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期末報告

動態隨機一般均衡模型於中國經濟之非傳統貨幣政策之探討(第2年)

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中 文 摘 要 ： 在此研究中，我們建構一個包含金融部門的小型開放動態隨機一般均衡(DSGE)模型，並納入符合中國大陸現況的國內金融體系管制以及國際資本市場管制，以對中國大陸貨幣政策改革進行福利分析。中國大陸貨幣政策刻正進行改革，逐步解除國內金融市場以及國際資本市場的管制，此將使貨幣政策以及外在衝擊的傳導機制改變，透過 DSGE 模型進行福利分析，將有助於我們了解相關改革措施對於總體經濟以及福利水準的影響。研究結果顯示，相較於國內金融體系管制的解除，開放資本帳的影響將更為顯著。也因此，本研究建議，在貨幣政策的改革中，資本帳的開放當應更為審慎。

中 文 關 鍵 詞 ： 動態隨機一般均衡模型; 中國經濟; 經濟轉型

英 文 摘 要 ： In this study, we establish an open-economy DSGE model with the frictional domestic credit market to conduct the welfare analyses of monetary policy reform plans of China. Currently, both the domestic credit market and international capital market are under various regulations. The progress of the gradual removal of these market regulations, which may crucially alter the transmission mechanism of domestic as well as foreign shocks, is important for the economic transformation of the Chinese economy. The welfare analyses generate important policy implications for the progress of policy reforms. The results suggest that, compared with domestic deregulations, opening capital account can be most critical as it makes the international transmission mechanism of shocks feasible.

英 文 關 鍵 詞 ： DSGE; Chinese economy; economic transformation

Welfare Implications of the Chinese Monetary Policy Reform: A Dynamic Stochastic General Equilibrium Approach

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Abstract

In this study, we establish an open-economy DSGE model with the frictional domestic credit market to conduct the welfare analyses of monetary policy reform plans of China. Currently, both the domestic credit market and international capital market are under various regulations. The progress of the gradual removal of these market regulations, which may crucially alter the transmission mechanism of domestic as well as foreign shocks, is important for the economic transformation of the Chinese economy. The welfare analyses generate important policy implications for the progress of policy reforms. The results suggest that, compared with domestic deregulations, opening capital account can be most critical as it makes the international transmission mechanism of shocks feasible.

Keyword : dynamic stochastic general equilibrium (DSGE), Chinese economy, economic transformation

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1. Introduction

In past three decades since the revolution and opening in 1978, China has made remarkable economic performance which has aroused lots of interests in studying macroeconomic fundamentals and policies of China's economy. After the high growth rate lasting for the past two decades, the Chinese economy is experiencing the critical stage of economic transformation. The priority task is to gradually remove various government's regulations on the economy which may have led to significant distortions of the market mechanism and fundamentally alter the channel that shocks and policies are transmitted. Whether or not the policy reforms succeed can be the critical determinant of the long-term economic development.

Due to the market distortion by regulations, the standard dynamic stochastic general equilibrium (DSGE) model with full market mechanism may not be appropriate for the studies of the Chinese economy. As a result, it was not until most recently this framework has been used for China.[1] The DSGE model may help us understand better the transmission mechanism of shocks and policies in the economy with, and without, the regulations. Thus, we may understand better how the policy reforms may alter the market mechanism and the way shocks are transmitted.

In this paper, we will shed light on the monetary policy reforms. The current monetary policy of China includes the conventional and unconventional measures. In addition to its general goal of controlling the money supply (M1 and M2), the People's Bank of the Republic of China (the PBoC) also imposes various regulations

[1] The more recent studies include Zhang (2009), Liu and Zhang (2010), Straub and Thinmann (2010), and some others. All of them use the standard framework in the literature. For instance, Liu and Zhang (2010) calibrate a standard New Keynesian model under monetary aggregate rule and interest rate rule to assess which policy rule works better for China. Straub and Thinmann (2010) investigate the dynamic adjustment of the economy with a standard open-economy framework under both flexible and fixed exchange rate regimes. The standard DSGE model may fail to capture the distorted market mechanism of the Chinese economy.

on the domestic credit market and foreign exchange market both of which are crucially related to the monetary policy. On the foreign exchange market, the PBoC conducts the managed floating exchange rate regime and also implements capital control where only little international capital flows are permitted. On the domestic credit market, the PBoC imposes the floor for the loan rate and ceiling for the deposit rate, as well as the amount of loan making.

Because of the Chinese characteristics, some most recent working papers have incorporated the market regulations in DSGE models to examine the macroeconomic responses to shocks with and without the regulations. Chen, Funke and Paetz (2012) include government's regulations on the deposit and loan rates, required reserve ratio, and quantity of credit in a closed-economy DSGE model to simulate the "unconventional" monetary policy which differs from most countries. The calibration results show that these policy tools interrelate, augment and intensify each other. Chang, Liu and Spiegel (2014) use an open-economy DSGE model with capital control where domestic households are not allowed to hold foreign assets. Under capital control, the conventional uncovered interest rate parity condition does not hold. To maintain the exchange rate management and closed capital account, the central bank buys up any net inflow of foreign assets using domestic currency. The central bank may not want to fully sterilize the increase in the money supply when the cost of sterilization, the home and foreign interest rate spread, increases. Thus, the capital control under managed floating exchange rate are the key factor driving up the inflation.

These two papers examine the domestic credit market and foreign exchange market separately. However, the credit policy for the domestic financial market and capital control for the international capital market can be closely interrelated: they may intensify each other, or one of the regulations can be redundant.

The regulations on the domestic credit market and international capital market can be closely related. Under capital control and managed floating exchange rate, the central bank will buy foreign bonds from the public if there are current account surplus. The increase in the money supply may drive up the inflation rate if the monetary expansion is not fully sterilized. This may further increase the liquidity prevailing on the domestic credit market. The regulations on the amount and interest rates of loan making, however, may alter the effects. On the other hand, the performance of the domestic financial market can lead to international capital flows and exchange rate movements. The macroeconomic effects under financial distress can be different if the capital account is closed.

Therefore, we establish an open-economy DSGE model incorporating the frictional domestic banking sector and international capital market. We examine the regulations on the domestic credit market and the international capital market, both of which are subject to the unconventional regulations. On the international capital market, the PBoC implements the managed floating exchange rate regime and capital control. The PBoC can also actively adjust the required reserve ratio with the emphasis of economic stabilization. During the process of China's economic transformation, this study may help us understand better how the policy reforms may alter the shock transmission and the welfare of various policy reform plans.

The remainder of this paper is organized as follows. In Section 2, there is a brief introduction of China's monetary policy. Section 3 outlines the model, as well as the monetary policies and interest rates. The calibration is stated in Section 4. The welfare analyses of policy reforms are presented in Section 5. Section 6 concludes.

2. China's Monetary Policy

The monetary policy that the PBoC conducts includes the conventional and unconventional measures. In regard to the conventional measures, similar to the Central Bank of Taiwan, in the end of each year, the PBoC announces the target of M1 and M2 growth rates for the succeeding year.

The PBoC also imposes the required reserve ratio for deposits in banks. However, different from most of the central banks in the world which adjust the ratio infrequently, the PBoC frequently adjusts the required reserve ratio as one of the primary macro control measures to stabilize the economy in past two decades.[2]

Furthermore, the PBoC implements various regulations on the prices and quantities on the domestic credit market and foreign exchange rate market. On the domestic credit market, the PBoC restricts the range of interest rate fluctuations by specifying the upper bound of the deposit rate and lower bound of loan rate. The deposit, loan rates and the deposit-loan rate spread in 2000-2014 are listed in Figure 1. Moreover, the PBoC imposes the quota for banks' loan making.[3]

The regulations on the foreign exchange market involve the regulations on the exchange rate movement and capital flows. Starting from July 2005, the RMB exchange rate is partially liberalized, from the fixed rate of 8.2 against the US dollar, to the managed floating regime targeted to a basket of currencies. Since then till December 2012, the Renminbi against the US dollars has appreciated by 25%.[4] The

[2] For example, to stabilize the economy, particularly in the attempt to dampen surging house prices, the government actively uses various macro control policies, one of which is the monetary policy. The PBoC has adjusted the required reserve ratio for 31 times from May 2007 to June 2014. The current level of required reserve ratio exceeds 20%.

[3] Chen, Funke and Paetz (2012) make a comprehensive summary of the domestic credit market regulations.

[4] The regulation on exchange rate from free floating has been attributed to its high current account surplus from trades with advanced countries. The share of net export in the GDP has risen from 5.46% in 2005 to 8.8% in 2007, then gradually declined to 2.61% in 2011. Various empirical studies have shown that the appreciation of Renminbi does help reduce trade surplus. (Yu, 2009, 2010; Hwang, Peng

crucial regulation measure on the foreign exchange market is the capital control. The capital account of China is under strict regulation where free international capital flows are not permitted. Only a limited number of certified financial institutions are eligible for conducting the financial transactions within the quota approved by the State Administration of Foreign Exchange (SAFE).

Being aware of the importance of market deregulations for the economic transformation, particularly the RMB internationalization has been considered as the ultimate goal of monetary policy reform, the Chinese government is gradually relaxing the regulations on financial markets. The fluctuation range of interest rates is widened. The upper bound of the deposit rate is just raised up to 1.2 times of the baseline deposit rate in November 2014, from 1.1 times of the baseline deposit rate earlier.

The range of exchange rate fluctuations is also widened. Currently, the daily RMB exchange rate movement is permitted to fluctuate within the range of 2%, larger than the range of 0.5% before April 2012.

The capital control is also little relaxed. Starting from 2002, the PBoC allows the limited amount of international capital flows by certified institutions. As for the end of October 2014, the overall amount is USD $64 billion for QFII (qualified foreign institutional investors, including 28 countries and 258 institutions), RMB $294 billion for the RQFII (Renminbi qualified foreign institutional investors, including 4 countries and 91 institutes), and USD $87 billion for the QDII (qualified domestic institutional investors, including 125 institutes). While these international financial transactions require the official approval, the most recent development, the Shanghai Hong Kong Stock Connect, which just started in November 2014, is the starting point of opening the capital account. It permits the financial transactions between the stock

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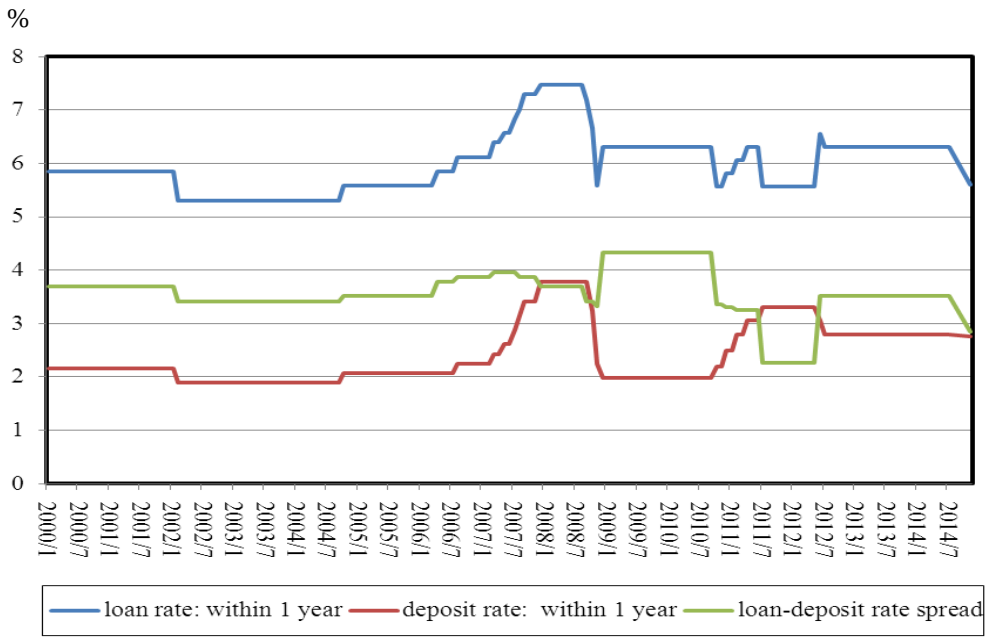
and Yang, 2012, and etc.)

market in Hong Kong and Shanghai, though there are still the ceiling for the transaction volume. We may expect the capital account can be gradually opened.



Source: The People's Bank of China (2014).

Figure 2: 1 year benchmark deposit, loan rates and the spread

3. The model

3.1 Goods market

In this paper, we establish a small open economy with a banking sector which is subject to financial friction.[5] Goods markets are monopolistically competitive. Firms produce goods for home consumption and exports. Consumers consume both home goods and imported foreign goods. The representative household consumes the composite goods, which are composed of domestic goods C_t^d and imported goods C_t^f:

[5] We follow the specification by Goodfriend and McCallum (2007).

$$C_t = \left[\left(\alpha^d\right)^{1-\theta} \left(C_t^d\right)^{\frac{\theta-1}{\theta}} + \left(\alpha^f\right)^{1-\theta} \left(C_t^f\right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{1}$$

where $\alpha^d, \alpha^f > 0$ represent the ratios of home and foreign goods in the aggregate consumption, C_t, respectively. θ is the intratemporal elasticity of substitution between domestic and foreign goods. The associated demand functions for the domestic and imported goods can be written as:

$$C_t^d(i) = \left(\frac{P_t^d(i)}{P_t^d} \right)^{-\nu} C_t^d, \quad C_t^f(i) = \left(\frac{P_t^f(i)}{P_t^f} \right)^{-\nu} C_t^f, \tag{2}$$

$$C_t^d = \alpha^d \left(\frac{P_t^d}{P_t} \right)^{-\theta} C_t, \quad C_t^f = \left(\alpha^f\right) \left(\frac{P_t^f}{P_t} \right)^{-\theta} C_t, \tag{3}$$

where $C_t^d(i)$ and $C_t^f(i)$ stand for the domestic goods and imported goods of variety i. ν is the elasticity of substitution among the different goods. The corresponding prices are shown as follows:

$$P_t^j = \left[\int_0^1 P_t^j(s)^{1-\nu} ds \right]^{\frac{1}{1-\nu}}, \quad j = d, f \tag{4}$$

$$P_t = \left[\alpha^d \left(P_t^d\right)^{1-\theta} + \left(\alpha^f\right) \left(P_t^f\right)^{1-\theta} \right]^{\frac{1}{1-\theta}}, \tag{5}$$

where $P_t^d(i)$ and P_t^d are the home-currency prices of individual and aggregate domestic goods, respectively, $P_t^f(i)$ and P_t^f are the home-currency prices for the imported goods and P_t is the aggregate price index. e_t is the nominal exchange rate, expressed in units of the domestic currency per one unit of foreign currency. We assume that the imports are priced according to the international prevailing price. Therefore, $P_t^f = e_t P_t^*$ where P_t^* is the international price, exogenous to the small open economy. Capital good is assumed to follow the same composition.

The home firm produces goods sold in both the domestic and foreign markets. The export demand function $C_t^X(i)$ of variety i is assumed to resemble the domestic demand function, Eq. (2):

$$C_t^X(i) = \left(\frac{P_t^{X*}(i)}{P_t^{X*}} \right)^{-\nu} C_t^X \quad \text{and} \quad C_t^X = X_t^* \left(\frac{P_t^{X*}}{P_t^*} \right)^{-\mu} \quad , \mu > 0, \tag{6}$$

where $P_t^{X*}(i)$ is the firm's export price in the foreign currency, P_t^{X*} is the aggregate price index of exported goods denominated in the foreign currency, and P_t^* is the foreign price index. μ is the price elasticity of the aggregate exports. We assume that X_t^* is subject to random shocks, exogenous to a small open economy.

3.2 Household

In this model, a representative household consumes the composite goods and supplies labor. She also owns the monopolistically competitive firm for production and operates a competitive bank for financial services.

We assume that the infinitely-lived household maximizes the expected lifetime utility based on the consumption bundle and leisure:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\varphi \log(C_t) + (1-\varphi) \log\left(1 - n_t^s - m_t^s\right) \right], \tag{7}$$

where $\beta \in (0,1)$ is the household's subjective discount factor. φ stands for the share of consumption in the utility, and n_t^s and m_t^s are supplies of labor in the production and banking sectors, respectively.

Under full capital control, the private sector is not allowed to hold foreign bonds. As a result, the household can hold only the home bonds, issued by the government. The budget constraint of the households can be described as below:

$$q_t\left(1-\delta\right)K_t+\frac{B_t}{P_t}+\frac{H_{t-1}}{P_t}+w_t\left(n_t^s+m_t^s\right)+\alpha^d\left(\frac{P_t^d\left(s\right)}{P_t^d}\right)^{1-\nu}\left(\frac{P_t^d}{P_t}\right)^{1-\theta}C_t^A$$
$$+\left(\frac{e_tP_t^X\left(s\right)}{P_t}\right)\left(\frac{P_t^{X*}\left(s\right)}{P_t^{X*}}\right)^{-\nu}\left(\frac{P_t^{X*}}{P_t^*}\right)^{-\mu}-w_t\left(n_t^d+m_t^d\right)-\frac{H_t}{P_t}-tax_t-q_tK_{t+1}$$
$$-\frac{B_{t+1}}{P_t\left(1+R_t^B\right)}-C_t=0. \tag{8}$$

Here, w_t is the real wage, which is assumed to be identical in both sectors. n_t^d and m_t^d are the labor demanded in the production and banking sectors, respectively. B_{t+1} is the domestic bond. The nominal interest rate which B_{t+1} pays is denoted by R_t^B. tax_t is the lump-sum tax, and H_t stands for the nominal holdings of base money at the end of the period t.

3.3 Production

The goods market is monopolistically competitive. The firms produce goods following the technology:

$$Y_t=K_t^{\eta}\left(A_t\,n_t^d\right)^{1-\eta}, \tag{9}$$

where η stands for the share of capital in the goods production and A_t is the labor productivity which is subject to exogenous shock. To simplify the model, we assume that the capital is fixed at its steady state level.[6] Under monopolistic competition and price rigidity, the firm produces goods to satisfy the demand from both the domestic and foreign markets. We assume that the firm can take price discrimination for the home and foreign consumptions so they will price the goods sold in the home and foreign countries separately.

[6] The assumption follows the specification of Goodfriend and McCallum (2007) for simplification. However, this may not be appropriate for the Chinese economy, whose capital has been quickly accumulated. We will relax this assumption in the future study.

In the home country, the home demand consists of the private consumption and investment:[7]

$$C_t^A = C_t + q_t\left(K_{t+1} - (1-\delta)K_t\right), \tag{10}$$

where q_t is the real price of capital and δ is the depreciation rate. We assume that firms adopt the Calvo (1983) staggered pricing strategy. In each period, the probability of firms to change the price, in response to the current shock, is $1-\xi_d$, implying the mean interval of price change is $1/(1-\xi_d)$. At period t, the profit maximization problem of a typical firm i who can change the price is to choose $P_t^d(i)$ to maximize the profit within the period t and $t+s$ when the price remains valid. The optimal price that a typical firm sets is (the subscript i is dropped due to symmetry):

$$P_{t,t}^{d,\,flex} = \frac{\nu}{\nu-1}\frac{\left\{\sum_{s=0}^{\infty}(\xi_d)^s E_t \Lambda_{t+s,t}^d mc_{t+s,t} C_{t+s,t}^A \cdot\right\}}{\left\{\sum_{s=0}^{\infty}(\xi_d)^s E_t \Lambda_{t+s,t} C_{t+s,t}^A \cdot\right\}}, \tag{11}$$

where $\Lambda_{t+s,s} = \left(\beta^s \lambda_{t+s}/\lambda_t\right)\left(P_t/P_{t+s}\right)$. $C_{t+s,t}$ is the demand under the price set this period which remains valid in the period $t+s$, and $mc_{t+s,t}$ is the associated marginal cost. λ_{t+s} is the Lagragian multiplier in the period $t+s$.

The price index for the domestic price will evolve following the dynamics:

$$\left(P_t^d\right)^{1-\nu} = \xi_d\left(P_{t-1}^d\right)^{1-\nu} + (1-\xi_d)\left(P_{t,t}^{d,\,flex}\right)^{1-\nu}, \tag{12}$$

For the foreign country, we assume that the law of one price (LOOP) holds. Therefore, $P_t^{X*} = P_t^d/e_t$.

[7] We neglect the government spending in the current version to simplify the role of government to emphasize the monetary policy implemented by the central bank.

The market clearing condition of the goods market can be written as:

$$Y_t - \alpha^d \left(\frac{P_t^d(i)}{P_t^d} \right)^{-\nu} \left(\frac{P_t^d}{P_t} \right)^{-\theta} C_t^A - \left(\frac{P_t^{X*}(i)}{P_t^{X*}} \right)^{-\nu} \left(\frac{P_t^{X*}}{P_t^*} \right)^{-\mu} = 0, \tag{13}$$

3.4 Bank

We follow Goodfriend and McCallum (2007) to characterize the banking sector which is subject to endogenous financial friction. The household's consumption is subject to a "deposit-in-advance" constraint, such that the household should hold deposits before consumption transactions. The transaction constraint can be written as:

$$C_t = \frac{VD_t}{P_t}, \tag{14}$$

where D_t is the deposit and V is a constant, representing the velocity of the aggregate deposit.

The bank operates by receiving the deposits and loan making to households. Each bank's balance sheet can be written as:

$$H_t + L_t = D_t, \tag{15}$$

where L_t and H_t represent the loans and reserve money, respectively. Let rr be the reserve ratio, so the funds available for loan making is equal to $(1-rr)D_t$.

Due to the asymmetric information problem on the credit market, the bank makes loans by using collateral and hiring labor to monitor credits. We assume that the loan production function follows a Cobb-Douglas form as follows:[8]

[8] From the deposit-in-advance constraint, we know that the loans are essentially made to finance consumption expenditure. Although this specification is different from the loans financing the capital investments of firms, which may account for the majority of loans in the real world, it is consistent with the estimation results in Wu (2004) in that the consumption expenditures of the private sector in

$$\frac{L_t}{P_t} = F\left(b_{t+1} + A_t^{\kappa} kq_t K_{t+1}\right)^{\alpha} \left(A_t^{m} m_t\right)^{1-\alpha}, \tag{16}$$

where m_t is the labor input for monitoring, and $b_{t+1} + kq_t K_{t+1}$ are the collateral, including capital goods and home bonds where $b_{t+1} = B_{t+1} \big/ P_t^A \left(1 + R_t^B\right)$. Because the household cannot hold foreign bonds, the collateral does not include the foreign bonds. α is the share of collateral in the loan production. Because capital goods require greater monitoring efforts than bonds to confirm the market value, $0 < k < 1$ states the inferiority of capital to bonds for collateral purposes. F is a constant, which stands for the efficiency of the loan-making process. The loan making function implies the loan making process is costly, due to the significant financial friction on the credit market. We attempt to use the loan-making process to characterize the credit market in China. A lower F represents higher friction on the credit market, which may resemble the status quo of the Chinese credit market.

Following Goodfriend and McCallum (2007), we also assume that there are shocks to the value of capital as the collateral and to the effectiveness of monitoring efforts, A_t^{κ} and A_t^{m} respectively.

3.5 Current Account

The current account surplus (in terms of the home goods) can be written as the trade surplus plus net interest income received from holdings of foreign assets

$$CA_t = p_t^X C_t^X - p_t^f IM_t + \frac{e_t \left(R_{t-1}^{B^*} - 1\right) B_t^*}{P_t}, \tag{17}$$

where IM_t represents the imports, B_t^* denotes the foreign bonds held by the country

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Taiwan are more sensitive to the shocks to loans than investments.

which pays the interest rate R_{t-1}^{B*}. The amount of current account balance reflects the change in the foreign assets held by the country:

$$CA_t = \frac{e_t\left(B_{t+1}^* - B_t^*\right)}{P_t}, \tag{18}$$

We should note that, under capital control, private sectors are not allowed to hold the foreign assets, but the amount of foreign assets earned from the international trades should be obtained by the central bank which may lead to the expansion of money supply if the effect is not fully sterilized.

3.6 Policies

The central bank of China currently conducts the conventional and unconventional monetary policy measures. We assume that, same as the central bank of most countries, the PBoC conducts the interest rate rule following the Taylor type:[9]

$$R_t^{IB} = (1-\alpha_R)\left[R^{IB} + \alpha_p^R \Delta p_t + \alpha_Y^R y_t + \alpha_q^R \Delta RER_t\right] + \alpha_R R_{t-1}^{IB}, \tag{19}$$

where R^{IB} is the steady-state interbank rate and $0 \le \alpha_R < 1$ characterizes the persistence of the policy rule. $\alpha_p, \alpha_Y, \alpha_e \ge 0$ are policy parameters, which control the degree of policy's responses to the CPI inflation rate, output gap and real exchange rate respectively. RER refers to the real exchange rate, and ΔRER_t describes the rate of real depreciation.

The monetary policy measures of the PBoC that differ from other countries include the capital control, the managed floating exchange rate regime as the intervention on the international capital market, and the active adjustment of required

[9] While the PBoC conducts the money growth rate rule by announcing the target of money growth rate, we assume the interest rate rule as it also actively controls the interest rates on the market.

reserve ratio that will crucially affect the liquidity on the domestic credit market.

Firstly, the required reserve ratio is assumed to be adjusted solely for inflation rate stabilization. Therefore, the required reserve ratio follows the form:[10]

$$rr_t = (1-\alpha_{rr})\left[\overline{rr} + \alpha_P^{rr}\Delta p_t\right] + \alpha_{rr} rr_{t-1}, \tag{20}$$

Similarly, $0 \le \alpha_{rr} < 1$ denotes the persistence of the required reserve ratio. $\overline{rr}$ is the steady-state required reserve ratio. $\alpha_P^{rr} \ge 0$ governs the required reserve ratio's adjustment to the CPI inflation rate. If both the α_{rr} and α_P^{rr} equals 0, the required reserve ratio will become a constant. This is the specification in most studies which characterize the passive adjustment of the required reserve ratio.

Secondly, the managed floating exchange rate regime is assumed to follow the rule:

$$\phi_t^e = (1-\alpha_e)\left[\phi^e + \alpha_P^e \Delta p_t + \alpha_Y^e y_t + \alpha_q^e \Delta RER_t\right] + \alpha_e \phi_{t-1}^e, \tag{21}$$

where $\phi_t^e = \log(e_t / e_{t-1})$, and ϕ^e denotes the steady-state exchange rate depreciation rate. $0 \le \alpha_e < 1$ denotes the persistence of exchange rate rule. $\alpha_P^e, \alpha_Y^e, \alpha_q^e \ge 0$ are policy parameters, which control the degree of policy's responses to the CPI inflation rate, output gap and real exchange rate depreciation.

Lastly, under capital control, the central bank purchases the inflow of funds from the holding of foreign bonds with the home bonds or money supply. Therefore, the central bank faces the flow-of-funds constraint:[11]

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[10] Chen, Fanke and Patez (2012) specify the similar form.

[11] As a country with massive current account surplus, the central bank's act to stabilize the exchange rate movement will lead to the increase in money supply. As a result, the central bank may want to sterilize the monetary expansion by issuing bonds. Therefore, $CA_t = (H_t - H_{t-1})/P_t$ states the situation with no sterilization, while $CA_t = (B_{t+1} - R_{t-1}B_t)/P_t$ refers to the full sterilization. While Chang, Liu and Spiegel (2014) focus on the inflationary effects of the sterilization and non-sterilization under the capital control and managed floating exchange rate regime, this study emphasizes the interrelation between the capital control on the international capital market and the regulations on the domestic credit market.

$$CA_t = \frac{e_t\left(B^*_{t+1} - R^*_{t-1}B^*_t\right)}{P_t} = \frac{B_{t+1} - R_{t-1}B_t}{P_t} + \frac{H_t - H_{t-1}}{P_t}, \tag{22}$$

Alternatively, if the capital account is fully open, the UIP condition should hold:

$$-\left(\frac{\varphi}{C_t\lambda_t} - 1\right)\Omega = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{P_t}{P_{t+1}}\right]\left[\left(1 + R^B_t\right) - \frac{e_{t+1}}{e_t}\left(1 + R^{B^*}_t\right)\right] \tag{23}$$

where $R^{B^*}_t = R^*_t - \gamma/\chi\left(B^*_{t+1}/P^*_t\right)$.

3.7 Exogenous variables

The processes of exogenous shocks in the model are all assumed to follow first-order autoregressive processes:

$$a_t = \left(1-\rho_A\right)a + \rho_A a_{t-1} + \varepsilon^A_t, \quad 0 \le \rho_A < 1, \tag{24}$$

$$a^\kappa_t = \left(1-\rho_\kappa\right)a^\kappa + \rho_\kappa a^\kappa_{t-1} + \varepsilon^\kappa_t, \quad 0 \le \rho_\kappa < 1, \tag{25}$$

$$a^m_t = \left(1-\rho_m\right)a^m + \rho_m a^m_{t-1} + \varepsilon^m_t, \quad 0 \le \rho_m < 1, \tag{26}$$

where $a_t = \log\left(A_t\right)$ and $a^i_t = \log\left(A^i_t\right),\ \forall i = \kappa, m$ m

Since the small open economy cannot influence the foreign prices and interest rate, we assume that these foreign variables are exogenous and move with the following AR(1) processes:

$$\Pi^*_t = \left(1-\rho_{\Pi^*}\right)\Pi^* + \rho_{\Pi^*}\Pi^*_{t-1} + \varepsilon^{\Pi^*}_t, \quad 0 \le \rho_{\Pi^*} < 1, \tag{27}$$

$$R^*_t = \left(1-\rho_{R^*}\right)R^* + \rho_{R^*}R^*_{t-1} + \varepsilon^{R^*}_t, \quad 0 \le \rho_{R^*} < 1 \tag{28}$$

where $\Pi^*_t = \log\left(P^*_t\right) - \log\left(P^*_{t-1}\right)$ stands for the foreign inflation rate. Π^* and R^* are the steady-state level of the foreign inflation and interest rate respectively.

Export shock is also assumed to follow an AR(1) process:

$$x_t^* = (1-\rho_X)x + \rho_X x_{t-1}^* + \varepsilon_t^X, \quad 0 \le \rho_X < 1 \tag{29}$$

Here, $x_t^* = \log\left(X_t^*\right)$. $\rho_A, \rho_\kappa, \rho_m, \rho_{\Pi^*}, \rho_{R^*}, \rho_X$ lying between 0 and 1, denoting the AR(1) persistence associated with each variable, and $\varepsilon_t^A, \varepsilon_t^\kappa, \varepsilon_t^m, \varepsilon_t^{\Pi^*}, \varepsilon_t^{R^*}$ and ε_t^X are the associated innovations which are assumed independent, white noises .

3.8 Interest rates and the external finance premium

With the frictional credit market, the interest rates associated with bonds, deposits and loans would diverge. Let R_t^T represent the interest rate in a conventional model without the banking sector, and this can be obtained by using the conventional Euler equation:

$$1+R_t^T = E_t \frac{\lambda_t P_{t+1}}{\beta \lambda_{t+1} P_t}. \tag{30}$$

This is also the interest rate for borrowing and lending without using the collateral. All the interest rates under the credit friction, particularly due to the costly loan making process, are listed as follows:[12]

$$\frac{1+R_t^B}{1+R_t^T} = 1-\left(\frac{\varphi}{C_t \lambda_t}-1\right)\Omega_t, \tag{31}$$

$$\left(1+R_t^T\right) = \left(1+R_t^{IB}\right)\left[1+\frac{Vw_t m_t}{(1-\alpha)(1-rr)C_t}\right] \tag{32}$$

$$\left(1+R_t^L\right) = \left(1+R_t^{IB}\right)\left[1+\frac{Vw_t m_t}{(1-rr)C_t}\right]. \tag{33}$$

[12] Because the credit market exists in the domestic economy, and we assume that only the capital and home bond can serve as the collateral, the interest rate relationships are essentially the same as those in Goodfriend and McCallum (2007).

The difference between the bond rate and the uncollateralized rate reflects the additional benefits that the bonds, eligible for collaterals for loans, provide to precipitate the loan making. Furthermore, a typical bank obtains funds on the reserve market at the interbank rate R_t^{IB}, and extends loans to households at the benchmark rate R_t^T without collateral or at the loan rate R_t^L with collateral. The spread between the uncollateralized or collateralized loan rates and the interbank rate covers the marginal cost that the loan making process incurs.

The EFP reflects the marginal cost of making loans and can be endogenously obtained by taking the difference between the external and internal funding costs of the firm, the spread between R_t^L and R_t^{IB}.[13] Consequently, the EFP can be written as:[14]

$$EFP_t = R_t^L - R_t^{IB} \approx \frac{Vw_t m_t}{(1-rr)C_t}. \tag{34}$$

The deficiency of the loan making process may result in the surge in the loan rate, driving up the EFP.

4. Calibration

4.1 Calibration

[13] From the household's perspective, the EFP can be derived by taking the difference between the loan and deposit rates. With a nonzero, but small, reserve ratio, the deposit rate is very close to the interbank rate.

[14] The EFP reflects the marginal cost of loan making, which is closely related to the value of collateral. When the value of collateral is higher, the loan making process requires fewer workers for credit check for the same amount of loans. This will lower the cost of loan making as well as the EFP. Therefore, given C_t and w_t in Eq. (33), higher value of collateral lowers the need for m_t and thereby the EFP. As a result, higher value of capital implying greater value for collateral will help reduce the cost for loan making and the EFP.

We calibrate the model to generate the steady state consistent with the data of China. We assume that the steady state is current account balanced. The share of the home produced goods in the foreign consumption X^* is adjusted to assure the balanced current account.[15] The market price of capital goods is assumed to be $q=1$, and the real exchange rate is specified as 1 in the steady state. β is assumed to be 0.99, following most literature.

The share of import goods in the aggregate consumption α^f is set to 0.3, which is close to 0.36 of the import share in the GDP in 2005. The parameters related to goods production are calibrated to generate the steady-state labor employment in production to be slightly higher than 1/3, as found in most countries. Therefore, we set the capital share in production $\eta=0.45$, utility of consumption relative to leisure $\varphi=0.65$ to generate roughly 0.35 of the available time in goods production in the steady state. The depreciation rate of capital is specified as $\delta=0.025$ (reflecting the annual depreciation rate to be 10%). The elasticity of substitution among goods ν is assumed to be 1.5, such that the markup is about 10%. The elasticity of substitution between the domestic and imported goods, θ, is set to 1.5, and the price elasticity of demand for exports $\mu=1.5$. The degree of price stickiness ξ_d is specified as 0.65, implying the average duration of price adjustment around 3 quarters.

The financial parameters are calibrated to generate the steady-state financial figures close to the data. First, we set the velocity of the aggregate bank deposits at $V=0.62$, measured by the average ratio of GDP to M2 in 1994-2011. Second, the reserve ratio is set as $rr=0.09$ which is the level in the end of 2006.[16] Third, the fiscal policy parameter, $boc=0.17$, is obtained from the ratio of the debt-GDP ratio

[15] However, the home bond rate R^B is lower than the foreign bond rate R^{B*} due to the liquidity service that the home bond can serve.

[16] Since the PBoC adjusts the required reserve ratio often, we simply use this level of the ratio in the end of 2006.

of China in 2005. Furthermore, following Goodfriend and McCallum (2007), three primary parameters in the loan production function, which characterize the credit market friction, are calibrated to generate the share of labor employment in the banking sector to the total labor employment to be close to 3.2%, the data reported in 2005.[17] Thus, the financial parameters are chosen as $\alpha = 0.42$, $k = 0.75$ and $F = 15$. The model generates the share of the labor employment in banking sector in the overall employment is about 0.9%. All the parameters are summarized in Table 1. The steady-state foreign bond rate R^{B^*} and the world interest rate R^* are equal to 1.1%, while the steady-state Home bond rate is 0.1% in the steady state. The spread between the home and foreign bond rates comes from the liquidity service that the home bonds serve as the collateral for loans.

The benchmark case is characterized to capture the current planned economy. We assume that the central bank controls not only the interbank rate rule (as most countries do), but also actively adjusts the required reserve ratio, and implements managed floating exchange rate rule and capital control. The policy parameters are also listed in Table 1. We assume that the central bank conducts the interbank rate rule with the focus of inflation rate stabilization. The persistence of the interbank rate policy and the central bank's responses to the inflation rate, output, and real exchange rate are specified as 0.9, 2.5, 0, and 0 respectively. In addition, the central bank adjusts the required reserve ratio actively to reinforce its attempt to moderate the inflation rate movements. The steady-state required reserve ratio is specified as 9%, the level of China in the end of 2006. The persistence of the required reserve ratio and its response to inflation are 0.6 and 10 respectively. On the other hand, the managed floating exchange rate is implemented with the emphasis of moderating the real

[17] This number is for urban corporations only.

exchange rate movements. Thus, the persistence and the responses to the inflation rate, output, and real exchange rate of the managed floating exchange rate policy are chosen as 0.8, 0, 0, and 1.5 respectively. The following analyses consider the various plans for policy reforms which involve the removal of the regulations.

4.2 Welfare measure

In Section 5, we will conduct the welfare examination of various stages of policy reforms. The welfare measure of the representative agent is given by the conditional expected lifetime utility function at time zero:[18]

$$V_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{1}{1-\rho} C_t^{1-\rho} - \frac{\chi}{1+\varepsilon} \left(L_t \right)^{1+\varepsilon} \right) \tag{35}$$

The initial state is specified as the deterministic steady state, according to Schmitt-Grohe and Uribe (2007). For a policy m, the welfare gain can be measured by the fraction γ^m of the steady-state consumption which the households can be as well off as under the policy m. The welfare gain γ^m of the policy m can be written as:

$$V_0^m = \sum_{t=0}^{\infty} \beta^t \left(\vartheta \log \left(\left(1 + \frac{\gamma^m}{100} \right) \bar{C} \right)^{1-\rho} + (1-\vartheta) \log \left(1 - \bar{n} - \bar{m} \right) \right), \tag{36}$$

Higher value of γ^m is associated with greater welfare gain that the policy entails.

5. Monetary policy reforms

As discussed, the current market regulations involve the capital control, exchange rate management, and active required reserve ratio adjustments. While the

[18] The utility from the real money holding can be negligible, following Obstfeld and Rogoff (1998, 2000).

deregulations of these policy measures seem to be critical for the economic transformation of the Chinese economy, the progress of policy reforms becomes the center of concerns. Should the capital control be removed before the deregulation of exchange rate management, or should floating the exchange rate earlier than opening the capital account can result in quite different economic performance, particularly, under shocks occurring from the home or foreign economies?

Therefore, in this section, we will examine the welfare gains (under different shocks) of the policy reforms. The policy reforms may involve the removal of capital control, more freely floating exchange rates, and the passive required reserve ratio adjustment. Firstly, if the capital control is liberalized, the UIP condition, Eq. (23) should hold instead. Secondly, the more floating exchange rate corresponds to an inactive response of exchange rate adjustment to the real exchange rate movement where α_q^e is lowered to 0.5. Thirdly, the policy parameters α_{rr} and α_p^{rr} are equal to 0 under the passive required reserve ratio adjustment, implying that the required reserve ratio is fixed at its steady-state level. The changes in the policy parameters are listed in the bottom of Table 1.

While the policy reforms are undertaken gradually, we discuss various policy reform plans, which are outlined in Table 2. We start from the benchmark case (denoted as "BM") with all the regulations in place, and gradually deregulate the required reserve ratio, the exchange rate management, and the capital control. The notation "x" denotes the deregulation of the policy measure. The "Full" case describes the market with full deregulations. We simulate each case under *adverse* home productivity shock, home financial shock and foreign shocks respectively to show how the economy with policy reforms may perform under negative shocks. The discussion will center on how the policy reforms can alter the transmission

mechanism of shocks and help stabilize the economy.

5.1 Domestic productivity shock

We run simulation of all policy reform plans under 1% negative home productivity shock with the AR(1) coefficient of 0.95. The results are listed in Table 3. It is clearly shown that the benchmark case with all the regulations in place will result in almost the second highest welfare loss, only lower than that of case I, while the full liberalization can generate the lowest welfare loss.

In the benchmark case, all the regulations on the domestic credit market and international capital market are in place. While the adverse domestic productivity shock occurs, the goods prices tend to rise due to higher marginal cost. This may result in higher inflation rate and lower production. Because the central bank may attempt to stabilize the inflation rate, the interest rate would also rise. While the central bank actively adjusts the required reserve ratio in response to inflation, the upward interest rate movement can be reinforced by the increased required reserve ratio.[19, 20] As a result, the active required reserve ratio, for inflation stabilization, may exacerbate the economic downturns. However, due to the real exchange rate appreciation (the home goods prices increase), the central bank may depreciate the home currency, while the capital account remains closed. This may help moderate the decline in exports and production.

Therefore, the active required reserve ratio adjustment, as the additional instrument to stabilize the inflation rate, can intensify the adverse impacts on the real

[19] The loan rate can be even higher after the adverse productivity shock. As Bernanke and Gertler (1995) points out, the asymmetric information problem can be worsened during the economic downturns, and thus lead to higher loan rate which can exacerbate the balance sheet of firms and economic performance.

[20] The increase in the required reserve ratio can further lead to loan rate and lower amount of loan making.

variables such as the output and consumption. The managed floating exchange rate, under capital control, however, may help stabilize the real economy. The discussions demonstrate that the regulations on the domestic and international financial markets are closely related. They may intensify or diminish each other.

The results suggest that opening the capital account is most critical. The open capital account, indicated by the case IV, V and Full, can result in significantly lower welfare loss, compared to the closed capital account in the benchmark case and case I, II, III. The result is quite intuitive. The open capital account successfully helps stabilize the economy by sharing the adverse domestic productivity shock with the foreign economies. Although the international capital flows can lead to more volatile exchange rates, and thereby more volatile inflation rate, the market mechanism helps stabilize the real variables such as output, consumption, employment and exports. Since the market mechanism helps stabilize the economy, the full deregulations can generate the lowest welfare cost.

5.2 Domestic financial shock

The financial crises in emerging economies in the 90's can have important implications for the close relationship between the domestic credit market and international capital market. The domestic financial distress led to capital flight which resulted in the drastic exchange rate depreciation of the currency. Although the worst case would not happen to China which owns the massive amount of foreign reserves, the Chinese authority is still very cautious about the liberalization of international capital flows. The relatively fragile financial system which may potentially embody the serious asymmetric information problem can be one of the primary concerns.

Therefore, in this section, we consider the negative shock to the domestic

financial sector, which are characterized by the decline in the monitoring efforts of loan making as well as the decline in the quality of capital as the collateral for loans. We assume that there are the simultaneous 1% shocks occurring to a_t^{κ} and a_t^{m} with the AR(1) persistence of 0.99 and 0.95 respectively.

The results are listed in Table 4. Similar to the adverse productivity shock, the numerical analyses show that the welfare losses are lower as long as the capital account is open, whether or not the exchange rate management and required reserve ratio adjustment are removed. The standard deviations of consumption and inflation, nominal exchange rate are significantly lowered under open capital account, which shows the consumption, nominal and real exchange rates and inflation rate can be significantly stabilized after the capital account is opened. Thus, the removal of exchange rate management and active required reserve ratio adjustment play no role. The capital outflow after the adverse financial shocks may result in the currency depreciation and thus significantly helps stabilize the export and production. This can offset the adverse effects from the rising domestic interest rate due to the worsened asymmetric information problem on the domestic financial market.

If the capital account is closed, and exchange rate floating is managed, the central bank will sell the home bonds to prevent the potentially currency depreciation from the potential capital outflow, this will reduce the money supply and further push up the interest rates which have initially risen after the adverse financial shocks occur. Therefore, the results seem to suggest, in the absence of the concerns on the exchange rate collapses, the open capital account may help share the financial shocks abroad and thus reduce the welfare loss.

5.3 Foreign shock

Another important issue for the liberalization of international capital market is the risk sharing of shocks from foreign countries. In this section, we consider there is simultaneous occurrence of 0.1% negative shock to the foreign demand of home exports, 0.1% negative shock to the foreign inflation rate, and 0.25% negative shock to the foreign interest rate. The persistence of shocks is assumed to be 0.9 for the export demand and foreign interest rate, and 0.75 for the foreign inflation rate.

The results are outlined in Table 5. Not surprisingly, the results show that the welfare losses under the open capital account can be higher, reverse to the effects of domestic shocks. Under closed capital account and managed floating exchange rate regime, all the foreign shocks that result in the current account imbalances will be absorbed by the central bank. This may partially or fully influence the domestic inflation rate, depending on the magnitude of sterilization. The open capital account, however, transmits the foreign shocks to the domestic economy through the international capital flows, and leads to the greatest macroeconomic fluctuations. We may also note that, the results of the case V and Full, compared to the case IV, suggest that, the further liberalization of exchange rate management can significantly help moderate the inflation rate and nominal exchange rate fluctuations after the capital account is opened.

The optimal policy reform plans under each type of shocks are listed in Table 6. In sum, the discussions show that the regulations on the domestic credit market and the international capital market, and the analyses have important policy implications for the progress of policy reforms. Under all types of shocks, opening the capital account appears to be the most critical stage of policy reforms. Furthermore, the exchange rate should be freely floating before the required reserve ratio adjustment

turns passively, whether or not the capital account is open. Thus, the welfare analyses may suggest that, the policy reforms would start from opening the capital account, and then liberalizing the exchange rate movements. This plan for the policy reforms can result in greatest economic stability under the home shocks. Although the economy may undertake greater fluctuations from the foreign shocks, the open capital account with floating exchange rate may help lower the adverse impacts.

6. Conclusion

In this paper, we investigate the welfare of various policy reform plans of China's economy which is currently implementing the managed floating exchange rate regime, capital control and active adjustment of required reserve ratio. The policy reforms involve the deregulation of prevailing market regulations. The reforms would take place gradually, and the progress of reforms is critical for the economic transformation.

Thus, we propose various policy reform plans. With an open-economy DSGE model, we evaluate the welfare that each of the plans entails. The results show that these regulations on the domestic credit market such as the active adjustment of required reserve ratio, and the regulations on the international capital market are closely related, and can intensify, or dampen each other.

Furthermore, the welfare analyses show that opening the capital account is the most critical step. Under the home shocks, real or financial, open capital account helps share the risk abroad. This helps stabilize the domestic economy, and significantly reduce the welfare loss. Nevertheless, opening the capital account will transmit the foreign shocks to the domestic economy, and thus significantly exacerbate the welfare loss than the case with closed capital account. However,

together with the flexible exchange rates, the welfare loss can be lowered. This study does not imply the financial reforms should start from opening the capital account, but suggests that we should be cautious about opening the capital account which can make significant differences in the shock transmission and welfare.

There are many issues left for future study. In the current model, we assume the central bank conducts the interest rate rule as the conventional measure, similar to most countries. However, the implementation of China's monetary policy can be closer to the money growth rate rule. The future study may take into account the money growth rate rule instead. Furthermore, this study considers the adjustment of required reserve ratio as the only regulation on the domestic credit market. The future study may include the prevailing regulations on the loan and deposit rates.

Appendix

Table 1 Parameter values (on quarterly basis)

Parameter	Description	Value
φ	The importance of consumption in the utility function	0.65
η	Capital share in goods production	0.45
β	Discount rate	0.99
δ	Depreciation rate of capital	0.025
q	Capital value	1
boc	Real government bond / consumption bundle	0.17
V	Velocity of aggregate bank deposits	0.62
rr	Reserve rate	0.09
α	Collateral share in loan production	0.42
F	Efficiency parameter of banking sector	15
k	Inferiority of capital to bonds for collateral purposes	0.75
α^m	Ratio of import goods to aggregate consumption in the steady state	0.3
α^d	Ratio of domestic goods to aggregate consumption in the steady state	0.7
ν	Elasticity of substitution among different variety of goods	1.5
θ	Elasticity of substitution between domestic goods and imported goods	1.5
μ	Price elasticity of demand for export	10
ξ_d	The degree of price rigidity	0.65
α_R、α_p^R、α_{Y}^R、α_q^R	Persistence and policy parameters of the Taylor rule	0.9, 2.5, 0, 0
α_e、α_p^e、α_{Y}^e、α_q^e	Policy parameters of the exchange rate rule	0.8, 0, 0, 1.5
α_{rr}、α_p^{rr}	Policy parameters of the required reserve ratio	0.6, 10
Policy reforms		
α_e、α_p^e、α_{Y}^e、α_q^e	Policy parameters of the exchange rate rule	0.8, 0, 0, 05
α_{rr}、α_p^{rr}	Policy parameters of the required reserve ratio	0, 0

Table 2 Policy Reforms

Regulations	BM	I	II	III	IV	V	Full
Interbank rate	v	v	v	v	v	v	v
Required reserve ratio	v	x	v	x	v	v	x
Exchange rate	v	v	x	x	v	x	x
Capital control	v	v	v	v	x	x	x

Note: "BM" refers to the benchmark case where all the policy tools are regulated. "Full" refers to full liberalization.

Table 3 Dynamics under the domestic productivity shock

Regimes	BM	I	II	III	IV	V	Full
Welfare (as the percentage of the steady state consumption)							
	-0.3892	-0.4666	-0.2085	-0.2312	-0.1127	-0.0757	-0.0742
Standard deviations (in the percentage deviation from the steady state)							
Y	0.0220	0.0223	0.0225	0.0227	0.0196	0.0203	0.0203
C	0.0221	0.0233	0.0185	0.0190	0.0154	0.0161	0.0161
n	0.0113	0.0120	0.0094	0.0096	0.0078	0.0075	0.0075
EX	0.0340	0.0362	0.0310	0.0320	0.0178	0.0185	0.0185
IM	0.0323	0.0352	0.0242	0.0257	0.0053	0.0052	0.0052
Δp	0.0028	0.0027	0.0030	0.0029	0.0051	0.0047	0.0047
Δe	0.0008	0.0008	0.0004	0.0003	0.0012	0.0004	0.0004
RER	0.0159	0.0169	0.0145	0.0149	0.0083	0.0086	0.0086
EFP	0.0005	0.0005	0.0004	0.0004	0.0013	0.0010	0.0010

Note: BM: active required reserve ratio adjustment, managed floating exchange rate, capital control;

I: inactive (fixed) required reserve ratio adjustment, managed floating exchange rate, capital control;

II: active required reserve ratio adjustment, floating exchange rate, capital control;

III: inactive (fixed) required reserve ratio adjustment, floating exchange rate, capital control;

IV: active required reserve ratio adjustment, managed floating exchange rate, open capital account;

V: active required reserve ratio adjustment, floating exchange rate, open capital account;

Full: inactive (fixed) required reserve ratio adjustment, floating exchange rate, open capital account;

Table 4 Dynamics under the domestic financial shocks

Regimes	BM	I	II	III	IV	V	Full
Welfare (as the percentage of the steady state consumption)							
	-0.2681	-0.3006	-0.1736	-0.1818	-0.0213	-0.0213	-0.0213
Standard deviations (in the percentage deviation from the steady state)							
Y	0.0049	0.0052	0.0038	0.0040	0.0002	0.0002	0.0002
C	0.0109	0.0116	0.0086	0.0089	0.0002	0.0002	0.0002
n	0.0069	0.0074	0.0055	0.0057	0.0002	0.0002	0.0002
EX	0.0207	0.0222	0.0164	0.0170	0.0001	0.0001	0.0001
IM	0.0228	0.0244	0.0181	0.0187	0.0001	0.0001	0.0001
Δp	0.0008	0.0008	0.0008	0.0008	0.0000	0.0000	0.0000
Δe	0.0003	0.0003	0.0001	0.0001	0.0000	0.0000	0.0000
RER	0.0097	0.0104	0.0077	0.0079	0.0001	0.0001	0.0001
EFP	0.0004	0.0004	0.0002	0.0002	0.0000	0.0000	0.0000

Note: BM: active required reserve ratio adjustment, managed floating exchange rate, capital control;

I: inactive (fixed) required reserve ratio adjustment, managed floating exchange rate, capital control;

II: active required reserve ratio adjustment, floating exchange rate, capital control;

III: inactive (fixed) required reserve ratio adjustment, floating exchange rate, capital control;

IV: active required reserve ratio adjustment, managed floating exchange rate, open capital account;

V: active required reserve ratio adjustment, floating exchange rate, open capital account;

Full: inactive (fixed) required reserve ratio adjustment, floating exchange rate, open capital account;

Table 5 Dynamics under foreign shocks

Regimes	BM	I	II	III	IV	V	Full
Welfare (as the percentage of the steady state consumption)							
	-0.3629	-0.4463	-0.2275	-0.2587	-0.9879	-0.8082	-0.7986
Standard deviations (in the percentage deviation from the steady state)							
Y	0.0070	0.0076	0.0064	0.0067	0.0109	0.0110	0.0110
C	0.0148	0.0163	0.0130	0.0139	0.0301	0.0289	0.0287
n	0.0099	0.0109	0.0091	0.0096	0.0156	0.0158	0.0157
EX	0.0294	0.0322	0.0270	0.0286	0.0244	0.0259	0.0259
IM	0.0320	0.0351	0.0294	0.0311	0.0407	0.0406	0.0404
Δp	0.0009	0.0010	0.0010	0.0010	0.0108	0.0103	0.0102
Δe	0.0007	0.0008	0.0003	0.0003	0.0023	0.0008	0.0008
RER	0.0137	0.0150	0.0126	0.0133	0.0114	0.0121	0.0121
EFP	0.0005	0.0005	0.0004	0.0004	0.0047	0.0042	0.0042

Note: BM: active required reserve ratio adjustment, managed floating exchange rate, capital control;

I: inactive (fixed) required reserve ratio adjustment, managed floating exchange rate, capital control;

II: active required reserve ratio adjustment, floating exchange rate, capital control;

III: inactive (fixed) required reserve ratio adjustment, floating exchange rate, capital control;

IV: active required reserve ratio adjustment, managed floating exchange rate, open capital account;

V: active required reserve ratio adjustment, floating exchange rate, open capital account;

Full: inactive (fixed) required reserve ratio adjustment, floating exchange rate, open capital account;

Table 6 Optimal policy reforms

Shocks	Optimal policy
Productivity shocks	Full
Financial shocks	VI, V, Full
Foreign shocks	II

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國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：104 年 7 月 30 日

計畫編號	NSC 102 － 2410 － H － 004 － 006 －MY2		
計畫名稱	動態隨機一般均衡模型於中國經濟之非傳統貨幣政策之探討		
出國人員 姓名	黃俞寧	服務機構 及職稱	政治大學經濟系副教授
會議時間	103 年 6 月 28 日至 103 年 7 月 2 日	會議地點	美國夏威夷
會議名稱	(中文) (英文) 90th Annual Conference, June 28-July 2, 2015 | Hilton Hawaiian Village, Waikiki		
發表論文 題目	(中文) (英文) Welfare Implications of the Chinese Monetary Policy Reform: A Dynamic Stochastic General Equilibrium Approach		

一、參加會議經過

本人於當地時間 6 月 28 上午抵達美國西雅圖，7 月 1 日上午報告本人所著" Welfare Implications of the Chinese Monetary Policy Reform: A Dynamic Stochastic General Equilibrium Approach"一文，由中國人民大學 Zongxin Qian 擔任評論人。他提供了中國貨幣政策執行時的相關建議，與會參與者亦積極參與討論，並於會後共進午餐，相關討論對於未來相關研究的進展甚有助益。於該會議中，欣逢之前於另一國際會議相識，現正在英國 Birmingham Business school 擔任 international research fellow 的 Eliana Lauretta, 參與其報告的 session。該 session 討論了總體變數（如貨幣、金融部門風險）的衡量方式以及其對於總體經濟表現的預測能力，與本人研究有相當密切的關係。參與該 session 的學者多為同一研究團隊成員，我們於相關議題有熱烈討論，會後並共進晚餐，規劃未來互訪。

二、與會心得

參與此次會議獲益良多。最大的收穫來自於結識多位來自美國、英國、德國從事貨幣政策、總體經濟研究的學者，交換我們對於國內外學術界與實務問題的看法，並積極討論未來合作、互訪的可能。特別是本人之前發表的貨幣政策的福利分析發現，相對於利率法則，貨幣總量控制法則對於穩定經濟會有較好的效果，也能提高福利。但在實務的貨幣政策操作上，貨幣數量（如 M2）究竟應該如何衡量，又是另一議題，於該 session 的討論，提供了未來可能的思考方向。整體來說，參與此一會議，對於未來對於貨幣政策、金融、總體經濟相關議題的深入研究有相當助益。

三、考察參觀活動(無是項活動者略)

四、建議

五、攜回資料名稱及內容

六、其他

Welfare Implications of the Chinese Monetary Policy Reform: A Dynamic Stochastic General Equilibrium Approach

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May 2015

Abstract

In this study, we establish an open-economy DSGE model with the frictional domestic credit market to conduct the welfare analyses of monetary policy reform plans of China. Currently, both the domestic credit market and international capital market are under various regulations. The progress of the gradual removal of these market regulations, which may crucially alter the transmission mechanism of domestic as well as foreign shocks, is important for the economic transformation of the Chinese economy. The welfare analyses generate important policy implications for the progress of policy reforms. The results suggest that, compared with domestic deregulations, opening capital account can be most critical as it makes the international transmission mechanism of shocks feasible.

Keyword : dynamic stochastic general equilibrium (DSGE), Chinese economy, economic transformation

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1. Introduction

In past three decades since the revolution and opening in 1978, China has made remarkable economic performance which has aroused lots of interests in studying macroeconomic fundamentals and policies of China's economy. After the high growth rate lasting for the past two decades, the Chinese economy is experiencing the critical stage of economic transformation. The priority task is to gradually remove various government's regulations on the economy which may have led to significant distortions of the market mechanism and fundamentally alter the channel that shocks and policies are transmitted. Whether or not the policy reforms succeed can be the critical determinant of the long-term economic development.

Due to the market distortion by regulations, the standard dynamic stochastic general equilibrium (DSGE) model with full market mechanism may not be appropriate for the studies of the Chinese economy. As a result, it was not until most recently this framework has been used for China.[1] The DSGE model may help us understand better the transmission mechanism of shocks and policies in the economy with, and without, the regulations. Thus, we may understand better how the policy reforms may alter the market mechanism and the way shocks are transmitted.

In this paper, we will shed light on the monetary policy reforms. The current monetary policy of China includes the conventional and unconventional measures. In addition to its general goal of controlling the money supply (M1 and M2), the People's Bank of the Republic of China (the PBoC) also imposes various regulations

[1] The more recent studies include Zhang (2009), Liu and Zhang (2010), Straub and Thinmann (2010), and some others. All of them use the standard framework in the literature. For instance, Liu and Zhang (2010) calibrate a standard New Keynesian model under monetary aggregate rule and interest rate rule to assess which policy rule works better for China. Straub and Thinmann (2010) investigate the dynamic adjustment of the economy with a standard open-economy framework under both flexible and fixed exchange rate regimes. The standard DSGE model may fail to capture the distorted market mechanism of the Chinese economy.

on the domestic credit market and foreign exchange market both of which are crucially related to the monetary policy. On the foreign exchange market, the PBoC conducts the managed floating exchange rate regime and also implements capital control where only little international capital flows are permitted. On the domestic credit market, the PBoC imposes the floor for the loan rate and ceiling for the deposit rate, as well as the amount of loan making.

Because of the Chinese characteristics, some most recent working papers have incorporated the market regulations in DSGE models to examine the macroeconomic responses to shocks with and without the regulations. Chen, Funke and Paetz (2012) include government's regulations on the deposit and loan rates, required reserve ratio, and quantity of credit in a closed-economy DSGE model to simulate the "unconventional" monetary policy which differs from most countries. The calibration results show that these policy tools interrelate, augment and intensify each other. Chang, Liu and Spiegel (2014) use an open-economy DSGE model with capital control where domestic households are not allowed to hold foreign assets. Under capital control, the conventional uncovered interest rate parity condition does not hold. To maintain the exchange rate management and closed capital account, the central bank buys up any net inflow of foreign assets using domestic currency. The central bank may not want to fully sterilize the increase in the money supply when the cost of sterilization, the home and foreign interest rate spread, increases. Thus, the capital control under managed floating exchange rate are the key factor driving up the inflation.

These two papers examine the domestic credit market and foreign exchange market separately. However, the credit policy for the domestic financial market and capital control for the international capital market can be closely interrelated: they may intensify each other, or one of the regulations can be redundant.

The regulations on the domestic credit market and international capital market can be closely related. Under capital control and managed floating exchange rate, the central bank will buy foreign bonds from the public if there are current account surplus. The increase in the money supply may drive up the inflation rate if the monetary expansion is not fully sterilized. This may further increase the liquidity prevailing on the domestic credit market. The regulations on the amount and interest rates of loan making, however, may alter the effects. On the other hand, the performance of the domestic financial market can lead to international capital flows and exchange rate movements. The macroeconomic effects under financial distress can be different if the capital account is closed.

Therefore, we establish an open-economy DSGE model incorporating the frictional domestic banking sector and international capital market. We examine the regulations on the domestic credit market and the international capital market, both of which are subject to the unconventional regulations. On the international capital market, the PBoC implements the managed floating exchange rate regime and capital control. The PBoC can also actively adjust the required reserve ratio with the emphasis of economic stabilization. During the process of China's economic transformation, this study may help us understand better how the policy reforms may alter the shock transmission and the welfare of various policy reform plans.

The remainder of this paper is organized as follows. In Section 2, there is a brief introduction of China's monetary policy. Section 3 outlines the model, as well as the monetary policies and interest rates. The calibration is stated in Section 4. The welfare analyses of policy reforms are presented in Section 5. Section 6 concludes.

2. China's Monetary Policy

The monetary policy that the PBoC conducts includes the conventional and unconventional measures. In regard to the conventional measures, similar to the Central Bank of Taiwan, in the end of each year, the PBoC announces the target of M1 and M2 growth rates for the succeeding year.

The PBoC also imposes the required reserve ratio for deposits in banks. However, different from most of the central banks in the world which adjust the ratio infrequently, the PBoC frequently adjusts the required reserve ratio as one of the primary macro control measures to stabilize the economy in past two decades.[2]

Furthermore, the PBoC implements various regulations on the prices and quantities on the domestic credit market and foreign exchange rate market. On the domestic credit market, the PBoC restricts the range of interest rate fluctuations by specifying the upper bound of the deposit rate and lower bound of loan rate. The deposit, loan rates and the deposit-loan rate spread in 2000-2014 are listed in Figure 1. Moreover, the PBoC imposes the quota for banks' loan making.[3]

The regulations on the foreign exchange market involve the regulations on the exchange rate movement and capital flows. Starting from July 2005, the RMB exchange rate is partially liberalized, from the fixed rate of 8.2 against the US dollar, to the managed floating regime targeted to a basket of currencies. Since then till December 2012, the Renminbi against the US dollars has appreciated by 25%.[4] The

[2] For example, to stabilize the economy, particularly in the attempt to dampen surging house prices, the government actively uses various macro control policies, one of which is the monetary policy. The PBoC has adjusted the required reserve ratio for 31 times from May 2007 to June 2014. The current level of required reserve ratio exceeds 20%.

[3] Chen, Funke and Paetz (2012) make a comprehensive summary of the domestic credit market regulations.

[4] The regulation on exchange rate from free floating has been attributed to its high current account surplus from trades with advanced countries. The share of net export in the GDP has risen from 5.46% in 2005 to 8.8% in 2007, then gradually declined to 2.61% in 2011. Various empirical studies have shown that the appreciation of Renminbi does help reduce trade surplus. (Yu, 2009, 2010; Hwang, Peng

crucial regulation measure on the foreign exchange market is the capital control. The capital account of China is under strict regulation where free international capital flows are not permitted. Only a limited number of certified financial institutions are eligible for conducting the financial transactions within the quota approved by the State Administration of Foreign Exchange (SAFE).

Being aware of the importance of market deregulations for the economic transformation, particularly the RMB internationalization has been considered as the ultimate goal of monetary policy reform, the Chinese government is gradually relaxing the regulations on financial markets. The fluctuation range of interest rates is widened. The upper bound of the deposit rate is just raised up to 1.2 times of the baseline deposit rate in November 2014, from 1.1 times of the baseline deposit rate earlier.

The range of exchange rate fluctuations is also widened. Currently, the daily RMB exchange rate movement is permitted to fluctuate within the range of 2%, larger than the range of 0.5% before April 2012.

The capital control is also little relaxed. Starting from 2002, the PBoC allows the limited amount of international capital flows by certified institutions. As for the end of October 2014, the overall amount is USD $64 billion for QFII (qualified foreign institutional investors, including 28 countries and 258 institutions), RMB $294 billion for the RQFII (Renminbi qualified foreign institutional investors, including 4 countries and 91 institutes), and USD $87 billion for the QDII (qualified domestic institutional investors, including 125 institutes). While these international financial transactions require the official approval, the most recent development, the Shanghai Hong Kong Stock Connect, which just started in November 2014, is the starting point of opening the capital account. It permits the financial transactions between the stock

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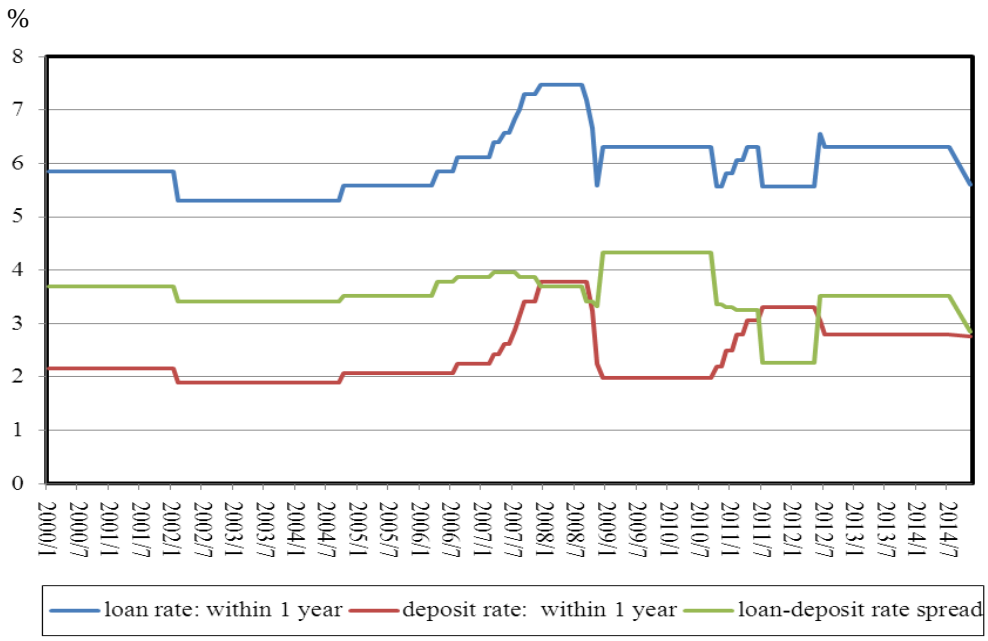
and Yang, 2012, and etc.)

market in Hong Kong and Shanghai, though there are still the ceiling for the transaction volume. We may expect the capital account can be gradually opened.



Source: The People's Bank of China (2014).

Figure 2: 1 year benchmark deposit, loan rates and the spread

3. The model

3.1 Goods market

In this paper, we establish a small open economy with a banking sector which is subject to financial friction.[5] Goods markets are monopolistically competitive. Firms produce goods for home consumption and exports. Consumers consume both home goods and imported foreign goods. The representative household consumes the composite goods, which are composed of domestic goods C_t^d and imported goods C_t^f:

[5] We follow the specification by Goodfriend and McCallum (2007).

$$C_t = \left[\left(\alpha^d\right)^{1-\theta} \left(C_t^d\right)^{\frac{\theta-1}{\theta}} + \left(\alpha^f\right)^{1-\theta} \left(C_t^f\right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{1}$$

where $\alpha^d, \alpha^f > 0$ represent the ratios of home and foreign goods in the aggregate consumption, C_t, respectively. θ is the intratemporal elasticity of substitution between domestic and foreign goods. The associated demand functions for the domestic and imported goods can be written as:

$$C_t^d(i) = \left(\frac{P_t^d(i)}{P_t^d} \right)^{-\nu} C_t^d, \quad C_t^f(i) = \left(\frac{P_t^f(i)}{P_t^f} \right)^{-\nu} C_t^f, \tag{2}$$

$$C_t^d = \alpha^d \left(\frac{P_t^d}{P_t} \right)^{-\theta} C_t, \quad C_t^f = \left(\alpha^f\right) \left(\frac{P_t^f}{P_t} \right)^{-\theta} C_t, \tag{3}$$

where $C_t^d(i)$ and $C_t^f(i)$ stand for the domestic goods and imported goods of variety i. ν is the elasticity of substitution among the different goods. The corresponding prices are shown as follows:

$$P_t^j = \left[\int_0^1 P_t^j(s)^{1-\nu} ds \right]^{\frac{1}{1-\nu}}, \quad j = d, f \tag{4}$$

$$P_t = \left[\alpha^d \left(P_t^d\right)^{1-\theta} + \left(\alpha^f\right) \left(P_t^f\right)^{1-\theta} \right]^{\frac{1}{1-\theta}}, \tag{5}$$

where $P_t^d(i)$ and P_t^d are the home-currency prices of individual and aggregate domestic goods, respectively, $P_t^f(i)$ and P_t^f are the home-currency prices for the imported goods and P_t is the aggregate price index. e_t is the nominal exchange rate, expressed in units of the domestic currency per one unit of foreign currency. We assume that the imports are priced according to the international prevailing price. Therefore, $P_t^f = e_t P_t^*$ where P_t^* is the international price, exogenous to the small open economy. Capital good is assumed to follow the same composition.

The home firm produces goods sold in both the domestic and foreign markets. The export demand function $C_t^X(i)$ of variety i is assumed to resemble the domestic demand function, Eq. (2):

$$C_t^X(i) = \left(\frac{P_t^{X*}(i)}{P_t^{X*}} \right)^{-\nu} C_t^X \quad \text{and} \quad C_t^X = X_t^* \left(\frac{P_t^{X*}}{P_t^*} \right)^{-\mu} \quad , \mu > 0, \tag{6}$$

where $P_t^{X*}(i)$ is the firm's export price in the foreign currency, P_t^{X*} is the aggregate price index of exported goods denominated in the foreign currency, and P_t^* is the foreign price index. μ is the price elasticity of the aggregate exports. We assume that X_t^* is subject to random shocks, exogenous to a small open economy.

3.2 Household

In this model, a representative household consumes the composite goods and supplies labor. She also owns the monopolistically competitive firm for production and operates a competitive bank for financial services.

We assume that the infinitely-lived household maximizes the expected lifetime utility based on the consumption bundle and leisure:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\varphi \log(C_t) + (1-\varphi) \log\left(1 - n_t^s - m_t^s\right) \right], \tag{7}$$

where $\beta \in (0,1)$ is the household's subjective discount factor. φ stands for the share of consumption in the utility, and n_t^s and m_t^s are supplies of labor in the production and banking sectors, respectively.

Under full capital control, the private sector is not allowed to hold foreign bonds. As a result, the household can hold only the home bonds, issued by the government. The budget constraint of the households can be described as below:

$$q_t\left(1-\delta\right)K_t+\frac{B_t}{P_t}+\frac{H_{t-1}}{P_t}+w_t\left(n_t^s+m_t^s\right)+\alpha^d\left(\frac{P_t^d\left(s\right)}{P_t^d}\right)^{1-\nu}\left(\frac{P_t^d}{P_t}\right)^{1-\theta}C_t^A$$
$$+\left(\frac{e_tP_t^X\left(s\right)}{P_t}\right)\left(\frac{P_t^{X*}\left(s\right)}{P_t^{X*}}\right)^{-\nu}\left(\frac{P_t^{X*}}{P_t^*}\right)^{-\mu}-w_t\left(n_t^d+m_t^d\right)-\frac{H_t}{P_t}-tax_t-q_tK_{t+1}$$
$$-\frac{B_{t+1}}{P_t\left(1+R_t^B\right)}-C_t=0. \tag{8}$$

Here, w_t is the real wage, which is assumed to be identical in both sectors. n_t^d and m_t^d are the labor demanded in the production and banking sectors, respectively. B_{t+1} is the domestic bond. The nominal interest rate which B_{t+1} pays is denoted by R_t^B. tax_t is the lump-sum tax, and H_t stands for the nominal holdings of base money at the end of the period t.

3.3 Production

The goods market is monopolistically competitive. The firms produce goods following the technology:

$$Y_t=K_t^{\eta}\left(A_t\,n_t^d\right)^{1-\eta}, \tag{9}$$

where η stands for the share of capital in the goods production and A_t is the labor productivity which is subject to exogenous shock. To simplify the model, we assume that the capital is fixed at its steady state level.[6] Under monopolistic competition and price rigidity, the firm produces goods to satisfy the demand from both the domestic and foreign markets. We assume that the firm can take price discrimination for the home and foreign consumptions so they will price the goods sold in the home and foreign countries separately.

[6] The assumption follows the specification of Goodfriend and McCallum (2007) for simplification. However, this may not be appropriate for the Chinese economy, whose capital has been quickly accumulated. We will relax this assumption in the future study.

In the home country, the home demand consists of the private consumption and investment:[7]

$$C_t^A = C_t + q_t\left(K_{t+1} - (1-\delta)K_t\right), \tag{10}$$

where q_t is the real price of capital and δ is the depreciation rate. We assume that firms adopt the Calvo (1983) staggered pricing strategy. In each period, the probability of firms to change the price, in response to the current shock, is $1-\xi_d$, implying the mean interval of price change is $1/(1-\xi_d)$. At period t, the profit maximization problem of a typical firm i who can change the price is to choose $P_t^d(i)$ to maximize the profit within the period t and $t+s$ when the price remains valid. The optimal price that a typical firm sets is (the subscript i is dropped due to symmetry):

$$P_{t,t}^{d,\,flex} = \frac{\nu}{\nu-1}\frac{\left\{\sum_{s=0}^{\infty}(\xi_d)^s E_t \Lambda_{t+s,t}^d mc_{t+s,t} C_{t+s,t}^A \cdot\right\}}{\left\{\sum_{s=0}^{\infty}(\xi_d)^s E_t \Lambda_{t+s,t} C_{t+s,t}^A \cdot\right\}}, \tag{11}$$

where $\Lambda_{t+s,s} = \left(\beta^s \lambda_{t+s}/\lambda_t\right)\left(P_t/P_{t+s}\right)$. $C_{t+s,t}$ is the demand under the price set this period which remains valid in the period $t+s$, and $mc_{t+s,t}$ is the associated marginal cost. λ_{t+s} is the Lagragian multiplier in the period $t+s$.

The price index for the domestic price will evolve following the dynamics:

$$\left(P_t^d\right)^{1-\nu} = \xi_d\left(P_{t-1}^d\right)^{1-\nu} + (1-\xi_d)\left(P_{t,t}^{d,\,flex}\right)^{1-\nu}, \tag{12}$$

For the foreign country, we assume that the law of one price (LOOP) holds. Therefore, $P_t^{X*} = P_t^d/e_t$.

[7] We neglect the government spending in the current version to simplify the role of government to emphasize the monetary policy implemented by the central bank.

The market clearing condition of the goods market can be written as:

$$Y_t - \alpha^d \left(\frac{P_t^d(i)}{P_t^d} \right)^{-\nu} \left(\frac{P_t^d}{P_t} \right)^{-\theta} C_t^A - \left(\frac{P_t^{X*}(i)}{P_t^{X*}} \right)^{-\nu} \left(\frac{P_t^{X*}}{P_t^*} \right)^{-\mu} = 0, \tag{13}$$

3.4 Bank

We follow Goodfriend and McCallum (2007) to characterize the banking sector which is subject to endogenous financial friction. The household's consumption is subject to a "deposit-in-advance" constraint, such that the household should hold deposits before consumption transactions. The transaction constraint can be written as:

$$C_t = \frac{VD_t}{P_t}, \tag{14}$$

where D_t is the deposit and V is a constant, representing the velocity of the aggregate deposit.

The bank operates by receiving the deposits and loan making to households. Each bank's balance sheet can be written as:

$$H_t + L_t = D_t, \tag{15}$$

where L_t and H_t represent the loans and reserve money, respectively. Let rr be the reserve ratio, so the funds available for loan making is equal to $(1-rr)D_t$.

Due to the asymmetric information problem on the credit market, the bank makes loans by using collateral and hiring labor to monitor credits. We assume that the loan production function follows a Cobb-Douglas form as follows:[8]

[8] From the deposit-in-advance constraint, we know that the loans are essentially made to finance consumption expenditure. Although this specification is different from the loans financing the capital investments of firms, which may account for the majority of loans in the real world, it is consistent with the estimation results in Wu (2004) in that the consumption expenditures of the private sector in

$$\frac{L_t}{P_t} = F\left(b_{t+1} + A_t^{\kappa} kq_t K_{t+1}\right)^{\alpha} \left(A_t^{m} m_t\right)^{1-\alpha}, \tag{16}$$

where m_t is the labor input for monitoring, and $b_{t+1} + kq_t K_{t+1}$ are the collateral, including capital goods and home bonds where $b_{t+1} = B_{t+1} \big/ P_t^A \left(1 + R_t^B\right)$. Because the household cannot hold foreign bonds, the collateral does not include the foreign bonds. α is the share of collateral in the loan production. Because capital goods require greater monitoring efforts than bonds to confirm the market value, $0 < k < 1$ states the inferiority of capital to bonds for collateral purposes. F is a constant, which stands for the efficiency of the loan-making process. The loan making function implies the loan making process is costly, due to the significant financial friction on the credit market. We attempt to use the loan-making process to characterize the credit market in China. A lower F represents higher friction on the credit market, which may resemble the status quo of the Chinese credit market.

Following Goodfriend and McCallum (2007), we also assume that there are shocks to the value of capital as the collateral and to the effectiveness of monitoring efforts, A_t^{κ} and A_t^{m} respectively.

3.5 Current Account

The current account surplus (in terms of the home goods) can be written as the trade surplus plus net interest income received from holdings of foreign assets

$$CA_t = p_t^X C_t^X - p_t^f IM_t + \frac{e_t \left(R_{t-1}^{B^*} - 1\right) B_t^*}{P_t}, \tag{17}$$

where IM_t represents the imports, B_t^* denotes the foreign bonds held by the country

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Taiwan are more sensitive to the shocks to loans than investments.

which pays the interest rate R_{t-1}^{B*}. The amount of current account balance reflects the change in the foreign assets held by the country:

$$CA_t = \frac{e_t\left(B_{t+1}^* - B_t^*\right)}{P_t}, \tag{18}$$

We should note that, under capital control, private sectors are not allowed to hold the foreign assets, but the amount of foreign assets earned from the international trades should be obtained by the central bank which may lead to the expansion of money supply if the effect is not fully sterilized.

3.6 Policies

The central bank of China currently conducts the conventional and unconventional monetary policy measures. We assume that, same as the central bank of most countries, the PBoC conducts the interest rate rule following the Taylor type:[9]

$$R_t^{IB} = (1-\alpha_R)\left[R^{IB} + \alpha_p^R \Delta p_t + \alpha_Y^R y_t + \alpha_q^R \Delta RER_t\right] + \alpha_R R_{t-1}^{IB}, \tag{19}$$

where R^{IB} is the steady-state interbank rate and $0 \le \alpha_R < 1$ characterizes the persistence of the policy rule. $\alpha_p, \alpha_Y, \alpha_e \ge 0$ are policy parameters, which control the degree of policy's responses to the CPI inflation rate, output gap and real exchange rate respectively. RER refers to the real exchange rate, and ΔRER_t describes the rate of real depreciation.

The monetary policy measures of the PBoC that differ from other countries include the capital control, the managed floating exchange rate regime as the intervention on the international capital market, and the active adjustment of required

[9] While the PBoC conducts the money growth rate rule by announcing the target of money growth rate, we assume the interest rate rule as it also actively controls the interest rates on the market.

reserve ratio that will crucially affect the liquidity on the domestic credit market.

Firstly, the required reserve ratio is assumed to be adjusted solely for inflation rate stabilization. Therefore, the required reserve ratio follows the form:[10]

$$rr_t = (1-\alpha_{rr})\left[\overline{rr} + \alpha_P^{rr}\Delta p_t\right] + \alpha_{rr} rr_{t-1}, \tag{20}$$

Similarly, $0 \le \alpha_{rr} < 1$ denotes the persistence of the required reserve ratio. $\overline{rr}$ is the steady-state required reserve ratio. $\alpha_P^{rr} \ge 0$ governs the required reserve ratio's adjustment to the CPI inflation rate. If both the α_{rr} and α_P^{rr} equals 0, the required reserve ratio will become a constant. This is the specification in most studies which characterize the passive adjustment of the required reserve ratio.

Secondly, the managed floating exchange rate regime is assumed to follow the rule:

$$\phi_t^e = (1-\alpha_e)\left[\phi^e + \alpha_P^e \Delta p_t + \alpha_Y^e y_t + \alpha_q^e \Delta RER_t\right] + \alpha_e \phi_{t-1}^e, \tag{21}$$

where $\phi_t^e = \log(e_t / e_{t-1})$, and ϕ^e denotes the steady-state exchange rate depreciation rate. $0 \le \alpha_e < 1$ denotes the persistence of exchange rate rule. $\alpha_P^e, \alpha_Y^e, \alpha_q^e \ge 0$ are policy parameters, which control the degree of policy's responses to the CPI inflation rate, output gap and real exchange rate depreciation.

Lastly, under capital control, the central bank purchases the inflow of funds from the holding of foreign bonds with the home bonds or money supply. Therefore, the central bank faces the flow-of-funds constraint:[11]

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[10] Chen, Fanke and Patez (2012) specify the similar form.

[11] As a country with massive current account surplus, the central bank's act to stabilize the exchange rate movement will lead to the increase in money supply. As a result, the central bank may want to sterilize the monetary expansion by issuing bonds. Therefore, $CA_t = (H_t - H_{t-1})/P_t$ states the situation with no sterilization, while $CA_t = (B_{t+1} - R_{t-1}B_t)/P_t$ refers to the full sterilization. While Chang, Liu and Spiegel (2014) focus on the inflationary effects of the sterilization and non-sterilization under the capital control and managed floating exchange rate regime, this study emphasizes the interrelation between the capital control on the international capital market and the regulations on the domestic credit market.

$$CA_t = \frac{e_t\left(B^*_{t+1} - R^*_{t-1}B^*_t\right)}{P_t} = \frac{B_{t+1} - R_{t-1}B_t}{P_t} + \frac{H_t - H_{t-1}}{P_t}, \tag{22}$$

Alternatively, if the capital account is fully open, the UIP condition should hold:

$$-\left(\frac{\varphi}{C_t\lambda_t} - 1\right)\Omega = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{P_t}{P_{t+1}}\right]\left[\left(1 + R^B_t\right) - \frac{e_{t+1}}{e_t}\left(1 + R^{B^*}_t\right)\right] \tag{23}$$

where $R^{B^*}_t = R^*_t - \gamma/\chi\left(B^*_{t+1}/P^*_t\right)$.

3.7 Exogenous variables

The processes of exogenous shocks in the model are all assumed to follow first-order autoregressive processes:

$$a_t = \left(1-\rho_A\right)a + \rho_A a_{t-1} + \varepsilon^A_t, \quad 0 \le \rho_A < 1, \tag{24}$$

$$a^\kappa_t = \left(1-\rho_\kappa\right)a^\kappa + \rho_\kappa a^\kappa_{t-1} + \varepsilon^\kappa_t, \quad 0 \le \rho_\kappa < 1, \tag{25}$$

$$a^m_t = \left(1-\rho_m\right)a^m + \rho_m a^m_{t-1} + \varepsilon^m_t, \quad 0 \le \rho_m < 1, \tag{26}$$

where $a_t = \log\left(A_t\right)$ and $a^i_t = \log\left(A^i_t\right),\ \forall i = \kappa, m$ m

Since the small open economy cannot influence the foreign prices and interest rate, we assume that these foreign variables are exogenous and move with the following AR(1) processes:

$$\Pi^*_t = \left(1-\rho_{\Pi^*}\right)\Pi^* + \rho_{\Pi^*}\Pi^*_{t-1} + \varepsilon^{\Pi^*}_t, \quad 0 \le \rho_{\Pi^*} < 1, \tag{27}$$

$$R^*_t = \left(1-\rho_{R^*}\right)R^* + \rho_{R^*}R^*_{t-1} + \varepsilon^{R^*}_t, \quad 0 \le \rho_{R^*} < 1 \tag{28}$$

where $\Pi^*_t = \log\left(P^*_t\right) - \log\left(P^*_{t-1}\right)$ stands for the foreign inflation rate. Π^* and R^* are the steady-state level of the foreign inflation and interest rate respectively.

Export shock is also assumed to follow an AR(1) process:

$$x_t^* = (1-\rho_X)x + \rho_X x_{t-1}^* + \varepsilon_t^X, \quad 0 \le \rho_X < 1 \tag{29}$$

Here, $x_t^* = \log\left(X_t^*\right)$. $\rho_A, \rho_\kappa, \rho_m, \rho_{\Pi^*}, \rho_{R^*}, \rho_X$ lying between 0 and 1, denoting the AR(1) persistence associated with each variable, and $\varepsilon_t^A, \varepsilon_t^\kappa, \varepsilon_t^m, \varepsilon_t^{\Pi^*}, \varepsilon_t^{R^*}$ and ε_t^X are the associated innovations which are assumed independent, white noises .

3.8 Interest rates and the external finance premium

With the frictional credit market, the interest rates associated with bonds, deposits and loans would diverge. Let R_t^T represent the interest rate in a conventional model without the banking sector, and this can be obtained by using the conventional Euler equation:

$$1+R_t^T = E_t \frac{\lambda_t P_{t+1}}{\beta \lambda_{t+1} P_t}. \tag{30}$$

This is also the interest rate for borrowing and lending without using the collateral. All the interest rates under the credit friction, particularly due to the costly loan making process, are listed as follows:[12]

$$\frac{1+R_t^B}{1+R_t^T} = 1-\left(\frac{\varphi}{C_t \lambda_t}-1\right)\Omega_t, \tag{31}$$

$$\left(1+R_t^T\right) = \left(1+R_t^{IB}\right)\left[1+\frac{Vw_t m_t}{(1-\alpha)(1-rr)C_t}\right] \tag{32}$$

$$\left(1+R_t^L\right) = \left(1+R_t^{IB}\right)\left[1+\frac{Vw_t m_t}{(1-rr)C_t}\right]. \tag{33}$$

[12] Because the credit market exists in the domestic economy, and we assume that only the capital and home bond can serve as the collateral, the interest rate relationships are essentially the same as those in Goodfriend and McCallum (2007).

The difference between the bond rate and the uncollateralized rate reflects the additional benefits that the bonds, eligible for collaterals for loans, provide to precipitate the loan making. Furthermore, a typical bank obtains funds on the reserve market at the interbank rate R_t^{IB}, and extends loans to households at the benchmark rate R_t^T without collateral or at the loan rate R_t^L with collateral. The spread between the uncollateralized or collateralized loan rates and the interbank rate covers the marginal cost that the loan making process incurs.

The EFP reflects the marginal cost of making loans and can be endogenously obtained by taking the difference between the external and internal funding costs of the firm, the spread between R_t^L and R_t^{IB}.[13] Consequently, the EFP can be written as:[14]

$$EFP_t = R_t^L - R_t^{IB} \approx \frac{Vw_t m_t}{(1-rr)C_t}. \tag{34}$$

The deficiency of the loan making process may result in the surge in the loan rate, driving up the EFP.

4. Calibration

4.1 Calibration

[13] From the household's perspective, the EFP can be derived by taking the difference between the loan and deposit rates. With a nonzero, but small, reserve ratio, the deposit rate is very close to the interbank rate.

[14] The EFP reflects the marginal cost of loan making, which is closely related to the value of collateral. When the value of collateral is higher, the loan making process requires fewer workers for credit check for the same amount of loans. This will lower the cost of loan making as well as the EFP. Therefore, given C_t and w_t in Eq. (33), higher value of collateral lowers the need for m_t and thereby the EFP. As a result, higher value of capital implying greater value for collateral will help reduce the cost for loan making and the EFP.

We calibrate the model to generate the steady state consistent with the data of China. We assume that the steady state is current account balanced. The share of the home produced goods in the foreign consumption X^* is adjusted to assure the balanced current account.[15] The market price of capital goods is assumed to be $q=1$, and the real exchange rate is specified as 1 in the steady state. β is assumed to be 0.99, following most literature.

The share of import goods in the aggregate consumption α^f is set to 0.3, which is close to 0.36 of the import share in the GDP in 2005. The parameters related to goods production are calibrated to generate the steady-state labor employment in production to be slightly higher than 1/3, as found in most countries. Therefore, we set the capital share in production $\eta=0.45$, utility of consumption relative to leisure $\varphi=0.65$ to generate roughly 0.35 of the available time in goods production in the steady state. The depreciation rate of capital is specified as $\delta=0.025$ (reflecting the annual depreciation rate to be 10%). The elasticity of substitution among goods ν is assumed to be 1.5, such that the markup is about 10%. The elasticity of substitution between the domestic and imported goods, θ, is set to 1.5, and the price elasticity of demand for exports $\mu=1.5$. The degree of price stickiness ξ_d is specified as 0.65, implying the average duration of price adjustment around 3 quarters.

The financial parameters are calibrated to generate the steady-state financial figures close to the data. First, we set the velocity of the aggregate bank deposits at $V=0.62$, measured by the average ratio of GDP to M2 in 1994-2011. Second, the reserve ratio is set as $rr=0.09$ which is the level in the end of 2006.[16] Third, the fiscal policy parameter, $boc=0.17$, is obtained from the ratio of the debt-GDP ratio

[15] However, the home bond rate R^B is lower than the foreign bond rate R^{B*} due to the liquidity service that the home bond can serve.

[16] Since the PBoC adjusts the required reserve ratio often, we simply use this level of the ratio in the end of 2006.

of China in 2005. Furthermore, following Goodfriend and McCallum (2007), three primary parameters in the loan production function, which characterize the credit market friction, are calibrated to generate the share of labor employment in the banking sector to the total labor employment to be close to 3.2%, the data reported in 2005.[17] Thus, the financial parameters are chosen as $\alpha = 0.42$, $k = 0.75$ and $F = 15$. The model generates the share of the labor employment in banking sector in the overall employment is about 0.9%. All the parameters are summarized in Table 1. The steady-state foreign bond rate R^{B^*} and the world interest rate R^* are equal to 1.1%, while the steady-state Home bond rate is 0.1% in the steady state. The spread between the home and foreign bond rates comes from the liquidity service that the home bonds serve as the collateral for loans.

The benchmark case is characterized to capture the current planned economy. We assume that the central bank controls not only the interbank rate rule (as most countries do), but also actively adjusts the required reserve ratio, and implements managed floating exchange rate rule and capital control. The policy parameters are also listed in Table 1. We assume that the central bank conducts the interbank rate rule with the focus of inflation rate stabilization. The persistence of the interbank rate policy and the central bank's responses to the inflation rate, output, and real exchange rate are specified as 0.9, 2.5, 0, and 0 respectively. In addition, the central bank adjusts the required reserve ratio actively to reinforce its attempt to moderate the inflation rate movements. The steady-state required reserve ratio is specified as 9%, the level of China in the end of 2006. The persistence of the required reserve ratio and its response to inflation are 0.6 and 10 respectively. On the other hand, the managed floating exchange rate is implemented with the emphasis of moderating the real

[17] This number is for urban corporations only.

exchange rate movements. Thus, the persistence and the responses to the inflation rate, output, and real exchange rate of the managed floating exchange rate policy are chosen as 0.8, 0, 0, and 1.5 respectively. The following analyses consider the various plans for policy reforms which involve the removal of the regulations.

4.2 Welfare measure

In Section 5, we will conduct the welfare examination of various stages of policy reforms. The welfare measure of the representative agent is given by the conditional expected lifetime utility function at time zero:[18]

$$V_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{1}{1-\rho} C_t^{1-\rho} - \frac{\chi}{1+\varepsilon} \left(L_t \right)^{1+\varepsilon} \right) \tag{35}$$

The initial state is specified as the deterministic steady state, according to Schmitt-Grohe and Uribe (2007). For a policy m, the welfare gain can be measured by the fraction γ^m of the steady-state consumption which the households can be as well off as under the policy m. The welfare gain γ^m of the policy m can be written as:

$$V_0^m = \sum_{t=0}^{\infty} \beta^t \left(\vartheta \log \left(\left(1 + \frac{\gamma^m}{100} \right) \bar{C} \right)^{1-\rho} + (1-\vartheta) \log \left(1 - \bar{n} - \bar{m} \right) \right), \tag{36}$$

Higher value of γ^m is associated with greater welfare gain that the policy entails.

5. Monetary policy reforms

As discussed, the current market regulations involve the capital control, exchange rate management, and active required reserve ratio adjustments. While the

[18] The utility from the real money holding can be negligible, following Obstfeld and Rogoff (1998, 2000).

deregulations of these policy measures seem to be critical for the economic transformation of the Chinese economy, the progress of policy reforms becomes the center of concerns. Should the capital control be removed before the deregulation of exchange rate management, or should floating the exchange rate earlier than opening the capital account can result in quite different economic performance, particularly, under shocks occurring from the home or foreign economies?

Therefore, in this section, we will examine the welfare gains (under different shocks) of the policy reforms. The policy reforms may involve the removal of capital control, more freely floating exchange rates, and the passive required reserve ratio adjustment. Firstly, if the capital control is liberalized, the UIP condition, Eq. (23) should hold instead. Secondly, the more floating exchange rate corresponds to an inactive response of exchange rate adjustment to the real exchange rate movement where α_q^e is lowered to 0.5. Thirdly, the policy parameters α_{rr} and α_p^{rr} are equal to 0 under the passive required reserve ratio adjustment, implying that the required reserve ratio is fixed at its steady-state level. The changes in the policy parameters are listed in the bottom of Table 1.

While the policy reforms are undertaken gradually, we discuss various policy reform plans, which are outlined in Table 2. We start from the benchmark case (denoted as "BM") with all the regulations in place, and gradually deregulate the required reserve ratio, the exchange rate management, and the capital control. The notation "x" denotes the deregulation of the policy measure. The "Full" case describes the market with full deregulations. We simulate each case under *adverse* home productivity shock, home financial shock and foreign shocks respectively to show how the economy with policy reforms may perform under negative shocks. The discussion will center on how the policy reforms can alter the transmission

mechanism of shocks and help stabilize the economy.

5.1 Domestic productivity shock

We run simulation of all policy reform plans under 1% negative home productivity shock with the AR(1) coefficient of 0.95. The results are listed in Table 3. It is clearly shown that the benchmark case with all the regulations in place will result in almost the second highest welfare loss, only lower than that of case I, while the full liberalization can generate the lowest welfare loss.

In the benchmark case, all the regulations on the domestic credit market and international capital market are in place. While the adverse domestic productivity shock occurs, the goods prices tend to rise due to higher marginal cost. This may result in higher inflation rate and lower production. Because the central bank may attempt to stabilize the inflation rate, the interest rate would also rise. While the central bank actively adjusts the required reserve ratio in response to inflation, the upward interest rate movement can be reinforced by the increased required reserve ratio.[19, 20] As a result, the active required reserve ratio, for inflation stabilization, may exacerbate the economic downturns. However, due to the real exchange rate appreciation (the home goods prices increase), the central bank may depreciate the home currency, while the capital account remains closed. This may help moderate the decline in exports and production.

Therefore, the active required reserve ratio adjustment, as the additional instrument to stabilize the inflation rate, can intensify the adverse impacts on the real

[19] The loan rate can be even higher after the adverse productivity shock. As Bernanke and Gertler (1995) points out, the asymmetric information problem can be worsened during the economic downturns, and thus lead to higher loan rate which can exacerbate the balance sheet of firms and economic performance.

[20] The increase in the required reserve ratio can further lead to loan rate and lower amount of loan making.

variables such as the output and consumption. The managed floating exchange rate, under capital control, however, may help stabilize the real economy. The discussions demonstrate that the regulations on the domestic and international financial markets are closely related. They may intensify or diminish each other.

The results suggest that opening the capital account is most critical. The open capital account, indicated by the case IV, V and Full, can result in significantly lower welfare loss, compared to the closed capital account in the benchmark case and case I, II, III. The result is quite intuitive. The open capital account successfully helps stabilize the economy by sharing the adverse domestic productivity shock with the foreign economies. Although the international capital flows can lead to more volatile exchange rates, and thereby more volatile inflation rate, the market mechanism helps stabilize the real variables such as output, consumption, employment and exports. Since the market mechanism helps stabilize the economy, the full deregulations can generate the lowest welfare cost.

5.2 Domestic financial shock

The financial crises in emerging economies in the 90's can have important implications for the close relationship between the domestic credit market and international capital market. The domestic financial distress led to capital flight which resulted in the drastic exchange rate depreciation of the currency. Although the worst case would not happen to China which owns the massive amount of foreign reserves, the Chinese authority is still very cautious about the liberalization of international capital flows. The relatively fragile financial system which may potentially embody the serious asymmetric information problem can be one of the primary concerns.

Therefore, in this section, we consider the negative shock to the domestic

financial sector, which are characterized by the decline in the monitoring efforts of loan making as well as the decline in the quality of capital as the collateral for loans. We assume that there are the simultaneous 1% shocks occurring to a_t^{κ} and a_t^{m} with the AR(1) persistence of 0.99 and 0.95 respectively.

The results are listed in Table 4. Similar to the adverse productivity shock, the numerical analyses show that the welfare losses are lower as long as the capital account is open, whether or not the exchange rate management and required reserve ratio adjustment are removed. The standard deviations of consumption and inflation, nominal exchange rate are significantly lowered under open capital account, which shows the consumption, nominal and real exchange rates and inflation rate can be significantly stabilized after the capital account is opened. Thus, the removal of exchange rate management and active required reserve ratio adjustment play no role. The capital outflow after the adverse financial shocks may result in the currency depreciation and thus significantly helps stabilize the export and production. This can offset the adverse effects from the rising domestic interest rate due to the worsened asymmetric information problem on the domestic financial market.

If the capital account is closed, and exchange rate floating is managed, the central bank will sell the home bonds to prevent the potentially currency depreciation from the potential capital outflow, this will reduce the money supply and further push up the interest rates which have initially risen after the adverse financial shocks occur. Therefore, the results seem to suggest, in the absence of the concerns on the exchange rate collapses, the open capital account may help share the financial shocks abroad and thus reduce the welfare loss.

5.3 Foreign shock

Another important issue for the liberalization of international capital market is the risk sharing of shocks from foreign countries. In this section, we consider there is simultaneous occurrence of 0.1% negative shock to the foreign demand of home exports, 0.1% negative shock to the foreign inflation rate, and 0.25% negative shock to the foreign interest rate. The persistence of shocks is assumed to be 0.9 for the export demand and foreign interest rate, and 0.75 for the foreign inflation rate.

The results are outlined in Table 5. Not surprisingly, the results show that the welfare losses under the open capital account can be higher, reverse to the effects of domestic shocks. Under closed capital account and managed floating exchange rate regime, all the foreign shocks that result in the current account imbalances will be absorbed by the central bank. This may partially or fully influence the domestic inflation rate, depending on the magnitude of sterilization. The open capital account, however, transmits the foreign shocks to the domestic economy through the international capital flows, and leads to the greatest macroeconomic fluctuations. We may also note that, the results of the case V and Full, compared to the case IV, suggest that, the further liberalization of exchange rate management can significantly help moderate the inflation rate and nominal exchange rate fluctuations after the capital account is opened.

The optimal policy reform plans under each type of shocks are listed in Table 6. In sum, the discussions show that the regulations on the domestic credit market and the international capital market, and the analyses have important policy implications for the progress of policy reforms. Under all types of shocks, opening the capital account appears to be the most critical stage of policy reforms. Furthermore, the exchange rate should be freely floating before the required reserve ratio adjustment

turns passively, whether or not the capital account is open. Thus, the welfare analyses may suggest that, the policy reforms would start from opening the capital account, and then liberalizing the exchange rate movements. This plan for the policy reforms can result in greatest economic stability under the home shocks. Although the economy may undertake greater fluctuations from the foreign shocks, the open capital account with floating exchange rate may help lower the adverse impacts.

6. Conclusion

In this paper, we investigate the welfare of various policy reform plans of China's economy which is currently implementing the managed floating exchange rate regime, capital control and active adjustment of required reserve ratio. The policy reforms involve the deregulation of prevailing market regulations. The reforms would take place gradually, and the progress of reforms is critical for the economic transformation.

Thus, we propose various policy reform plans. With an open-economy DSGE model, we evaluate the welfare that each of the plans entails. The results show that these regulations on the domestic credit market such as the active adjustment of required reserve ratio, and the regulations on the international capital market are closely related, and can intensify, or dampen each other.

Furthermore, the welfare analyses show that opening the capital account is the most critical step. Under the home shocks, real or financial, open capital account helps share the risk abroad. This helps stabilize the domestic economy, and significantly reduce the welfare loss. Nevertheless, opening the capital account will transmit the foreign shocks to the domestic economy, and thus significantly exacerbate the welfare loss than the case with closed capital account. However,

together with the flexible exchange rates, the welfare loss can be lowered. This study does not imply the financial reforms should start from opening the capital account, but suggests that we should be cautious about opening the capital account which can make significant differences in the shock transmission and welfare.

There are many issues left for future study. In the current model, we assume the central bank conducts the interest rate rule as the conventional measure, similar to most countries. However, the implementation of China's monetary policy can be closer to the money growth rate rule. The future study may take into account the money growth rate rule instead. Furthermore, this study considers the adjustment of required reserve ratio as the only regulation on the domestic credit market. The future study may include the prevailing regulations on the loan and deposit rates.

Appendix

Table 1 Parameter values (on quarterly basis)

Parameter	Description	Value
φ	The importance of consumption in the utility function	0.65
η	Capital share in goods production	0.45
β	Discount rate	0.99
δ	Depreciation rate of capital	0.025
q	Capital value	1
boc	Real government bond / consumption bundle	0.17
V	Velocity of aggregate bank deposits	0.62
rr	Reserve rate	0.09
α	Collateral share in loan production	0.42
F	Efficiency parameter of banking sector	15
k	Inferiority of capital to bonds for collateral purposes	0.75
α^m	Ratio of import goods to aggregate consumption in the steady state	0.3
α^d	Ratio of domestic goods to aggregate consumption in the steady state	0.7
ν	Elasticity of substitution among different variety of goods	1.5
θ	Elasticity of substitution between domestic goods and imported goods	1.5
μ	Price elasticity of demand for export	10
ξ_d	The degree of price rigidity	0.65
α_R、α_p^R、α_{Y}^R、α_q^R	Persistence and policy parameters of the Taylor rule	0.9, 2.5, 0, 0
α_e、α_p^e、α_{Y}^e、α_q^e	Policy parameters of the exchange rate rule	0.8, 0, 0, 1.5
α_{rr}、α_p^{rr}	Policy parameters of the required reserve ratio	0.6, 10
Policy reforms		
α_e、α_p^e、α_{Y}^e、α_q^e	Policy parameters of the exchange rate rule	0.8, 0, 0, 05
α_{rr}、α_p^{rr}	Policy parameters of the required reserve ratio	0, 0

Table 2 Policy Reforms

Regulations	BM	I	II	III	IV	V	Full
Interbank rate	v	v	v	v	v	v	v
Required reserve ratio	v	x	v	x	v	v	x
Exchange rate	v	v	x	x	v	x	x
Capital control	v	v	v	v	x	x	x

Note: "BM" refers to the benchmark case where all the policy tools are regulated. "Full" refers to full liberalization.

Table 3 Dynamics under the domestic productivity shock

Regimes	BM	I	II	III	IV	V	Full
Welfare (as the percentage of the steady state consumption)							
	-0.3892	-0.4666	-0.2085	-0.2312	-0.1127	-0.0757	-0.0742
Standard deviations (in the percentage deviation from the steady state)							
Y	0.0220	0.0223	0.0225	0.0227	0.0196	0.0203	0.0203
C	0.0221	0.0233	0.0185	0.0190	0.0154	0.0161	0.0161
n	0.0113	0.0120	0.0094	0.0096	0.0078	0.0075	0.0075
EX	0.0340	0.0362	0.0310	0.0320	0.0178	0.0185	0.0185
IM	0.0323	0.0352	0.0242	0.0257	0.0053	0.0052	0.0052
Δp	0.0028	0.0027	0.0030	0.0029	0.0051	0.0047	0.0047
Δe	0.0008	0.0008	0.0004	0.0003	0.0012	0.0004	0.0004
RER	0.0159	0.0169	0.0145	0.0149	0.0083	0.0086	0.0086
EFP	0.0005	0.0005	0.0004	0.0004	0.0013	0.0010	0.0010

Note: BM: active required reserve ratio adjustment, managed floating exchange rate, capital control;

I: inactive (fixed) required reserve ratio adjustment, managed floating exchange rate, capital control;

II: active required reserve ratio adjustment, floating exchange rate, capital control;

III: inactive (fixed) required reserve ratio adjustment, floating exchange rate, capital control;

IV: active required reserve ratio adjustment, managed floating exchange rate, open capital account;

V: active required reserve ratio adjustment, floating exchange rate, open capital account;

Full: inactive (fixed) required reserve ratio adjustment, floating exchange rate, open capital account;

Table 4 Dynamics under the domestic financial shocks

Regimes	BM	I	II	III	IV	V	Full
Welfare (as the percentage of the steady state consumption)							
	-0.2681	-0.3006	-0.1736	-0.1818	-0.0213	-0.0213	-0.0213
Standard deviations (in the percentage deviation from the steady state)							
Y	0.0049	0.0052	0.0038	0.0040	0.0002	0.0002	0.0002
C	0.0109	0.0116	0.0086	0.0089	0.0002	0.0002	0.0002
n	0.0069	0.0074	0.0055	0.0057	0.0002	0.0002	0.0002
EX	0.0207	0.0222	0.0164	0.0170	0.0001	0.0001	0.0001
IM	0.0228	0.0244	0.0181	0.0187	0.0001	0.0001	0.0001
Δp	0.0008	0.0008	0.0008	0.0008	0.0000	0.0000	0.0000
Δe	0.0003	0.0003	0.0001	0.0001	0.0000	0.0000	0.0000
RER	0.0097	0.0104	0.0077	0.0079	0.0001	0.0001	0.0001
EFP	0.0004	0.0004	0.0002	0.0002	0.0000	0.0000	0.0000

Note: BM: active required reserve ratio adjustment, managed floating exchange rate, capital control;

I: inactive (fixed) required reserve ratio adjustment, managed floating exchange rate, capital control;

II: active required reserve ratio adjustment, floating exchange rate, capital control;

III: inactive (fixed) required reserve ratio adjustment, floating exchange rate, capital control;

IV: active required reserve ratio adjustment, managed floating exchange rate, open capital account;

V: active required reserve ratio adjustment, floating exchange rate, open capital account;

Full: inactive (fixed) required reserve ratio adjustment, floating exchange rate, open capital account;

Table 5 Dynamics under foreign shocks

Regimes	BM	I	II	III	IV	V	Full
Welfare (as the percentage of the steady state consumption)							
	-0.3629	-0.4463	-0.2275	-0.2587	-0.9879	-0.8082	-0.7986
Standard deviations (in the percentage deviation from the steady state)							
Y	0.0070	0.0076	0.0064	0.0067	0.0109	0.0110	0.0110
C	0.0148	0.0163	0.0130	0.0139	0.0301	0.0289	0.0287
n	0.0099	0.0109	0.0091	0.0096	0.0156	0.0158	0.0157
EX	0.0294	0.0322	0.0270	0.0286	0.0244	0.0259	0.0259
IM	0.0320	0.0351	0.0294	0.0311	0.0407	0.0406	0.0404
Δp	0.0009	0.0010	0.0010	0.0010	0.0108	0.0103	0.0102
Δe	0.0007	0.0008	0.0003	0.0003	0.0023	0.0008	0.0008
RER	0.0137	0.0150	0.0126	0.0133	0.0114	0.0121	0.0121
EFP	0.0005	0.0005	0.0004	0.0004	0.0047	0.0042	0.0042

Note: BM: active required reserve ratio adjustment, managed floating exchange rate, capital control;

I: inactive (fixed) required reserve ratio adjustment, managed floating exchange rate, capital control;

II: active required reserve ratio adjustment, floating exchange rate, capital control;

III: inactive (fixed) required reserve ratio adjustment, floating exchange rate, capital control;

IV: active required reserve ratio adjustment, managed floating exchange rate, open capital account;

V: active required reserve ratio adjustment, floating exchange rate, open capital account;

Full: inactive (fixed) required reserve ratio adjustment, floating exchange rate, open capital account;

Table 6 Optimal policy reforms

Shocks	Optimal policy
Productivity shocks	Full
Financial shocks	VI, V, Full
Foreign shocks	II

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科技部補助計畫衍生研發成果推廣資料表

日期:2015/10/28

科技部補助計畫	計畫名稱: 動態隨機一般均衡模型於中國經濟之非傳統貨幣政策之探討
	計畫主持人: 黃俞寧
	計畫編號: 102-2410-H-004-006-MY2　　學門領域: 總體經濟學與貨幣經濟學

無研發成果推廣資料

102年度專題研究計畫研究成果彙整表

計畫主持人：黃俞寧			計畫編號：102-2410-H-004-006-MY2				
計畫名稱：動態隨機一般均衡模型於中國經濟之非傳統貨幣政策之探討							
成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數（含實際已達成數）	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	2	2	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	2	2	100%	人次	
		博士生	2	2	100%		
		博士後研究員	0	0	100%		
		專任助理	2	2	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	2	2	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
其他成果（無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）		無。					

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

科技部補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估
   ■達成目標
   □未達成目標（請說明，以100字為限）
   　□實驗失敗
   　□因故實驗中斷
   　□其他原因
   說明：

2. 研究成果在學術期刊發表或申請專利等情形：
   論文：□已發表 ■未發表之文稿 □撰寫中 □無
   專利：□已獲得 □申請中 ■無
   技轉：□已技轉 □洽談中 ■無
   其他：（以100字為限）
   目前該研究論文已於「中國大陸崛起之制度變遷與經濟發展」學術研討會(2013, 2014)、Econometric Society Asian meeting 2014 年會、WEAI 2015 年會中發表。現正依據評論意見，進行修改撰寫，以投稿國際學術期刊。

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以500字為限）
   本研究主要是因應中國大陸現行的金融環境（如利率管制）以及對外資本市場仍具有高度管制，此種種管制將影響貨幣政策的傳導機制以及其效果。欲達到人民幣國際化的最終目標，中國大陸勢必需要逐步解除其限制，使金融市場自由化以及開放資本帳。然而，究竟應該先進行國內金融市場的開放，或是先開放資本帳，已引起相當多的討論。因此，本研究在一動態隨機一般均衡模型下，納入非傳統貨幣政策（如資本帳不開放、匯率管制等）的考量來對不同的解除管制方案進行福利分析。研究結果顯示，資本帳開放與否將帶來顯著影響。在國內生產力、金融部門發生負向衝擊時，開放資本帳，使匯率貶值將有助於緩解國內所面對的負面影響，而帶來較高的福利水準。而在國外發生負向衝擊時（如國外利率上升），開放資本帳則會使國內受到國外影響而使福利水準下降。然而，本研究結果並非意指資本帳開放當應先於國內金融部門的自由化，而是清楚地指出，資本帳的開放將有顯著影響，而當應更為審慎。