit market can be characterized by negative shocks to A_t^k and A_t^n. Θ is a constant which manifests the inferiority of capital than the government bonds for collateral uses.[b]

2.2 First-order conditions

Before obtaining the first-order conditions, we let

$$\Omega_t = \alpha c_t / \left(b_{t+1} + A_t^k \Theta q_t K_{t+1}\right) \tag{9}$$

Since all the agents are symmetric, prices of goods in the same category will be identical. The first-order conditions with respect to l_t^s, l_t, n_t^s, K_t, B_{t+1}, B_{t+1}^*, P_t are

[a] That is to say, τ is the reserve requirement plus excess reserves.

[b] Because capital requires higher monitoring cost and has lower liquidity.

listed as follows:

$$\frac{1-\psi}{1-l_t-n_t}=w_t\lambda_t \tag{10}$$

$$w_t=\left(\frac{\psi}{c_t\lambda_t}-1\right)\frac{(1-\alpha)c_t}{n_t} \tag{11}$$

$$w_t=\left(\frac{\xi_t}{\lambda_t}\right)A_t^l(1-\eta)\left(\frac{K}{A_t^l l_t}\right)^{\eta} \tag{12}$$

$$\left(\frac{\psi}{c_t\lambda_t}-1\right)A_t^k\Theta q_t\Omega_t-q_t+\beta(1-\delta)E_t\left(\frac{\lambda_{t+1}}{\lambda_t}q_t\right)+\beta\eta E_t\left(\frac{\lambda_{t+1}\xi_{t+1}}{\lambda_t\lambda_{t+1}}\left(\frac{A_{t+1}^l l_{t+1}}{K}\right)^{1-\eta}\right)=0$$

(13)

$$\left(\frac{\psi}{c_t\lambda_t}-1\right)\Omega_t-1+\beta E_t\left(\frac{\lambda_{t+1}P_t}{\lambda_t P_{t+1}}\left(1+R_t^B\right)\right)=0 \tag{14}$$

$$-1+\beta E_t\left(\frac{\lambda_{t+1}P_t e_{t+1}}{\lambda_t P_{t+1}e_t}\left(1+R_t^{B^*}\right)\right)=0 \tag{15}$$

$$\frac{\xi_t}{\lambda_t}=\frac{\nu-1}{\nu}\cdot\frac{P_t^d}{P_t} \tag{16}$$

$$b_{t+1}=B_{t+1}/P_t\left(1+R_t^B\right) \tag{17}$$

$$b_{t+1}^*=e_t B_{t+1}^*/P_t\left(1+R_t^{B^*}\right) \tag{18}$$

$$P_t^x=\frac{P_t^d}{e_t} \tag{19}$$

$$g_t-T_t=\frac{M_t}{P_t}-\frac{M_{t-1}}{P_t}+\frac{B_{t+1}}{P_t\left(1+R_t^B\right)}-\frac{B_t}{P_t} \tag{20}$$

The difference between Eq. (15) and Eq. (16) is the liquidity service offered by the home bonds to serve as the collateral for loans. Therefore, the interest rate of foreign bonds has to be high enough to offset its failure to serve as the collateral for loans. Eq. (20) is the law of one price condition and Eq. (21) is the government budget constraint. The government does not hold any international traded bond, but finances its expenditures by levying tax, issuing high-powered money and bonds. In the symmetric, flexible-price equilibrium, Eqs.(1), (2), (4) - (21) determine the values of twenty endogenous variables, $c, l, n, w, \lambda, \Omega, L, D, q, B, B^*, b^*, e, P, P^d, c^A, \xi, T$ and R^B, R^{B^*} given the processes of exogenous variables and government policies M, b and g. For simplicity, we assume the government spending g_t equals to zero throughout.

2.3 Exogenous variables

Now we turn to the exogenous variables. There are the world's price index, import good price, and world interest rate for the rest of the world which have to be specified exogenously, because the small open economy does not have the power to affect the rest of the world. Following Kollmann (2002), we assume all of these exogenous variables follow the AR (1) process:[a]

$$\Pi_t^* = (1-\rho^{\Pi^*})\Pi^* + \rho^{\Pi^*}\Pi_{t-1}^* + \varepsilon_t^{\Pi^*}, \quad 0 \le \rho^{\Pi^*} < 1 \tag{21}$$

$$\Pi_t^m = (1-\rho^{\Pi^m})\Pi^m + \rho^{\Pi^m}\Pi_{t-1}^m + \varepsilon_t^{\Pi^m}, \quad 0 \le \rho^{\Pi^m} < 1 \tag{22}$$

$$R_t^* = (1-\rho^R)R^* + \rho^R \pi_{t-1}^* + \varepsilon_t^R, \quad 0 \le \rho^R < 1 \tag{23}$$

where $\Pi_t^* = P_t^* / P_{t-1}^*$ and $\Pi_t^m = P_t^m / P_{t-1}^m$.

Moreover, the exogenous shocks also obey the AR(1) process:

$$A_t^l = \left(1-\rho^l\right)A^l + \rho^l A_{t-1}^l + \varepsilon_t^l, \quad 0 \le \rho^l < 1 \tag{24}$$

$$A_t^k = \left(1-\rho^k\right)A^k + \rho^k A_{t-1}^k + \varepsilon_t^k, \quad 0 \le \rho^k < 1 \tag{25}$$

$$A_t^n = \left(1-\rho^n\right)A^n + \rho^n A_{t-1}^n + \varepsilon_t^n, \quad 0 \le \rho^n < 1 \tag{26}$$

where ε^{Π^*}, ε^{Π^m}, ε^R, ε_t^l, ε_t^k, ε_t^n are i.i.d. distributed.

[a] We accept the most standard formula; I think it is best to stay close to the mainstream of this theory.

In addition, we assume that the growth rate of high-powered money follows the similar evolution process:

$$h_t = \rho^h h_{t-1} + \varepsilon_t^h, \quad 0 \le \rho^h < 1 \tag{28}$$

where $h_t = \log M_t - \log M_{t-1}$. By assuming the monetary policy as the control over the stock of high-powered money, instead of the interest rate rule, this model can generate the interest rates endogenously.

3. Interest rate

3.1 interest rate relationship

Various interest rates are determined endogenously in the model. To compare with the conventional models, we introduce an uncollateralized loan rate, R^T, as the benchmark interest rate. With the specification of the household optimization problem above, R_t^T must satisfy the condition below that resembles the Euler equation in the conventional literature:

$$1 + R_t^T = E_t \frac{\lambda_t P_{t+1}}{\beta \lambda_{t+1} P_t} \tag{29}$$

The link between R_t^T and the government bond rate R_t^B could be obtained from Eq. (29) and Eq. (15)

$$\frac{1 + R_t^B}{1 + R_t^T} = 1 - \left(\frac{\psi}{c_t \lambda_t} - 1 \right) \Omega_t \tag{30}$$

From the equation above, we can see that these two rates would be identical when $\Omega_t = 0$ or $\left(\psi / c_t \lambda_t - 1\right) = 0$. The far right term of Eq. (29) could be viewed as the liquidity premium of bonds.

The interbank rate R_t^{IB} is the most common tool of the central bank's monetary policy. Equipped with the reserve market, banks can obtain funds at the cost R_t^{IB} and loan them out to households without requiring the collateral at the uncollateralized rate R_t^T. So there must be a no-arbitrage condition between the interbank rate and loan rate for the competitive banks. The marginal cost of the loan making is equal to the wage divided by the marginal product of labor. The combination of Eqs. (7), (8), (9) yields the wage w_t. The relationship between these two interest rates must satisfy the condition below:

$$\left(1+R_t^T\right)=\left(1+R_t^{IB}\right)\left[1+\frac{Vw_t n_t}{(1-\alpha)(1-\tau)c_t}\right] \tag{31}$$

On the other hand, households can also obtain loans with collaterals. The relationship between R_t^{IB} and R_t^L should follow the similar fashion. Since the collateral can help reduce the monitoring effort by the share of α, the marginal cost of the collateralized loans can be multiplied by $(1-\alpha)$. Therefore, the difference between the collateralized loan rate and the interbank rate can be stated as below:

$$\left(1+R_t^L\right)=\left(1+R_t^{IB}\right)\left[1+\frac{Vw_t n_t}{(1-\tau)c_t}\right] \tag{32}$$

Lastly, since the bank holds the fraction τ of deposit as the reserve. It is natural for R_t^{IB} and R_t^D to differ in reserve ratio under the perfectly competitive setup. Thus, the relationship between the deposit and the interbank rate is:

$$R_t^D=R_t^{IB}(1-\tau) \tag{33}$$

The distinction of various interest rates allows the endogenous determination of EFP.

Here EFP can be determined by $R_t^L - R_t^{IB}$ which reflects the real marginal cost of managing and monitoring effort multiplied by the nominal wage of the loan production. Since the EFP would influence the bank loan strategy, the following analysis will emphasize its movements.

4. Steady state

4.1 Steady state

In this section, we will examine the deterministic steady sate with zero inflation. In the steady state, we assume that the price of capital $q = 1$ and the nominal exchange rate is equal to 1. Moreover, to simplify the analysis, we assume that $P = P^d = P^m = P^x = 1$ and the world price index for the rest of the world $P^* = 0.67$. The international interest rates, R^{B^*} and R^* are specified as 0.01, following Kollmann (2002). Moreover, according to GM (2007), gb is the constant share of the government bonds to consumption and is assumed to be 0.6 in the steady state. As a result, Eqs. (1) & (2), (4) - (21) will be degenerated to nine equations for nine endogenous variables $c, l, n, w, \lambda, \Omega, K, b^*, R^B$.

The steady-state conditions can be stated as below. Firstly, the combination of Eq. (7), (8), (9)

$$1 = \frac{V}{1-\tau} Z \left(gb + \frac{\Theta q K}{c} \right)^{\alpha} \left(\frac{n}{c} \right)^{1-\alpha} \tag{34}$$

Then Eqs. (10) – (14), (6) can be stated as follows:

$$\Omega = \frac{\alpha}{gb + \frac{\Theta q K}{c}} \tag{35}$$

$$\frac{1-\psi}{1-l-n}=w\lambda \tag{36}$$

$$w=(\frac{\psi}{c\lambda}-1)\frac{(1-\alpha)c}{n} \tag{37}$$

$$w=\frac{(\nu-1)(1-\eta)}{\nu}\left(\frac{K}{l}\right)^{\eta} \tag{38}$$

$$\left(\frac{\psi}{c\lambda}-1\right)\Theta\Omega-1+\beta\left[1-\delta+\frac{\eta(\nu-1)}{\nu}\left(\frac{K}{l}\right)^{\eta-1}\right]=0 \tag{39}$$

$$K^{\eta}n^{1-\eta}-\alpha^{d}c^{A}-\left(\frac{P^{x}}{P^{*}}\right)^{-\mu}=0 \tag{40}$$

After these seven steady-state variables are obtained from Eqs. (33) to (39), we can derive R^{B^*} and b^* from the Euler equations associated with the home and foreign bonds, and the current account balance by combining Eqs.(4), (6), and (21).

$$\left(\frac{\psi}{c\lambda}-1\right)\Omega+\beta\left(R^{B^*}-R^{B}\right)=0 \tag{27}$$

$$b^{*}R^{B^*}=\alpha^{m}c^{A}-\left(P^{x}/P^{*}\right)^{-\mu} \tag{28}$$

After solving the core model, we can easily solve the steady-state level of R^T, R^{IB}, R^L, R^D and the EFP from the interest rate conditions Eqs. (28) – (31).

4.2 Model Parameterization

Now we calibrate the model with the appropriate specification of parameter values. In particular, we will emphasize the importance of the banking sector and how much the economic openness matters.

Firstly, we set the quarterly discount factor β to 0.99, and $\delta=0.025$ for the quarterly depreciation rate as the conventional setting. ψ is assumed to be 0.48 to generate the reasonable labor input in the production sector which is approximately

$1/3$ of the total time endowment. $\alpha^m = 0.3$ is specified so that the steady-state imports/GDP ratio is 30%, consistent with the Germany and U.K. data. The steady-state price-marginal cost markup factor for goods produced by the domestic firms is set at $\nu/(\nu-1) = 1.1$, and the price elasticity for all goods in the economy and the rest of the world is chosen $\theta = \mu = 5$. Following GM (2007), we choose $\eta = 0.36$ to reflect the relative shares of capital and labor in the goods production.

Then there are the parameters related to money and banking sector need to be determined. The velocity of monetary turnover rate is specified as $V = 0.4$, and the bank reserve ratio is equal to 0.005.[a] The parameters in the loan production are Θ, Z, α, and are assumed to be 0.2, 10, 0.65, following the specification in GM (2007). In the steady state, we let the bond rate $R^* = 0.01$. φ=0.002 is the value of panel regression for 21 OECD countries by Milesi-Ferretti & Lane (2001).

4.3 Numerical results

The steady-state results of the baseline model are summarized in Table 1. Since the steady state is in the zero inflation condition, all the interest rates are in the "real" term. Firstly, the total labor $l + n \approx 33.69\%$ is a reasonable value close to $1/3$ that is generally accepted in the business cycle literature. Because we set the world interest rate $R^* = 1\%$ as the normal level, other rates are determined accordingly from the interest rate relationships in Section 3. As shown, the loan rate R_t^L is about 0.56% quarterly, the interbank rate is 0.32% and consequently the EFP is at the level around

[a] $V = 0.31$ in Goodfriend & McCallum(2007), but the interest rates will be negative in this study with the same velocity.

Table1: Benchmark model $\left(Z=10,\ \alpha^{m}=0.3\right)$

Variable	c	c^{A}	l	n	w	K	b^{*}	b
Steady State	1.2399	1.5294	0.3363	0.0035	2.0799	11.575	32.712	0.7439
Variable	R^{IB}	R^{B}	R^{L}	R^{T}	R^{D}	λ	Ω	EFP
Steady State	0.00323	0.0041	0.0056	0.01	0.00322	0.3787	0.2635	0.0024

0.24%. While various interest rates in the model are in different levels, if the central bank uses only one interest rate for the monetary policy making, it may lead to misjudgments.

Furthermore, we calibrate two more cases to examine the significance of banking sector and economic openness in an economy. First, we consider a highly efficient financial market by specifying Z to be 10 times higher than the benchmark model. The calibration outcomes are listed in Table 2. Under the assumption of perfectly competitive bank industry and the bank which could produce loans in a highly efficient way, all the interest rates converge to R^{*}. Therefore, the EFP is driven down to a level close to zero and so is the labor in the banking sector. Indeed, the high efficiency of the banking sector can successfully reduce the EFP in a small open economy as in a closed economy, which signals the worsening of the asymmetric information problem on the credit market.

The other case is the lower openness of the country by letting α^{m} to be equal to 0.1. The calibration outcome is presented in Table 3. By comparing Table 2 and 3, we can see that consumption rises with the openness of trades, but capital drops. The most significant change is the rise in the steady-state real current account balance as shown by b^{*}. As shown in Eq. (39), the accumulation of the international bonds must be accompanied by excess imports. While the trade deficit rises with the degree of openness, the bonds needed are greater. Furthermore, stronger consumption demand

Table2: Highly efficient banking system $\left(Z = 90,\ \alpha^m = 0.3\right)$

Variable	c	c^A	l	n	w	K	b^*	b
Steady State	1.2427	1.5217	0.3409	0.000	2.0427	11.159	32.482	0.7456
Variable	R^{IB}	R^B	R^L	R^T	R^D	λ	Ω	EFP
Steady State	0.01	0.01	0.01	0.01	0.01	0.3862	0.2713	0.000

Table3: Less open market $\left(Z = 10,\ \alpha^m = 0.1\right)$

Variable	c	c^A	l	n	w	K	b^*	b
Steady State	1.1108	1.4519	0.4058	0.0024	2.0624	13.643	1.3503	0.6665
Variable	R^{IB}	R^B	R^L	R^T	R^D	λ	Ω	EFP
Steady State	0.00497	0.0069	0.0067	0.01	0.00494	0.426	0.2127	0.0018

due to greater openness induces higher demand for deposits, and thus causes lower interest rates in the steady state. However, this results in a higher level of EFP.

5. Dynamic Analyses

In this section, we will discuss the impacts of productivity and financial shocks on the economy. The numerical examination of dynamic analyses will focus on two parts. One is the quantitative importance of credit channel in a small open economy. The interest rate movements caused by international transactions will have an additional influence on the EFP movements. Furthermore, while current credit channel studies are examined in a closed economy, our study will investigate the implications of a small open economy on the financial sector. Since shocks alter the demand and supply for deposits and loans in an economy, closely related to the consumption which is altered by the international trades, the exchange rate movements and trades drive the interest rate disparity across countries which further affects the transaction of international tradable bonds as well as the EFP.

The following calibrations are conducted under highly persistent shocks. We assume the AR(1) coefficients of shocks, $\rho^l = \rho^k = \rho^n = \rho^m = 0.99$, while the persistence of the prices, $\rho^{\Pi^*} = \rho^{\Pi^m} = 0.8$ and $\rho^R = 0.95$.

Moreover, we assume that prices are rigid in the short run and that firms adopt the Calvo staggered pricing as the pricing strategy. To avoid further complication of the model, the price adjustment process is characterized as follows:

$$\Pi_t = \beta E_t \Pi_{t+1} + \kappa \sigma_t + u_t \tag{20}$$

where $\kappa > 0$ and

$$\Pi_t = \log P_t - \log P_{t-1} \tag{21}$$

which stands for the inflation rate of the aggregate price level. σ_t denotes the real marginal cost of goods production and can be identified as:

$$\sigma_t = \xi_t / \lambda_t \tag{22}$$

κ is assumed to be 0.05 for calibrations.

5.1 Positive productivity shock: $A_t^l = 0.01$

Figure 1 shows the impacts of positive productivity on the economy. Similar to the conventional wisdom, output rises which is accompanied by lower labor input resulting from the technological improvement. The expansion in the home production leads to lower export prices and exchange rate appreciations, which lowers the import price, causing greater imports. Therefore, the domestic consumption increases.

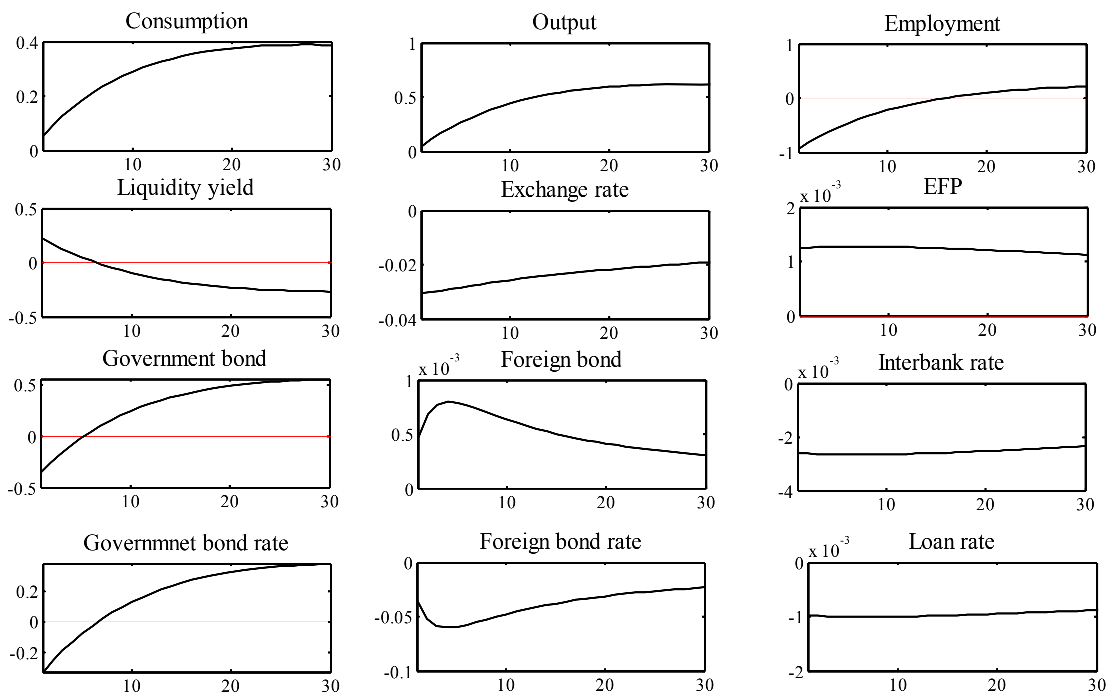

Figure 1: A positive unit shock to productivity: $A_t^l = 0.01$

On the other hand, the domestic bond rate declines upon shock, but rises above the normal level with time, while the foreign bond rate drops below the steady-state level all the time and will turn negative in the end. The relative change of interest rates shrinks the spread between the home and foreign bond rates over time. This implies that the benefit from the liquidity service offered by the home bond declines gradually and thus drives greater demand for the foreign bonds, causing the home currency to depreciate over time. The home depreciation dampens the interest rate difference across countries, but fails to completely offset the disparity.

The lower benefit from the loan results in lower demand for loans and thereby drives down the loan rate. However, the central bank also reduces the interbank rate in reaction to the deflation due to the technological progress and causes the strongly procyclical EFP, in contrast to the countercyclical EFP in the conventional credit channel literature which excludes money and is conducted in a closed economy. This

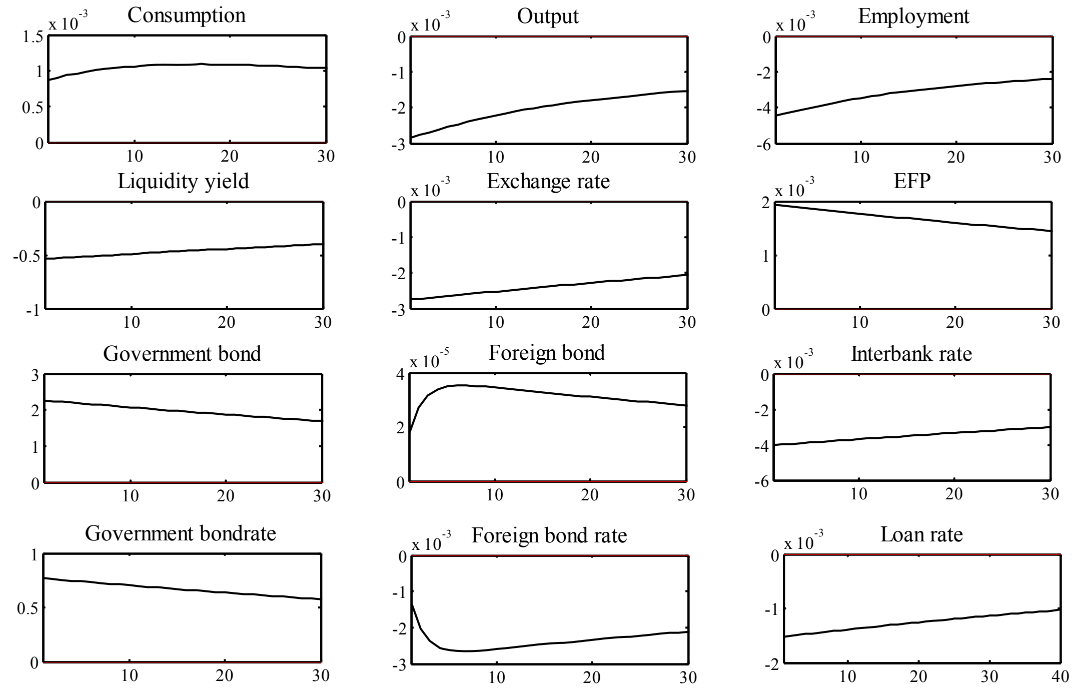

Figure 2: A unit shock to monitoring: $A_t^n = -0.01$, $\alpha^m = 0.3$

result prevails no matter how persistent the growth rate of the high-powered money is. This coincides with the "financial attenuator" of monetary policy in Goodfriend and McCallum (2007) which essentially demonstrates the importance of money in credit channel. It is because the expansionary money supply directly increases the demand for consumption, thereby deposits, which drives up the EFP.

5.2 A unit shock to the monitor of loans: $A_t^n = -0.01$

In line with the current financial crisis, shocks to the credit market would be critical to the economy and the openness of the capital market has made the crisis spread all over the world rapidly. The widespread crisis has cast strong doubt on globalization. In addition to the examination of the financial crisis which originates from the inefficiency of monitoring for the loan making process, we also want to discuss whether

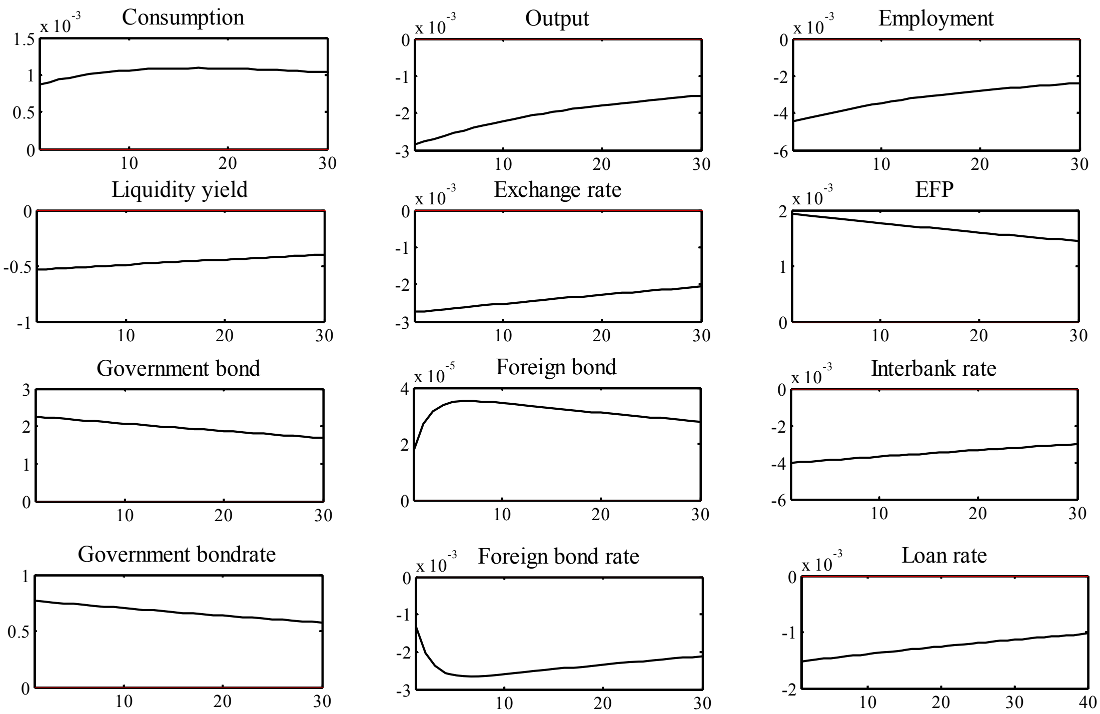

Figure 3: A unit shock to monitoring under a less open economy: $A_t^n = -0.01$, $\alpha^m = 0.1$

globalization helps reduce the spread of the financial shock. However, instead of investigating the transmission mechanism of the financial distress, we will focus on whether the financial shock to a small open economy can be dampened by the openness of the economy.

Figure 2 demonstrates the impacts of the shock to the monitoring for the loan on the economy. While the loan making lacks monitoring, it requires greater amount of collaterals for making the loans. Therefore, the demand for the home bond increases sharply, induced by the rising bond rate. The reduction of the liquidity services that the home bonds generate leads to greater demand for foreign bonds, accompanied by falling foreign bond rate. While the spread between the foreign and home bond rates turns negative, the home currency appreciates. On the other hand, international trades also cause the exchange rate movements.

The home appreciation, together with the financial distress, causes the home production to drop while the consumption rises, benefiting from cheaper import prices. Other interest rates, on the other hand, fall upon shocks. In particular, the central bank has to reduce the interbank rate to help the economy recover which has encountered declining output and deflation. The loan rate also drops due to the lower supply of loans. The failure of monitoring triggers the asymmetric information problem in the model causes the EFP to rise, same as the EFP movement in the closed-economy framework in GM (2007) under the financial shock. The divergent movements of the bond rate and other interest rates place an emphasis on the importance of the distinction of interest rates in an economy with the financial sector. This effect is absent from the conventional credit channel literature.

The home currency appreciation seems peculiar for an economy experiencing financial crisis, but interestingly, it coincides with the movements of the US dollars since the subprime crisis broke out in 2007. Not only that the US dollars did not experience significant depreciations, but also there seems to be a great demand for the currency of the country where the crisis originated. The model here offers an explanation for the strong dollar: the demand for the US assets remain high to offset the loss in the collaterals for the loan making.[a]

Moreover, we have seen that the exchange rate movement has reinforced the impacts of the ineffectiveness of the loan monitoring on the economy. The home appreciation caused by the financial shock leads to higher export prices, thereby lowers the home production further. The calibration results of the model under lower degree of openness are shown in Figure 3. The comparison of Figure 2 and 3 demonstrates that the impacts of the financial shock on output increase with the openness.

[a] The small-open-economy setup here may not be consistent with the US economy. We assume that foreigners do not hold home bonds, and the currency of the small open economy is definitely not the international currency as the US dollars.

5. Conclusion

In this paper, we examine the credit channel in a small open economy by using a small-open-economy DSGE model with the banking sector. The discussions center on two aspects. One is the role of the credit channel in a small open economy and the other is the implications of economic openness for the banking sector. The steady state analyses show that the banking sector remains a significant role in the small open economy as in a closed economy. Moreover, the openness of trades drives down the interest rates, but raises the EFP. The analyses on dynamics, driven by the productivity and financial shocks, are consistent with the steady-state results, but additionally demonstrate that the exchange rate movements may reinforce the impacts of financial shocks on the economy.

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