The Independent Monetary Policy under the Fixed Exchange Regime —Modeling Monetary Policy in China Economy

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Abstract

Using a macro-econometric model that is specified for the current Chinese economy, we investigate the performance of monetary policy in China with the assumption (which anyway will hold in the near future) that capital market was open. Our purpose is to find whether there is a possibility for China to keep the independence of monetary policy under the fixed exchange regime while the capital market is open. For this, we suggest some institutional arrangements. Given these institutional restrictions, we find that the open economy tri-lemma, which is widely accepted in academy, will no longer hold. This indicates that the monetary policy can still keep its effective in stabilizing domestic economy when capital market is open and the exchange rate is fixed. The dynamic analysis of the model further shows that the fixed exchange regime will strengthen the macroeconomic stability while the uner-valuded RMB is necessary for the target exchange rate to be sustainable.

Keywords: open economy tri-lemma, macroeconomic stability, exchange rate regime.

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1 Introduction

The issue on RMB exchange rate is increasingly concerned not only in China but also internationally among academies, governments and publics. It is generally believed that RMB is under-valued due to the intervene at the foreign exchange market by the monetary authority in China. It is also believed that the under-valued RMB causes the huge trade surplus in China against U. S. and other developed countries. Therefore, China should, as called by U. S. government, raise the value of RMB or even give up the current fixed exchange regime and switch to more market oriented system of floating exchange. It is argued that the swtich to the foating exchange will not only move RMB toward its equilibrium value (so that trade surplus can be reduced), but is also desperately needed if China wants continuously to keep its independence of monetary policy when the capital market is open in the near future. Apparently, this is the argument derived from the theorem of open economy tri-lemma (or triple-impossible), which has now been widely accepted in the academy.

According the theorem of open economy tri-lemma, if capital market is open while exchange rate is fixed, the capital inflow (or outflow) will equalize the interest rates in domestic and world market. This will leave no space for the monetary policy to stabilize the domestic economy via interest rate mechanism. On the other hand, if the exchange rate is floating, the uncertainty in exchange rate will weaken the connection of domestic interest rate to the interest rate in the world market. This will leave some space for monetary policy to be effective in stabilizing the domestic economy. This is the major result since the Mundell-Fleming model in 1960's.[1] The recent new open economy macroeconomy initiated by the Redux model of Obstfeld and Rogoff (1995) does not change the basic result.[2] The tri-lemma theorem has also lead to the current bipolar view, which basically reject the fixed or pegged exchange regime as a possible selection of exchange rate system. [3]

Although the issue remains whether China should reduce its target exchange rate to appreciate RMB,[4] this paper tries to provide the following

[1]See Mundell (1963, 1964), Fleming (1962) and Dornbusch (1976).

[2]For the recent review on the new open economy macroeconomics, see Lane (2001).

[3]See Fischer (2002), Summer (2000) among others.

[4]Indeed, we believe that the RMB appreciation is not the final solution to the current huge trade surplus in China. A more foundmental reason for the trade surplus is the trade pattern (especially the import pattern) of the current economy in China: the import in China is highly export-detemined. We thus expect that while the RMB appreciation will reduce the export from China the import to China will then be equally reduced. This will be verified by the behavior functions of export and import as estimated latter in the paper. However, this will not be the major concern in our this paper.

arguments:

> *Argument 1*: The tri-lemma theorem can be hold only under certain institutional restrictions. Given the institutional arrangements as suggested latter in the paper, the monetary policy can be effective independently even if the exchange rate is fixed and the capital market is open.
>
> *Argument 2*: The fixed exchange regime in China will benefit the domestic economy as well its trade partner in terms of macroeconomic stability.
>
> *Argument 3*: To sustain the fixed exchange regime, the target exchange rate should be set to the level at which the value of RMB is under-valued.

These arguments will be provided in a macro-econometric model specified for the current Chinese economy. Among the three arguments, we find that the most important one is the first. The other two arguments can be easily derived once the argument on the tri-lemma theorem is verified. It is well known that in those, which generate tri-lemma theorem, such as Mundell-Fleming model and Redux model, there exist implicitly some institutional restrictions which make all the financial assets are perfectly substitutable and thus the variety of interest rates can be merged essentially into one in terms of volatility.[5] Since one of the interest rates, such as bond interest rate, must be restricted to the interest rate in the world market under the fixed exchange regime when the capital market is open, the other interest rates, such as loan interest rate, can hardly be impacted by the monetary policy. The monetary policy thus loses its independence to stabilize the domestic economy via interest rate mechanism. However, as we will find in this paper, there exist some institutional arrangements under which the variety of financial assets are not perfectly substitutable and thus their interest rates could be varied in different directions even if the capital market is open and the exchange rate is fixed. We also find that these institutional arrangements is plaussible to be implemented practically under the appropriate regulation within the commercial banking system.

The rest of paper is organized as follows. Section 2 describes the environmental and institutional properties of current Chinese economy. Section 3 sets out the model. Section 4 provides the analysis, which allows us to derive our three arguments. Section 5 concludes.

[5]The empirically observed deviations among different interest rates are often named as risk premium.

2 Institution and Environment

This section discusses the environment and institution (including the future possible transform) that may help us to understand not only how China can grow on average at a higher rate since the economic reform, but also the construction of the model that will be presented in the next section.

2.1 Dual Structure

Since economic reform started in 1978, China has undergone substantial decentralization. This decentralization can be understood in two respects. First, the government has abandoned the previous central planning system and has given autonomy to state-owned enterprises in deciding their price and quantity in most non-financial sectors. Second, decentralization has also allowed the rapid growth of non-state enterprises in many competitive industries. This decentralization process made the Chinese economy more market oriented and economic resources more efficiently allocated. One of the achievements in the efficiency of resource allocation is to free the huge amount of surplus labor in the rural areas of China.

The dual structure in rural and urban areas is an obvious feature of developing economy of China. In rural areas, each family is endowed with a piece of land that may sustain the family's living but at a very low level compared to the standard of living in urban areas. Since the land for each family is extremely limited, there is an enormous surplus of labor in the rural areas of China. Economic reform and the emergence of a large amount of non state-owned enterprises has allowed the labor surplus in rural areas to move into urban areas as has been occurring in the past. Since the labor surplus in rural areas is so huge, the labor market in city has always been in over-supplied. This further indicates that wages in urban areas is not sensitive to the labor market, but only to inflation and productivity.[6] We should note that this developing feature of the Chinese economy is exactly what Lewis, a Nobel laureate in 1979, described in his seminal paper on developing economics (see Lewis 1954).

The existence of a dual structure has an important implication in explaining China's economic growth. As many have argued, the major driving force of high growth in China is the high growth in investment.[7] The high growth in investment creates not only fast accumulation of capacity but also high growth in demand. The fast accumulation of capacity requires the ab-

[6]This will be verified in our estimation of wage equation (see section 3.9).

[7]See Lin (2000), Lin, Cai and Zhou (2003) and Brandt and Zhu (2000, 2001)

sorption of more people to work in urban areas. Therefore, high growth in investment is not possible without sufficient labor surplus.

2.2 Credit Plan and Stabilization Policy

High growth in investment is also not possible without sufficient financial resources. In contrast to most OECD countries, the major financial resource for investment in China is credit. In past years, the monetary authority in China has set up a yearly target growth in the money supply, M1 and M2. Once the target has been set up, the monetary authority will employ the credit plan as its principle instrument to implement the target.

In each year's credit plan, the state banks are given credit quotas, which can be regarded as the target on the amount they could and should lend in total for investment and other purposes. Sometimes the credit quotas are given along with a variety of details with respect to the provinces, industries and state and non-state firms. Although in most cases the credit plan is only indicative under which the state banks were given some discretion over their lending activities, occasionally the government resorts to using administrative mechanisms to implement the credit plan.[8]

The credit supply in China can be regarded as being cheap and easy. Such cheap and easy credit can be observed from several statistics. As we can find in Table 1, the average real interest rate in loan supply is about 2% in China, much lower than other OECD countries. In the same time, the average growth rate of the money supply is about 20%, which is not only much higher than the level of OECD countries (about 6-7%), but also significantly higher than the nominal growth rate (about 16%) of GDP in China. We shall also remark that while the growth rate of the money supply is so high, the state banks are also suffering huge amount of non-performing loans.

Table 1: Credit Comparison: China and Some OECD Countries[9]

	China	U.S.	Germany	France.
real interest rate (%)	2.1418 (1980−2001)	3.4757 (1964−2003)	4.1092 (1970−2003)	4.5654 (1980−2003)
growth rate of money supply	0.2006 (1985−2001)	0.0712 (1964−2003)	0.0626 (1975−2003)	0.0601 (1980−2003)
growth rate in nominal GDP	0.1606 (1981−2001)	0.0725 (1964−2003)	0.0564 (1970−2003)	0.0619 (1980−2003)

[8]In the view of Brandt and Zhu (2000) and (2001), it is the alteration of indicative and administrative credit plan that generates the business cycles in China.

[9]The data for U.S., Germany and France comes from OECD (2004). The data for China comes from National Bureau of Statistics of China (2004).

The easy and cheap credit provided by the government via its state banking system is certainly an important transitional feature of the Chinese economy. It reflects the strong intention of government to use its monetary policy to promote economic growth in addition to usual demand management.

2.3 The Fixed Exchange Regime

The exchange rate system in China has historically been regarded as a fixed exchange rate, though the target exchange rate has been changed several times since the economic reform. It is only until recently (July 21, 2005) that China has switched to the regime of manageable floating exchange. Due to the developing feature of the current Chinese economy, a stable exchange rate is considered to be important for the healthy and stable financial environment that will benefit the economic development in China. Indeed, we also believe that a stable exchange rate of RMB also benefit the world economy, though there is an issue what level of exchange rate should be stabilized.

Both the fixed exchange rate system and the manageable floating exchange rate system imply the active involvement of the central bank in the foreign exchange market. Due to such similarity, we shall in this paper treat them as being equal. In particular we shall assume that the central bank want to stabilize the exchange rate at x^*. In the manageable floating system, this x^* can be explained as a range. We shall remark that for the central bank, the involvement in foreign exchange market is somehow similar to its open market operation in the bond market: both affect the money supply circulated in the economy. The difference is the objective to stabilize and the assets transacted in the market. Indeed, the purchase of foreign exchange (U.S. dollars) is one of the major channels in the past for the monetary authority in China to increase the money supply in addition to the credit plan mechanism. As we will find in this paper, such an increase is possible only when the target exchange rate of RMB against U.S. dollars is set below its market value (or making RMB deliberately undervalued).

2.4 Financial Reform

The credit plan mechanism of money supply in current Chinese economy indicates that the money supply in China is exogenous and is able to be controlled by government. Yet the exogenous property of money supply can not be independent from the ownership properties of the commercial banks: in the current Chinese economy, the commercial banks are almost all state-owned. It is the state-owned commercial banks that allow the credit plan mechanism to work.

Recently, China has begun its financial reform. One of the objectives of this reform is to transform gradually the current state-owned banks into the modern corporation with shareholding. In particular, a system of strategic partnership will be adopted, according to which a worldwide well-known financial corporation will be introduced to be a strategic partner (so that it will hold a significant share) in a current state bank. We would expect that with the progress of such reform, the credit plan mechanism will gradually become ineffective. Another important reform in the financial system in China is the gradual openness of capital market due to the WTO agreement signed by the Chinese government in 2003. This will lead us to anther expectation: in the near future, the money in China can be circulated within the world capital market via capital inflow and outflow.

The financial reforms as have just discussed will pose the following challenges to the macroeconomic policy mechanism as is currently working in Chinese economy:

- First, the ineffectiveness of credit plan and the worldwide circulation of money will make the money in China no longer be exogenous and controllable, but more likely endogenous.

- Second, the monetary policy may even lose its independency if China still wants to keep its fixed exchange regime.

The first indicates that the monetary authority in China will have to switch to targeting interest rate rather than money supply via credit plan. The second challenge, which results from the theorem of open economy trilemma, is indeed the major concern in the paper.

Should China have to give up the fixed exchange regime when the capital market is open in the near future? For a developing country like China, this may have the cost that the economy will be more vulnerable to the outside shock. But if China wants to maintain its fixed exchange regime, is there a possibility, e.g., by some institutional arrangements, to remain the active monetary policy for stabilizing the domestic economy?

2.5 Suggested Institutional Arrangements

We believe that there does exist some institutional arrangements that will allow the Chinese economy to maintain the fixed exchange regime, but without losing the independence of monetary policy even if the capital market is open. These institutional arrangements include the follows:

Arrangement 1: There is a block for the loan issued from commercial banks to be used for the business of financial investment, such as buying the bonds in the bond market;

Arrangement 2: There is a block for the commercial banks to engage in the business of financial investment (such as buying bonds).

Arrangement 3: The commercial bank (and only commercial bank), whenever they feel necessary, are permitted to borrow or deposit their reserve at the discount window given the discount rates settled by the central bank.

In the followed analysis, we shall evaluate the effectiveness of monetary policy for the future Chinese economy under such institutional arrangements.

3 The Model

Given the three institutional arrangements as discussed in the last section, we shall in this section construct a simple macro dynamic model that will provide a basis to evaluate the monetary policy that we recommended for the future Chinese economy. The model built here is for an open economy in which many Keynesian features can be found. The real sector (e.g., product market and labor market, etc.) of the model resembles to those standard Keynesian macrodynamic models in which disequilibria are permitted and the price and wage are adjusted in a staggered way.[10] Due to the transition and developing feature of the current Chinese economy, such a Keynesian property, we believe, is more important to evaluate the business cycle phenomena as they occur in current Chinese economy.

Since our objective is to evaluate the monetary policy, the model formulation here will be heavily on the financial sector of the economy. In particular, we shall distinguish a variety of financial markets, e.g., money market, bond market, foreign exchange market, among others. Further, the model we construct here (especially the financial sector) does not completely resemble to the current Chinese economy but to the economy towards which the Chinese economy may transform in the near future. As we has discussed in the last section, such a hypothetical economy may imply that money is not only circulated beyond the domestic market but also endogenous so that the monetary authority may not be able to control its supply.

[10] as presented in Chiarella and Flaschel (2000) and Flaschel, Gong and Semmler (2001) and Chiarella, Flaschel and Franke (2005).

3.1 The Money in Circulation

We shall start with the formulation on the financial side of the economy. Our first equation regards the change in the money stock (deposit in commercial banks) that is circulated in the economy:

$$M_t = M_{t-1} + \Delta F_{m,t} + \Delta D_t \tag{1}$$

Above M_t is the deposit money in period t; $\Delta F_{m,t}$ is the net transfer of money from the bond market to the deposit account of the public; and ΔD_t is the net loan creation from the commercial banks.[11] This equation simply said that the change in money stock either come from the transfer from the bond market or from the loan creation. In other words, the transaction in the real market (product market and labor market, etc.) will have no impact on the stock of money in circulation. This is a plausible assumption since any transaction in real market will only transfer the money between traders while leaving the total money in circulation untouched.

If money is endogenous as we have discussed in section 2, the money in circulation as expressed in (1) should be demand-determined. We therefore need to formulate the demand for money. Following the textbook discussion, we may consider the following demand function for money:

$$M_t^d = h(r_{b,t})\hat{P}_t\hat{Y}_t, \quad h' < 0,\, h \geq h_0 > 0 \tag{2}$$

where $r_{b,t}$ is the given bond rate; $\hat{P}_t$ is the expected price and $\hat{Y}_t$ is the expected real GDP so that $\hat{P}_t\hat{Y}_t$ is the expected nominal GDP. We here use the expectation because at the beginning of period t the price and output in period t have not been known. This formulation indicates that the economy holds a certain proposition of money as transaction demand over nominal GDP, though this proposition may change over time, depending on the bond rate $r_{b,t}$.[12] Also we have assumed a lower bound h_0 here of that proportion so that there will always be some money circulated in the money market for transactional purpose even if the bond rate is high.

Given the discussion on demand for money, we should now have

$$M_t = M_t^d \tag{3}$$

indicating actual money in circulation as expressed in (1) should be equal to the money demand as expressed in (2).

[11] Note that here we define the net loan creation as new created loan minus the returned loan and the interest payments to the banks.

[12] The interest rate on deposit is implicitly assumed to be zero in this paper.

Next we shall discuss how $\Delta F_{m,t}$ and ΔD_t are determined that make the money in circulation via (1) equal to the money demand as expressed in (2). We find that this is indeed a decision on asset allocation between bond and debt. Also note that $\Delta F_{m,t} + \Delta D_t$ can be negative, indicating a reduction in money circulation. This is the case when the demand for money M_t^d is less than the money currently in circulation M_{t-1}. Denote λ_t to be the proportion of $\Delta F_{m,t}$ over the sum of $\Delta F_{m,t}$ and ΔD_t in absolute value, that is,

$$\lambda_t = \frac{|\Delta F_{m,t}|}{|\Delta F_{m,t} + \Delta D_t|} \tag{4}$$

subject to $\lambda_t \in [0, 1]$. This proportion should depend on the comparison between loan rate r_t and bond rate $r_{b,t}$. In particular, we can write λ_t as

$$\lambda_t = \lambda(r_t - r_{b,t}), \tag{5}$$

Note that we may assume that $\lambda' > 0$ if $\Delta F_{m,t} + \Delta D_t$ is positive, otherwise, $\lambda' < 0$. This restriction on λ' indicates that when additional financial resource is demanded, i.e., $\Delta F_{m,t} + \Delta D_t > 0$, people are more willing to use the money withdrawn from the bond market if the loan rate is higher relative to the bond rate. On the other hand, if the money demand is reduced so that people are withdrawing the money from their deposit, i.e., $\Delta F_{m,t} + \Delta D_t < 0$, then they are more likely to return the loan (or reduce their debt) if the existing loan rate is higher relative to bond rate.

3.2 The Bond Market

If the capital market is open, as we have assumed for the future Chinese economy, the bond market here should be connected to the capital market in the world. Since China is a small economy so that its capital inflow and outflow will have no influence on the bond rate in the world market, we can assume that the bond rate is given exogenously. To simplify our analysis while without effecting our major analytical result, we set this exogenous bond rate to a constant r^*. This indicates

$$r_{b,t} = r^* \tag{6}$$

Bonds are supplied by the government and therefore its quantity can be regarded as being exogenous. To simplify our analysis, we may assume that all the bonds be matured in one period and therefore the quantity of bonds could be measured in terms of the total face value circulated in the market. We denote this quantity as B_t. The demand for bonds comes from the fund

invested in the bond market. We denote this fund to be F_t. Apparently, the change in this fund in period t, ΔF_t, can be written as

$$\Delta F_t = \Delta F_{w,t} - \Delta F_{m,t} + \Delta F_{o,t} \tag{7}$$

where $\Delta F_{w,t}$ is the net capital inflow to the domestic bond market, $-\Delta F_{m,t}$ is the net transfer of money from domestic money market to bond market and $\Delta F_{o,t}$ is the net injection of money by central bank via open market operation.

Given the demand and supply, the price of the bond will be determined at the balanced condition of the domestic bond market. We thus have

$$P_{b,t} B_t = F_t \tag{8}$$

For a small open economy, the variation in bond price $P_{b,t}$ should make the return on domestic bond, or bond rate equal to r^*, the bond rate in the world capital market. Therefore the determination of $P_{b,t}$ should be subject to

$$r^* = \frac{1 - P_{b,t}}{P_{b,t}}$$

which further lead to

$$P_{b,t} = \frac{1}{1 + r^*} \tag{9}$$

Substituting (9) into (8), we find that

$$F_t = \frac{B_t}{1 + r^*} \tag{10}$$

Equation (10) further indicates that

$$\Delta F_t = \Delta B_t \frac{1}{1 + r^*} \tag{11}$$

Therefore, if there is no new issued bond circulated in the bond market, i.e., $\Delta B_t = 0$, the net transfer of money into the bond market ΔF_t will be zero in order to keep the bond price to be constant as in (9) and so does the bond rate.

3.3 The Interest Rates in Money Market

Next, we shall discuss the determination of interest rates in the money market. Due to the multiple assets in the money market, we can find a variety of interest rates. These may include the deposit rate and loan rate in commercial banks, the inter-bank rate (or federal fund rate as named in U. S.)

and the discount rates for loan and deposit at discount window of the central bank. Here we can assume the deposit rate at commercial banks to be zero. The two discount rates can be regarded as policy variables, whose determination will be discussed later in section 3.8. Our major discussion is thus on how the commercial loan rate and the inter-bank rate are determined.

In the first place, we can assume that there is a very close relation between inter-bank rate and loan rate. For example, we may assume that

$$r_t = b_0 + b_r r_{i,t}, \qquad b_0, b_r > 0;\ r_t \geq r_{i,t} \tag{12}$$

where $r_{i,t}$ is the inter-bank rate. This assumption is supported by the empirical evidence from those economy in which administration plays no rule in determining the commercial loan interest rate. To some extent, we can regard the process of loan supply as being that the commercial bank gets the fund first at the inter-bank market and then supply the loan to the loan demander whose investment project is evaluated to be rewardable. This leaves us only to discuss how the inter-bank rate $r_{i,t}$ is determined. The following proposition regards the determination of inter-bank rate.

Proposition 1 *Let $d_{1,t}$ and $d_{2,t}$ denote the two discount rates, the deposit rate and the loan rate repectively, of the central bank with $d_{1,t} \leq d_{2,t}$. Under the three institutional restrictions as expressed in section 2.5, the determination of inter-bank rate will follow*

$$d_{1,t} \leq r_{i,t} \leq d_{2,t} \tag{13}$$

while the two discount rates can be set by central bank at its own descretion.

The proof of this proposition is trivial. Assume that $d_{1,t}$ and $d_{2,t}$ are given while $r_{i,t} > d_{2,t}$. The demander in the inter-bank market will switch to the discount window to borrow the fund. This will reduce the demand and therefore the inter-bank rate will be down. On the other hand, if $r_{i.t} < d_{1,t}$, then the loan supplier will prefer to deposit money at the discount window rather than supply the money at the inter-bank market. This will reduce the loan supply and therefore the inter-bank rate will be up.

It should be noted that this proposition will not hold without our three institutional arrangements. Specifically, the central bank cannot set the two discout rates at its "descretion" so that it cannot use the two discount rates as policy variables for stabilization purpose even if the inequality (13) still holds. Here for stabilization purpose, the two discount rates should be adjustable to any positive value without bring some negative effect such as to cause the continuous arbitrages from individuals or financial intermediates to borrow

the money from commercial banks or central bank at a lower rate and buy bonds for higher return. For example, without arrangement 2 $d_{2,t}$ cannot be set below the bond rate r^*. Otherwise, the commercial bank will borrow the money from the central bank to invest in bond market. Similiarly, to avoid the arbitrage from individuals or other financial intermediates to borrow the money from the commerical bank in order to buy bonds while arrangement 1 is absent, the interest rate in commercial loan r_t must be higher than the bond rate r^*. From (12) and (13), this also means that there is some lower bound to set $d_{2,t}$ given the externally determined bond rate r^*.

Note that equation (13) in proposition 1 also indicates that if $d_{1,t} = d_{2,t} = r_{d,t}$, then

$$r_{i,t} = r_{d,t} \tag{14}$$

Therefore, if the two discount rates merge, the inter-bank rate $r_{i,t}$ should also be equal to the merged discount rate $r_{d,t}$.

3.4 The Foreign Exchange Market

Next, we shall discuss the foreign exchange market at which the exchange rate is determined. To simplify our analysis, we shall assume that the foreign direct investment will bring no additional forces to the exchange market. We may image that those investors simply import their equipments and material to China as their investment. Therefore when the capital market is opened, the exchange rate will be determined at the following balanced condition between demand and supply:

$$N_t P_t + \Delta F_{g,t} = E_t P_t + \Delta F_{w,t} \tag{15}$$

where P_t is the domestic price; E_t and N_t are the real export and import; $\Delta F_{g,t}$ is the net purchase of foreign exchange (dollars) by the central bank and $\Delta F_{w,t}$ is the net capital inflow, all measured in term of RMB. Apparently the right side of equation (15) expresses the demand for foreign exchange (dollars) and the left side the supply.

It is reasonable to assume that both export E_t and import N_t depend on the exchange rate (the detail will be discussed later when we turn to the real side of the economy) so that we can write them as

$$E_t = E(x_t, ...); \qquad N_t = N(x_t, ...) \tag{16}$$

Expressing $\Delta F_{w,t}$ in terms of (7) while E_t and N_t in terms of (16), the balance condition (15) in the foreign exchange market can be written as

$$N(x_t, ...)P_t + \Delta F_{g,t} = E(x_t, ...)P_t + \Delta F_t + \Delta F_{m,t} - \Delta F_{o,t} \tag{17}$$

Note that here ΔF_t can be derived from (11), $\Delta F_{m,t}$ from (1) - (4); both $\Delta F_{o,t}$ and $\Delta F_{g,t}$ are the policy variables and thus can be regarded as being exogenous; finally P_t is determined from the product market, which will be discussed later. Thus the balance condition in (17) will determine the equilibrium exchange rate x_t.

3.5 Consumption, Investment and Government Expenditure

We now leave away from the financial side and turn to the discussion on the real side of the economy. To simplify our analysis, we shall assume that the output Y_t is purely determined by the aggregate demand so that

$$Y_t = C_t + I_t + G_t + E_t - N_t \tag{18}$$

where C_t, I_t, G_t, E_t and N_t are referred to consumption, investment, government expenditure, export and import respectively, all measured in real term. For consumption and government expenditure, we assume that they follow the simple rule:

$$C_t = c(Y_{t-1} - T_{t-1}) \tag{19}$$
$$G_t = gY_{t-1} \tag{20}$$

where T_t is the tax; c and θ are constant. We may assume that

$$T_t = \tau Y_t \tag{21}$$

with τ to be the tax rate.

As discussed in Gong and Lin (2005), one possible investment function for the current Chinese economy can be written as

$$I_t/K_{t-1} = \xi_i + \xi_u U_{t-1} + \xi_m(m_t - p_t), \quad \xi_u, \xi_m > 0 \tag{22}$$

where K_t is the capital stock; m_t is the growth rate of the money supply; p_t is the inflation rate. Therefore, $m_t - p_t$ is approximately the growth rate of the real money supply. This investment function, as discussed in Gong and Lin (2005),[13] is consistent with the credit plan that has currently worked as a major monetary policy mechanism. This mechanism indicates that money is exogenous and able to be controlled by the central bank. Yet, as we have discussed in the last section, this monetary policy mechanism will no longer

[13]where a dynamic optimization model is constructed that allow us to derive the investment function as expressed in (22).

hold in the near future due to the financial reform that is currently proceeding in China. Money in the future Chinese economy will be endogenous. The endogenous money indicates that the monetary authority in China will have to give up its credit plan as its major instrument of monetary policy, but switch to targeting the interest rate. When this occurs, a more appropriate investment function should be written as

$$I_t/K_{t-1} = \xi_0 + \xi_u U_{t-1} - \xi_r(r_t - p_t) \quad \xi_u, \xi_r > 0 \tag{23}$$

where r_t, the loan interest rate is determined in (12); Equation (23) indicates that it is the real interest rate $r_t - p_t$ rather than the credit constraint that will determine the investment in the future Chinese economy.

With regard to U_t and K_t, we define them as

$$U_t = \frac{Y_t}{AK_t} \tag{24}$$

$$K_t = (1-\delta)K_{t-1} + I_t \tag{25}$$

where δ is the depreciation rate and A is the output-capital ratio that is determined by technology.

3.6 The Export and Import

We shall remark that our modeling on export and import is mainly established on the empirical evidence that we have observed from Chinese economy. We assume that the export not only depends on real exchange rate, but also on external demand from the world market. This consideration allow us to write the export function as

$$e_t = \zeta_0 + \zeta_w y_{w,t} + \zeta_\gamma \gamma_t + \zeta_e e_{t-1}, \quad \zeta_w, \zeta_\gamma, \zeta_e > 0 \tag{26}$$

Above, e_t is regarded to be the real export over the real GDP of the last period: $e_t = \frac{N_t}{Y_{t-1}}$; $y_{w,t}$ is the growth rate of output in the world market, which generates the demand for China's export; γ_t is the real exchange rate, which should be written as

$$\gamma_t = \frac{x_t}{P_t} P_t^f \tag{27}$$

where x_t is the nominal exchange rate (RMB/dollar); P_t is the domestic price index and P_t^f is the price index in the world market. Note that here we also include the export in the past period to be the determinant to current export. This indicates that the export may have the habit formation as often discussed in the consumption theory.

From our empirical study, we find that the import in China relies heavily on the export. In particular, the following equation seems to be significant:

$$n_t = \varsigma_0 - \varsigma_\gamma \gamma_t + \varsigma_e e_t, \quad \varsigma_\gamma, \varsigma_e > 0 \tag{28}$$

where n_t is the real import over the output of the last period: $n_t = \frac{N_t}{Y_{t-1}}$. More discussion on import will be made when we turns to empirical estimation.

3.7 Price and Wage Dynamics

Next, we shall discuss how price is determined. We shall not assume that the price will be determined at the level that can clear the market at every period. This is particularly true to China since China is still a transitional and developing economy. Following the widely discussed dual Philip curves of price and wage (see Flaschel, Gong and Semmler 2001 and Fair 2000), we may consider the following price and wage dynamics:

$$w_t = \alpha_0 + \alpha_p p_t + \alpha_l L_t + \alpha_a a_t, \qquad \alpha_p, \alpha_n, \alpha_x > 0 \tag{29}$$

$$p_t = \beta_0 + \beta_w w_{t-1} + \beta_u U_{t-1} - \beta_a a_{t-1}, \quad \beta_w, \beta_u, \beta_x > 0 \tag{30}$$

where w_t is the growth rate of nominal wage; L_t is the employment rate and a_t is the growth rate of labor productivity. Apparently, our expression of price and wage dynamics is based on the fairly symmetric assumptions on the causes of price and wage inflation. Both of them are driven, on the one hand, by a demand pressure component given by U_{t-1} and L_t. On the other hand, they are driven by a cost push term measured by p_t, w_{t-1}, a_{t-1} and a_t in the right sides of (29) and (30).

With regard to the employment rate L_t, we can write it as

$$L_t = \frac{l(Y_t, ...)}{L_t^s}$$

where L_t^s is the labor supply and $l(\cdot)$ is the demand for labor, which is a function of output Y_t among others. Due to the current dual structure of the Chinese economy, we would expect that L_t^s could be enormous compared to the demand for labor. This will effect the wage equation. The detail will be provided when we turn to the empirical estimation of our dynamic model.

3.8 The Monetary Policy

As we have discussed in the last section, the government in the current Chinese economy sets up a yearly target of money growth, which can be

regarded as a major macroeconomic policy for demand management and growth promotion. Once the target has been set up, the monetary authority employs the credit plan as its principle instrument to implement the target. Though in many cases the credit plan is only indicative, due to the state-owned commercial banks in China, the credit plan (which could also be compulsive especially when the economy is in a serious condition) may have important impact on the credit supply from the state banks. This indicates that the actual money supply can be regarded as being exogenous.

However, with the progress of financial reform, we believe that such a monetary policy mechanism will no longer work well due to the transformation of money from being exogenous to endogenous. When the money becomes endogenous, the monetary authority will have to switch to targeting interest rate for its purpose to stabilizing the domestic economy. Since it is the discount rates through Proposition 1 that determine the inter-bank rate which further determine the loan rate via (12) and then investment via (23), we therefore suggest that the monetary authority should use the discount rate as a major instrument of its monetary policy. To keep our analysis as simple as possible, we even assume one (rather than two) discount rate so that $d_{1,t} = d_{2,t} = r_{d,t}$. As expressed in (14) the inter-bank rate in this case is simply equal to the discount rate $r_{d,t}$. Suppose that the central bank set the target inflation rate as p^*, its interest rate rule can thus be expressed as

$$r_{d,t} - r_{d,t-1} = \theta(p_{t-1} - p^*), \quad \theta > 0 \tag{31}$$

This interest rate rule indicates that the central bank will adjust the discount rate in response to the deviation of actual inflation to the target inflation. Here θ can be regarded as the adjustment speed.

Equation (31) can only be regarded as for stabilizing the domestic economy. The central bank may also have the responsibility to stabilize the exchange rate. As expressed in (17), the central bank, for this purpose, can use the policy variables $\Delta F_{g,t}$ or $\Delta F_{o,t}$, that is, the trade in foreign exchange market or the open market operation in bond market.[14] Here for simplicity, we assume $\Delta F_{o,t} = 0$ and therefore we only consider $\Delta F_{g,t}$. Suppose that the central bank target the exchange rate at x^*. We thus find from (17) that the rule of trade in foreign exchange market can be written as

$$\Delta F_{g,t} = E(x^*, ...)P_t - N(x^*, ...)P_t + \Delta F_t + \Delta F_{m,t} \tag{32}$$

[14]The open market operation affects the foreign exchange market in the followed way. The injection of money in bond market will increase the demand for bond. Therefore the bond price increases, and bond rate decreases. The decrease in bond rate will lead the capital outflown to the world market and thus increase the demand for foreign exchange.

3.9 Estimation

As we have discussed before, the model we constructed here is mainly on the basis of empirical evidence that can be observed from the Chinese economy. For this, we should estimate the model by relying the empirical data. The estimation will be focused on the five behavior functions (23), (26), (28), (29) and (30). The data for this estimation is the quarterly data. As well known, the data in China is often difficult to be obtained. In many cases, we have to construct the data by ourselves. In appendix, we provide the detail how the quarterly data are constructed. Table 1 records the estimated parameters while Figure 1 shows the match of the estimation with the observation.

Table 1: Estimates of Parameters in Five Behavior Equations
(the number in parenthesis are the standard errors)

set 1	investment	$\xi_0 = \underset{(0.013097)}{0.016320}$	$\xi_r = \underset{(0.074489)}{0.144215}$
		$\xi_u = \underset{(0.0334460)}{0.079603}$	$DW = 2.1357951$
set 2	export	$\zeta_0 = \underset{(0.041822)}{-0.09386}$	$\zeta_\gamma = \underset{(0.008958)}{0.020035}$
		$\zeta_w = \underset{(0.564426)}{1.021150}$	$\zeta_e = \underset{(0.091891)}{0.973511}$
		$DW = 3.1817622$	
set 3	import	$\varsigma_0 = \underset{(0.049775)}{0.027400}$	$\varsigma_e = \underset{(0.097690)}{0.996259}$
		$\varsigma_\gamma = \underset{(0.009929)}{0.010284}$	$\rho_n = \underset{(0.109269)}{0.695233}$
		$DW = 2.0202960$	
set 4	wage	$\alpha_0 = \underset{(0.003727)}{0.011407}$	$\alpha_p = \underset{(0.142076)}{1.006975}$
		$\alpha_x = \underset{(0.066521)}{0.426640}$	$DW = 1.673028$
set 5	price	$\beta_0 = \underset{(0.005722)}{-0.02212}$	$\beta_w = \underset{(0.073672)}{0.293973}$
		$\beta_u = \underset{(0.009215)}{0.049040}$	$\beta_a = \underset{(0.053656)}{0.223110}$
		$DW = 1.933513$	

The estimation equations for the five behavior functions take the form

$$i_t = \xi_0 + \xi_u U_{t-1} - \xi_r(r_t - p_t) + \varepsilon_t \tag{33}$$

$$w_t = \alpha_0 + \alpha_p p_t + \alpha_a a_t + \nu_t \tag{34}$$

$$p_t = \beta_0 + \beta_w w_{t-1} + \beta_u U_{t-1} - \beta_a a_{t-1} + \varrho_t \tag{35}$$

$$e_t = \zeta_0 + \zeta_w y_{w,t} + \zeta_\gamma \gamma_t + \zeta_e e_{t-1} + \eta_t \tag{36}$$

$$n_t = \varsigma_0 - \varsigma_\gamma \gamma_t + \varsigma_e e_t + \mu_t, \quad \mu_t = \rho_n \mu_{t-1} + \epsilon_t \tag{37}$$

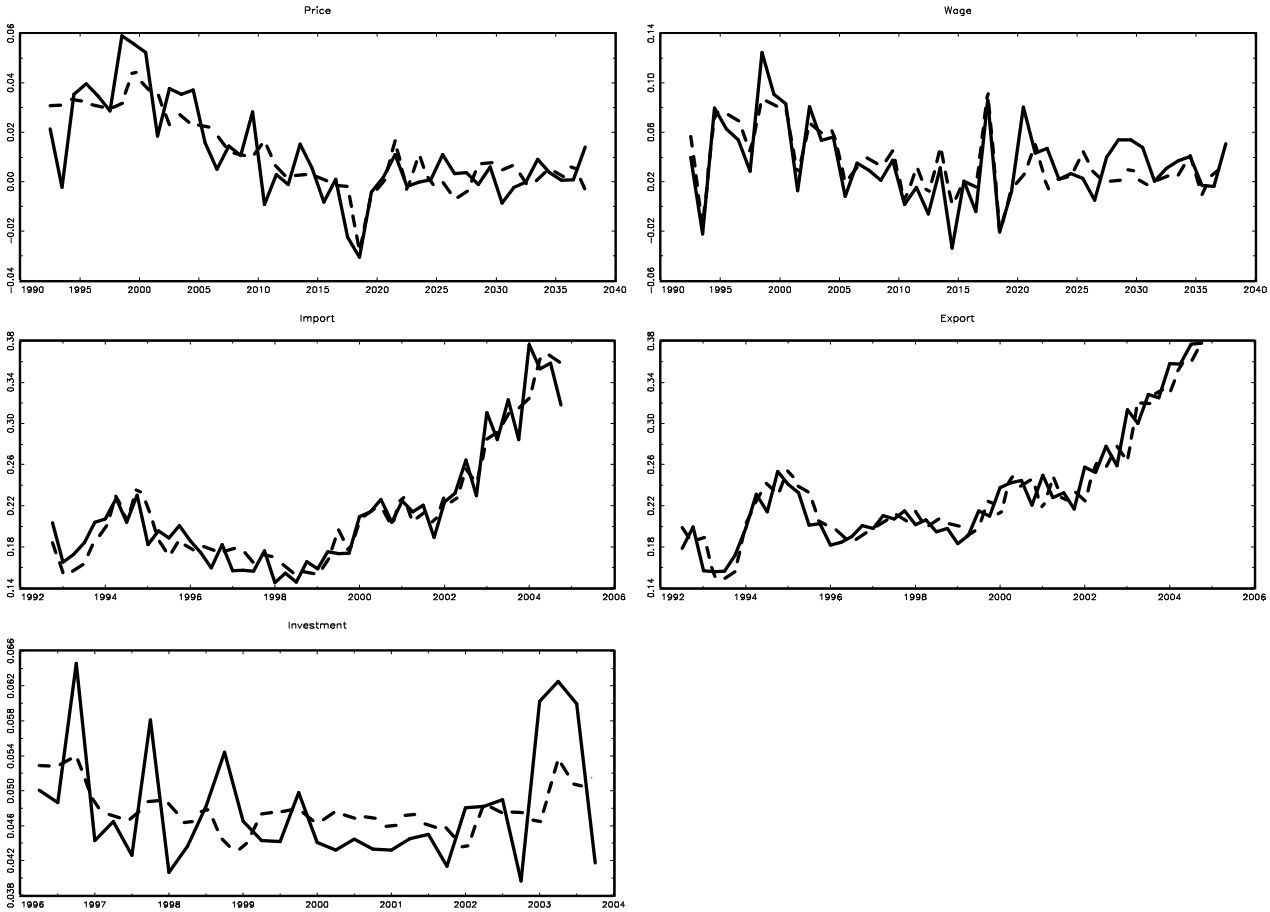

Figure 1: Observed and Predicted Interest Rate

Above $i_t \equiv \frac{I_t}{K_{t-1}}$, and ε_t, ν_t, ϱ_t, η_t and ϵ_t are all assumed to i.i.d. innovations. We apply the Cochrane-Orcutt procedure to estimate the import function (37) while the OLS method is directly applied to (33) - (36).

All parameters seem to be significant except some constants and the parameters in the import function, which we shall discuss soon. Two points are noted here.

First, we have dropped the employment rate L_t as the explanatory variable as appearing in the wage equations (29). The estimate α_l with respect to L_t is not only close to zero but also statistically insignificant. As we have discussed in section 3.7, the labor supply in current Chinese economy as in many developing countries is unlimited due to the enormous labor surplus from rural areas of China. This indicates that we could assume $L_t^s = +\infty$. Given this, we obtain $L_t = 0$. We shall remark that elsewhere (see Gong and Lin (2005)), we get the similar result as we employ the annual data for estimation.

Second, the parameters ς_γ in addition to the constant ς_0 in the import function is insignificant. The estimation shows that import in China is mainly determined by export while its response to the real exchange rate is unclear. This is probably because in some periods over the sample (1992.3 - 2004.4), the government may still influence the import, though we believe that such influence has been greatly weaken in the recent Chinese economy.

4 The Analysis

In this section, we shall provide the analysis of the model constructed in the last section. Our purpose here is to evaluate the effectiveness of our two monetary policy rules (31) and (32) under our suggested three institutional arrangements. The analysis here will lead to our three arguments as we claimed at the begining of this paper.

4.1 The Intensive Form of the Model

To analyze the model, we shall first transform the model into an intensive form. For this purpose, we first normalize those variables that have upward trends. In particular, we set

$$f_{m,t} \equiv \frac{\Delta F_{m,t}}{P_{t-1}Y_{t-1}}, \quad d_{m,t} \equiv \frac{\Delta D_t}{P_{t-1}Y_{t-1}}, \quad y_t \equiv \frac{Y_t - Y_{t-1}}{Y_{t-1}}, \quad f_{g,t} \equiv \frac{\Delta F_{g,t}}{P_{t-1}Y_{t-1}} \quad (38)$$

To make our analysis as simple as possible while not affecting our major analytical result, we may also pose the following assumptions:

$$\begin{aligned}
\Delta B_t &= 0 && (39)\\
\hat{P}_t &= P_{t-1}(1+p^*), \qquad \hat{Y}_t = Y_{t-1}(1+y^*) && (40)\\
a_t &= \bar{a}, \qquad y_{w,t} = \bar{y}_w, \qquad P_t^f = (1+\bar{p}_w)P_{t-1}^f && (41)\\
b_0 &= 0, \qquad b_1 = 1 && (42)
\end{aligned}$$

where p^*, y^*, $\bar{a}$, $\bar{y}_w$ and $\bar{p}_w$ are all constant. Assumption (39) indicates that the government does not issue new bonds so that the fiscal policy is not considered here. Assumptions (40) and (41) imply that we do not attempt to model the dynamics of $\hat{P}_t$, $\hat{Y}_t$, a_t, P_t^f and $y_{w,t}$ and thus we simply take their averages or assume them to grow at a constant rate. In particular, we assume that the expected inflation rate by the public is equal to the target inflation rate of the central bank. This is plausible when the central bank announces its target inflation rate and the public trusts the ability of the central bank. Assumption (42) regards the parameters in (12). It indicates that the loan rate r_t is equal to the inter-bank rate and therefore we do not have to settled the parameters b_0 and b_1 in our dynamic analysis.

Now we provide the proposition regarding the intensive form of our model.

Proposition 2 *Given the assumption as expressed in (39)-(42), the inten-*

sive form of the model can be written as

$$
\begin{aligned}
r_t &= r(p_{t-1}, r_{t-1}) \\
&= r_{t-1} + \theta(p_{t-1} - p^*) && (43)\\
p_t &= p(w_{t-1}, U_{t-1}) \\
&= \tilde{\beta}_0 + \beta_w w_{t-1} + \beta_u U_{t-1} && (44)\\
w_t &= w(w_{t-1}, U_{t-1}) \\
&= \tilde{\alpha}_0 + \alpha_p p(\cdot) && (45)\\
\gamma_t &= \gamma(U_{t-1}, w_{t-1}, \gamma_{t-1}) \\
&= \frac{(1+\bar{p}_w)\gamma_{t-1}}{1+p(\cdot)} && (46)\\
e_t &= e(e_{t-1}, \gamma_{t-1}, w_{t-1}, U_{t-1}) \\
&= \tilde{\zeta}_0 + \zeta_\gamma \gamma(\cdot) + \zeta_e e_{t-1} && (47)\\
n_t &= n(e_{t-1}, \gamma_{t-1}, w_{t-1}, U_{t-1}) \\
&= \varsigma_0 - \varsigma_\gamma \gamma(\cdot) + \varsigma_e e(\cdot) && (48)\\
i_t &= i(U_{t-1}, w_{t-1}, p_{t-1}, r_{t-1}) \\
&= \xi_0 + \xi_u U_{t-1} - \xi_r r(\cdot) + \xi_r p(\cdot) && (49)\\
y_t &= y(U_{t-1}, w_{t-1}, p_{t-1}, r_{t-1}, \gamma_{t-1}, e_{t-1}) \\
&= \tilde{c} + e(\cdot) - n(\cdot) + \frac{i(\cdot)}{AU_{t-1}} && (50)\\
U_t &= U(U_{t-1}, w_{t-1}, p_{t-1}, r_{t-1}, \gamma_{t-1}, e_{t-1}) \\
&= \frac{(1+y(\cdot))U_{t-1}}{1-\delta+i(\cdot)} && (51)\\
f_{m,t} &= f(p_{t-1}, y_{t-1}, r_{t-1}) \\
&= \kappa\lambda(r(\cdot) - r^*)\left[1 - \frac{1}{(1+p_{t-1})(1+y_{t-1})}\right] && (52)\\
d_{m,t} &= d(p_{t-1}, y_{t-1}, r_{t-1}) \\
&= \kappa(1 - \lambda(r(\cdot) - r^*))\left[1 - \frac{1}{(1+p_{t-1})(1+y_{t-1})}\right] && (53)\\
f_{g,t} &= \tilde{f}(e_{t-1}, \gamma_{t-1}, w_{t-1}, U_{t-1}, p_{t-1}, y_{t-1}, r_{t-1}) \\
&= (1+p(\cdot))(e(\cdot) - n(\cdot)) + f(\cdot) && (54)
\end{aligned}
$$

where $\tilde{\beta}_0 = \beta_0 - \beta_a\bar{a}$; $\tilde{\alpha}_0 = \alpha_0 + \alpha_a\bar{a}$; $\tilde{\zeta}_0 = \zeta_0 + \zeta_w y_w^*$; $\tilde{c} = c(1-\tau) + g - 1$ *and* $\kappa = h(r^*)(1+p^*)(1+y^*)$.

The proof of this proposition is given in the appendix.

There are altogether 12 variables in the model. However, the model is also recursive in the sense that some of the variables have no feedback effect

on the determination of the other variables in the model. These variables are mainly those of financial variables $f_{m,t}$, $f_{g,t}$, $d_{m,t}$. Also the variables n_t, i_t and y_t have no feedback effect on the other variables in real side of the economy. Therefore the model has at its minimum 6 dimensions in terms of (r_t, p_t, w_t, γ_t, e_t, U_t). With such a high dimensions for a descrete time dynamic model, a strict mathematical analysis on its dynamic property is intractable. Fortunately, we are still able to derive the steady state of the model.

4.2 The steady state

Next, we shall derive the steady state of the model composed of (43) - (54). From equation (46), one may first find that for the economy to possess a steady state, the steady state of inflation must equal the inflation $\bar{p}_w$ in the world market. This further implies from (43) that the central bank has to settled the target inflation p^* to the world inflation. Another speciality with regard to the steady state of the model is again from equation (46): the steady state of the economy, if it does exist and is asymptotically stable, depends on the initial condition with respect to the domestic and foreign price level P_t and P_t^f. The following provides the detail regarding the steady state of the economy.

Proposition 3 *Let* ($\bar{r}$, $\bar{p}$, $\bar{w}$, $\bar{\gamma}$, $\bar{e}$, $\bar{n}$, $\bar{i}$, $\bar{y}$, $\bar{U}$, $\bar{f}_m$, $\bar{d}_m$, $\bar{f}_g$) *denote respectively the steady state of* (r_t, p_t, w_t, γ_t, e_t, n_t, i_t, y_t, U_t, $f_{m,t}$, $d_{m,t}$, $f_{g,t}$). *Assume that the economy is asymptotically stable. Then system composed of (43) - (54) implies that*

$$
\begin{aligned}
\bar{p} &= p^* = \bar{p}_w; & \bar{\gamma} &= \frac{x^*}{P_T} P_T^f; \\
\bar{e} &= \frac{\tilde{\zeta}_0 + \zeta_\gamma \bar{\gamma}}{1 - \zeta_e}; & \bar{n} &= \varsigma_0 - \varsigma_\gamma \bar{\gamma} + \varsigma_e \bar{e}; \\
\bar{w} &= \tilde{\alpha}_0 + \alpha_p p^*; & \bar{U} &= \frac{1}{\beta_u}(p^* - \tilde{\beta}_0 - \beta_w \bar{w}); \\
\bar{i} &= \bar{y} + \delta; & \bar{y} &= \frac{A\bar{U}\left[\tilde{c} + (1-\varsigma_e)\bar{e} + \varsigma_\gamma \bar{\gamma}\right] + \delta}{A\bar{U} - 1} \\
\bar{r} &= \frac{1}{\xi_r}(\xi_0 + \xi_u \bar{U} + \xi_r \bar{p} - \bar{i}); & \bar{f}_m &= \kappa\lambda(\bar{r} - r^*)\left[1 - \frac{1}{(1+\bar{p})(1+\bar{y})}\right] \\
\bar{d}_m &= \kappa\left[1 - \lambda(\bar{r} - r^*)\right]\left[1 - \frac{1}{(1+\bar{p})(1+\bar{y})}\right]; & \bar{f}_g &= (1+\bar{p})(\bar{e} - \bar{n}) + \bar{f}_m
\end{aligned}
$$

where P_T^f and P_T are the foreign and domestic price index at the period when the economy has just reached to the steady state.

The economic meaning of P_T^f and P_T can be expressed as follows. Suppose initially the foreign and domestic prices are at P_0^f and P_0 while the economy takes T periods to reach to the steady state. Then,

$$P_T^f = P_0^f(1+p^*)^T, \quad P_T = P_0\Pi_{t=0}^T(1+p_t) \tag{55}$$

We thus find that for most variables their steady state depend on the initial conditions P_0^f and P_0, if the economy is asymptotically stable. On the other hand, we further find that $\bar{p}$, $\bar{w}$ and $\bar{U}$ are independent from $\bar{\gamma}$ and therefore their steady states are certain and not determined by the initial conditions.

4.3 The Monetary Policy in Closed Economy

As we have discussed previously, with such a high dimensions, a formal mathatical analysis on the dynamic property of our model is intractable. Therefore, we mainly rely on numerical method to detect the dynamic property of our model. Our major purpose here is to evaluate the effectiveness of monetary policy as suggested in our model.

To observe the transmission mechanism of monetary policy clearly, we may first consider a simple case, the case of closed economy (so that the export and import are ignored). In this case, only rule (31) is relevant. Suppose that the monetary policy (31) is not in action, that is, $\theta = 0$ and thus $r_t = r_0$, we first find that there is a destabilizing mechanism which leads the economy inherently unstable:

$$p \uparrow, \quad (r-p) \downarrow, \quad i \uparrow, \quad y \uparrow, \quad U \uparrow, \quad p \uparrow \tag{56}$$

To illustrate this destabilization mechanism, we present in figure 2 a simulation of the model for the closed economy while the monetary policy rule (31) is absent. In particular, we assume that $e_t = 0$, $n_t = 0$, and $\theta = 0$. Therefore, the dynamic system include (44), (45), (49) and (51) with $r_t = r_0$ and

$$y_t = \tilde{c} + \frac{i_t}{AU_{t-1}}$$

The parameters used in this and the latter simulations are partly given in table 2, which include those parameters with respect to our five behavior functions. The other parameters are provided in table 3.

Table 3: The Other Parameters in the Model

$\tilde{c}$	δ	$\bar{a}$	A	$\bar{y}_w$	$\bar{p}_w$
-0.2025	0.0080	0.0298	0.3279	0.0083	0.0092
P_0^f	P_0	r^*	$h(r^*)$	y^*	x^*
57	100	0.08	1	0.03	7.5

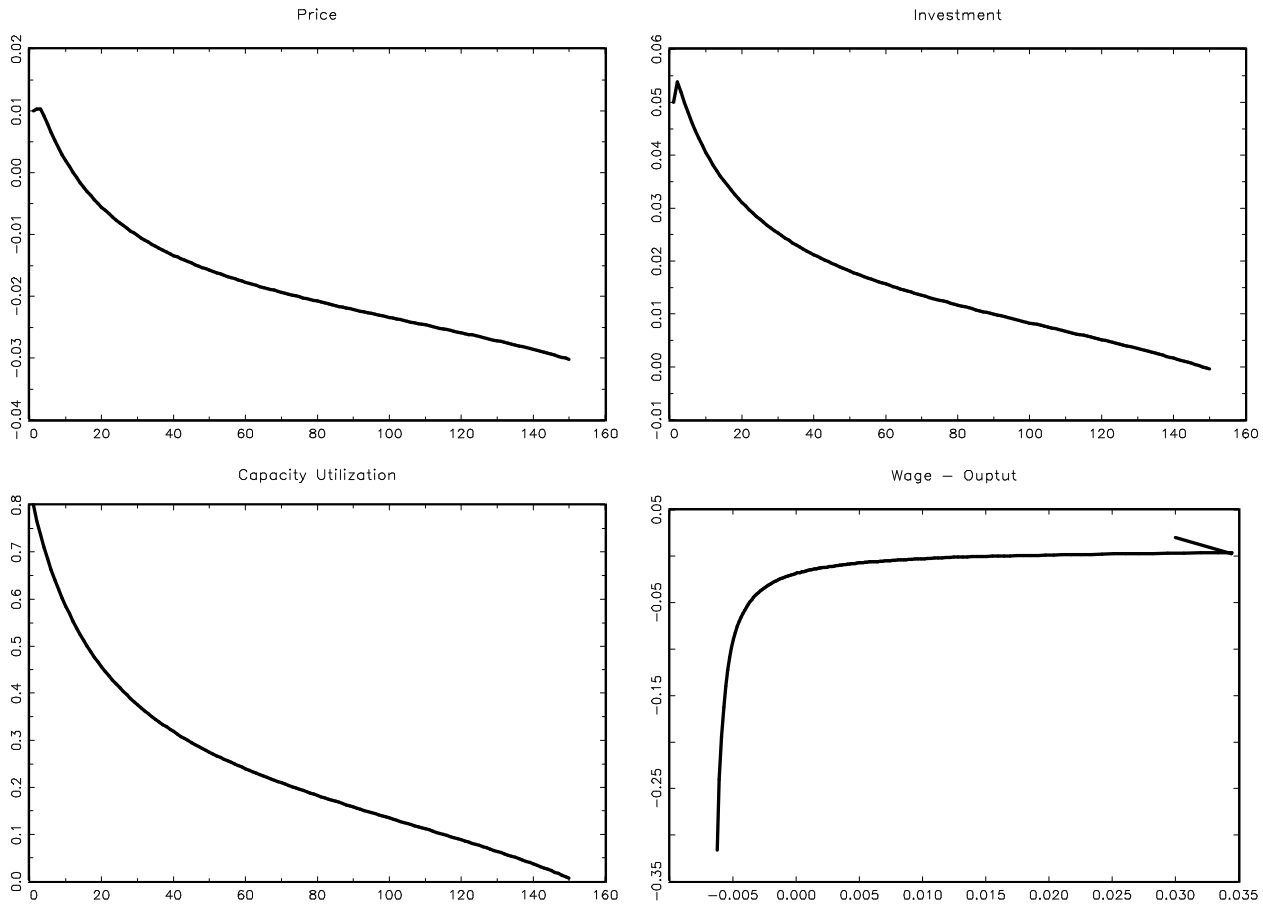

Figure 2: Absence of Monetary Policy Rule (31): Closed Economy, $\theta = 0$

Some of these parameters in table 3 are estimated with the method of moments by matching the first moments of the corresponding data. In particular, $\bar{a}$, $\bar{y}_w$ and $\bar{p}_w$ are the sample means of labor productivity a_t, the U. S. growth rate in real GDP $y_{w,t}$ and the U. S. inflation rate $p_{w,t}$ respectively. The data for estimating A is implied by (24). τ is set to g, which is assumed in the model. x^* is closed to the current exchange rate (RMB/Dollar). δ is the depreciation rate that is used for creating capital stock. r^* is assumed to be the average bond rate in the world market. y^* is the expected, on average, quarterly growth rate of real GDP in Chinese economy. We settle $h(r^*)$ to 1 indicating that the household and firm keep full cash in advance for their economic activities in the coming period. We do not have enough information to set P_0^f and P_0. This is chosen to make the steady states of export and import in the model (not reflected in this simulation, but in the latter simulation) close to the empirical data. The same principle is also applied to choose $\tilde{c}$. Here we choose $\tilde{c}$ to make the steady state of y_t close to the corresponding empirical data. The initial condition for this and next three simulations is set as follows: $p_0 = 0.01$, $U_0 = 0.8$, $w_0 = 0.03$, $r_0 = 0.09$, $i_0 = 0.05$, $y_0 = 0.02$.

As we can find in figure 2, the economy in this case is divergent. A more formal mathematical property of this dynamic system is provided in the appendix.

Adding monetary policy rule (31) will stabilize the economy by the usual transmission mechanism of monetary policy:

$$p \uparrow, \quad (r - p) \uparrow, \quad i \downarrow, \quad y \downarrow, \quad U \downarrow, \quad p \downarrow \tag{57}$$

As discussed in the literature,[15] this transmission mechanism may work well only if the adjustment speed θ is larger enough so that the interest rate effect resulting from rule (31) and expressed in (57) can cover the price effect of destabilization as expressed in (56). On the other hand, if θ is too large, the economy could be cyclically explosive.

In figure 3 - 5, the dynamic system is the same as in figure 2, except here r_t follows the monetary policy rule (31) with θ equal to 2.5, 0.0005 and 5 respectively. Here we illustrate the transmission mechanism of monetary policy rule (31) as expressed in (57). As we can find, if the interest rate effect resulting from the monetary policy rule (31) is sufficient, indicating an appropriate adjustment speed θ, the economy in this case can be stabilized (see figure 3). On the other hand, if the interest rate effect is not sufficient, indicating too small adjustment speed θ, the price effect of destabilization mechanism will be dominant and the economy is still divergent as in figure

[15] See for instance, Chiarella, Flaschel, Gong and Semmler (2003).

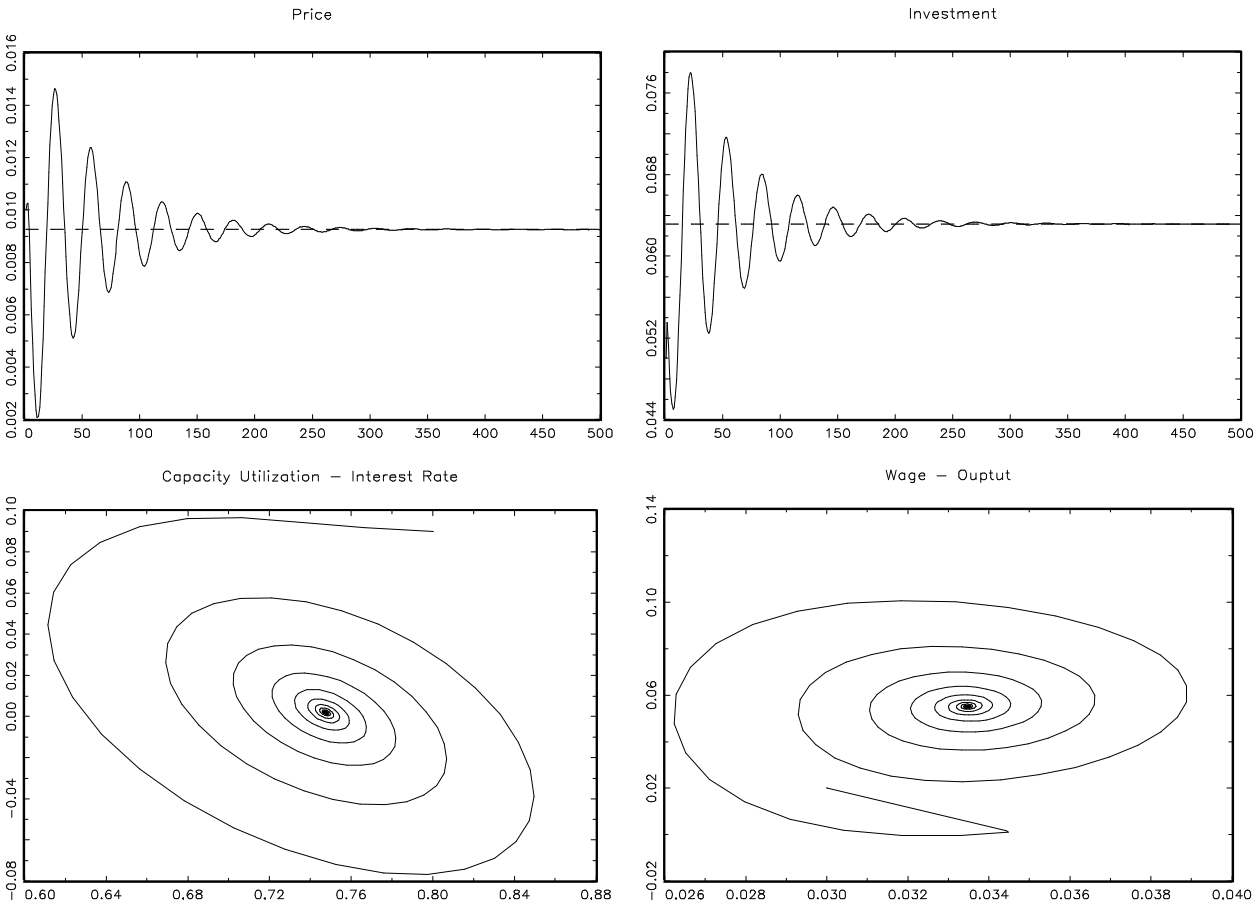

Figure 3: Sufficient Interest Rate Effect via Monetary Policy Rule (31): Closed Economy, $\theta = 2.5$

2 (see figure 4). Finally, if the interest rate effect is too strong, indicating too large θ, the economy could be be cyclically explosive. This implies that the Hopf-Bifurcation may exist with regard to θ and therefore the model can generate the limit cycle (see figure 5)

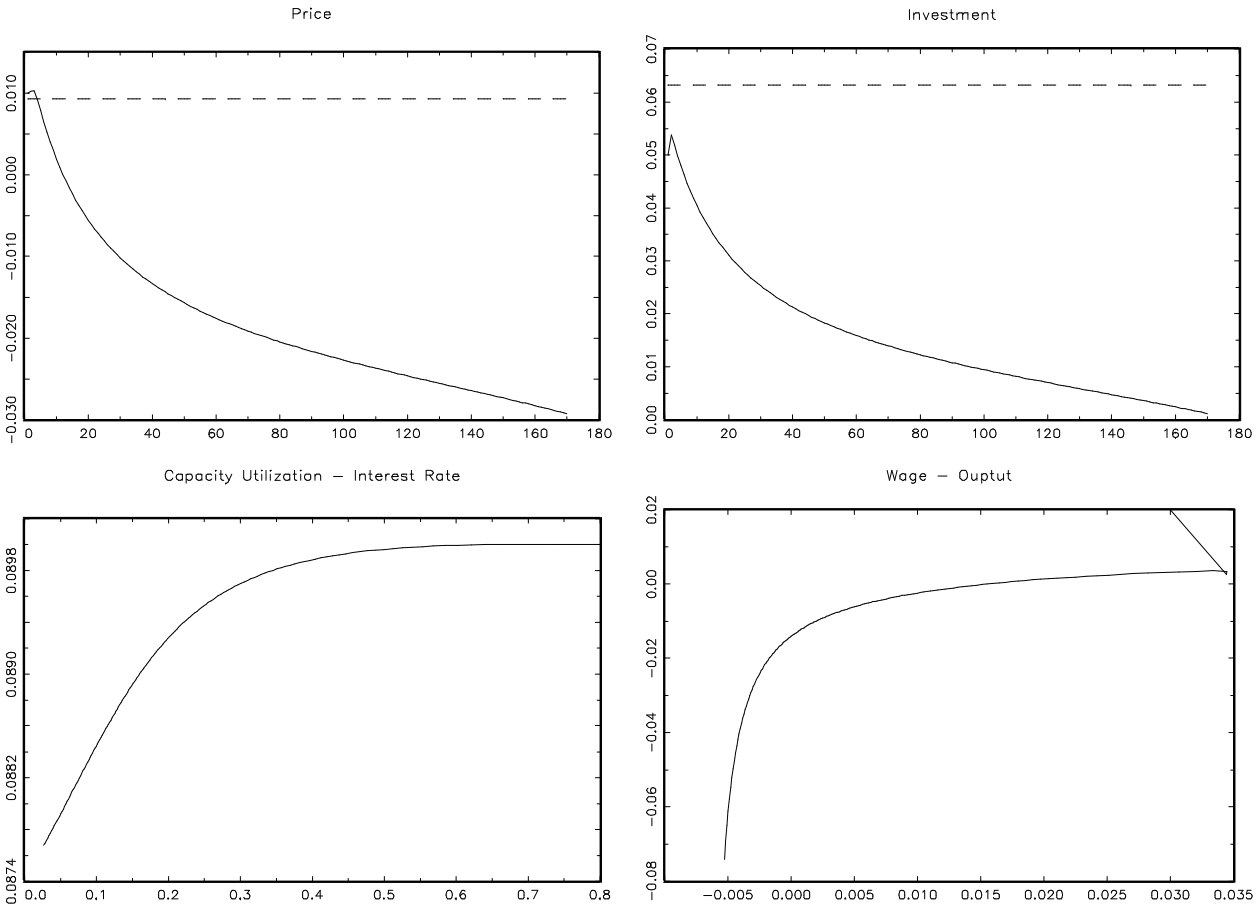

Figure 4: Insufficient Interest Rate Effect via Monetary Policy Rule (31): Closed Economy, $\theta = 0.0005$

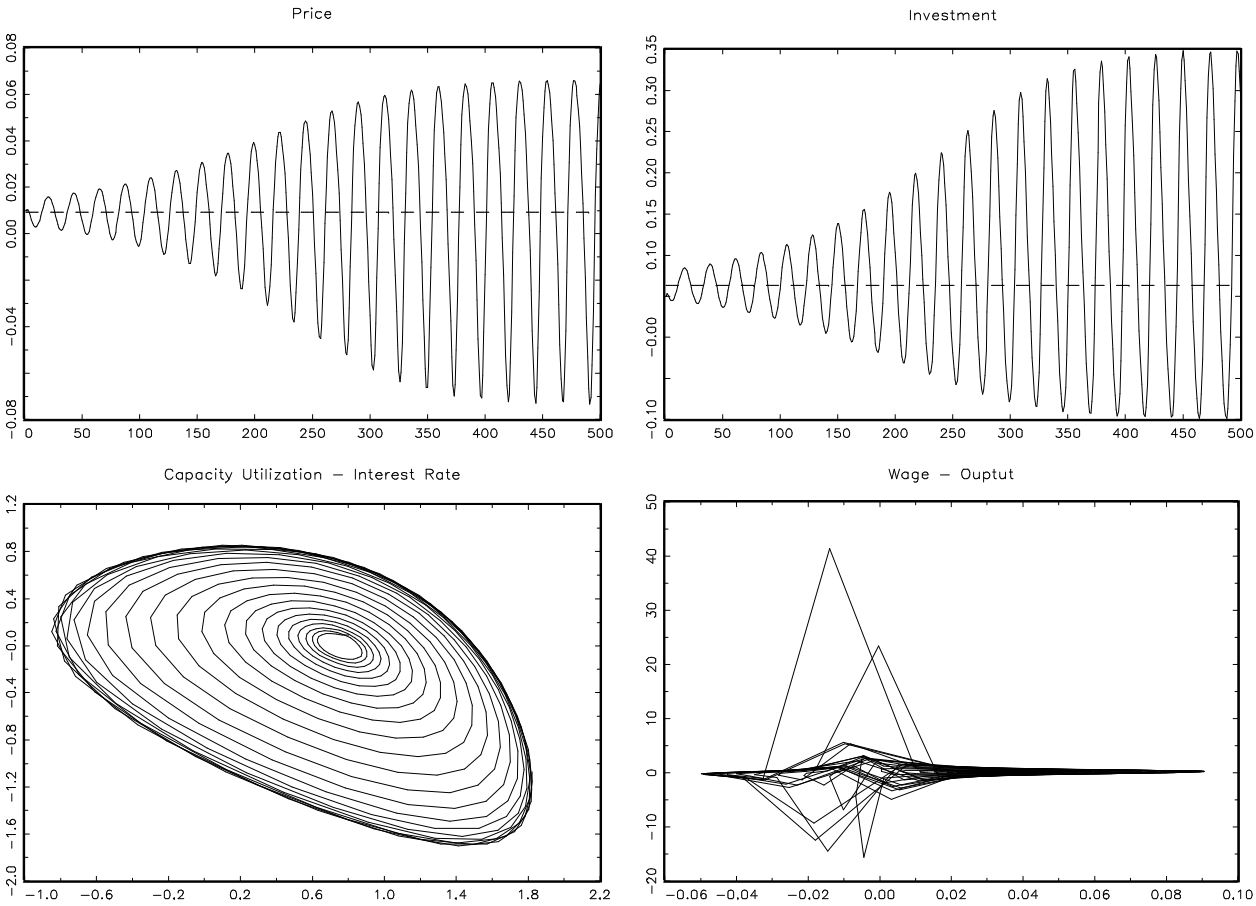

Figure 5: Over Sufficient Interest Rate Effect via Monetary Policy Rule (31): Closed Economy, $\theta = 5$

4.4 Monetary Policy in Open Economy with Fixed Exchange Regime

Now let us consider the second monetary policy rule (32). For this we need to go back to the open economy. We first find that when the second monetary policy rule (32) is effective, that is, to make the exchange rate stabilized, the price effect may also generate the following stabilization mechanism in addition to the destabilization mechanism as explained in (56):

$$p \uparrow, \quad \gamma \downarrow, \quad (e-n) \downarrow, \quad y \downarrow, \quad U \downarrow, \quad p \downarrow \tag{58}$$

If this price effect of stabilization mechanism is sufficient, it may cover the effect generated from destabilization mechanism (56) and therefore the economy could be asympototically stable even if the central bank does not adopt the monetary policy rule (31). This is the case which we have shown in figure 6.

The dynamic system in figure 6 includes (44) - (51) with $r_t = r_0$ so that the monetary policy rule (31) is absent though rule (32) is adopted to stabilize the target exchange rate. The parameters in this simulation are again from table 2 and 3 except ζ_e is adjusted down to 80% of its estimate.[16] The initial conditions for e_t, n_t, P_0^f and P_0 are settled respectively to 0.23, 0.21, 57 and 100. The other initial conditions are the same as in figure 2 - 5.

Yet, if the price effect generated from stabilization mechanism (58) is not sufficient comparing to the price effect generated from the destabilization mechanism (56), the economy can still be divergent. To illustrate this situation, we adjust parameters ζ_γ and ς_γ both down to the 10% of their estimates so that the price effect via real exchange (or stabilization) mechanism is reduced. Figure 7 simulates this situation. Here the economy is the same as in figure 6 except the down-adjustment of ζ_γ and ς_γ.

When the stabilization effect of price is not sufficient in comparing to the destabilization effect, the monetary policy rule (31) should be adopted to stabilize the economy. This is the case we show in figure 8 where we settle θ to 2.5. As we find there, the economy regain the stability due to the monetary policy rule (31).[17]

[16] This is to make the steady states of export e_t and import n_t close to the empirical data. Note that we have indeed changed the model here and therefore some adjustment is necessary to make steady states match to the empirical data. On the other hand, given the standard error of the estimate ζ_e, this down-adjustment is within the interval of statistic significance.

[17] In this simulation, we further adjust the parameters ζ_0 and ς_0 down to the 10% of their estimates. This is to avoid the negative export and import when the economy is stabilized. Since we have adjusted down the parameters ζ_γ and ς_γ, such further adjustment is necessary.

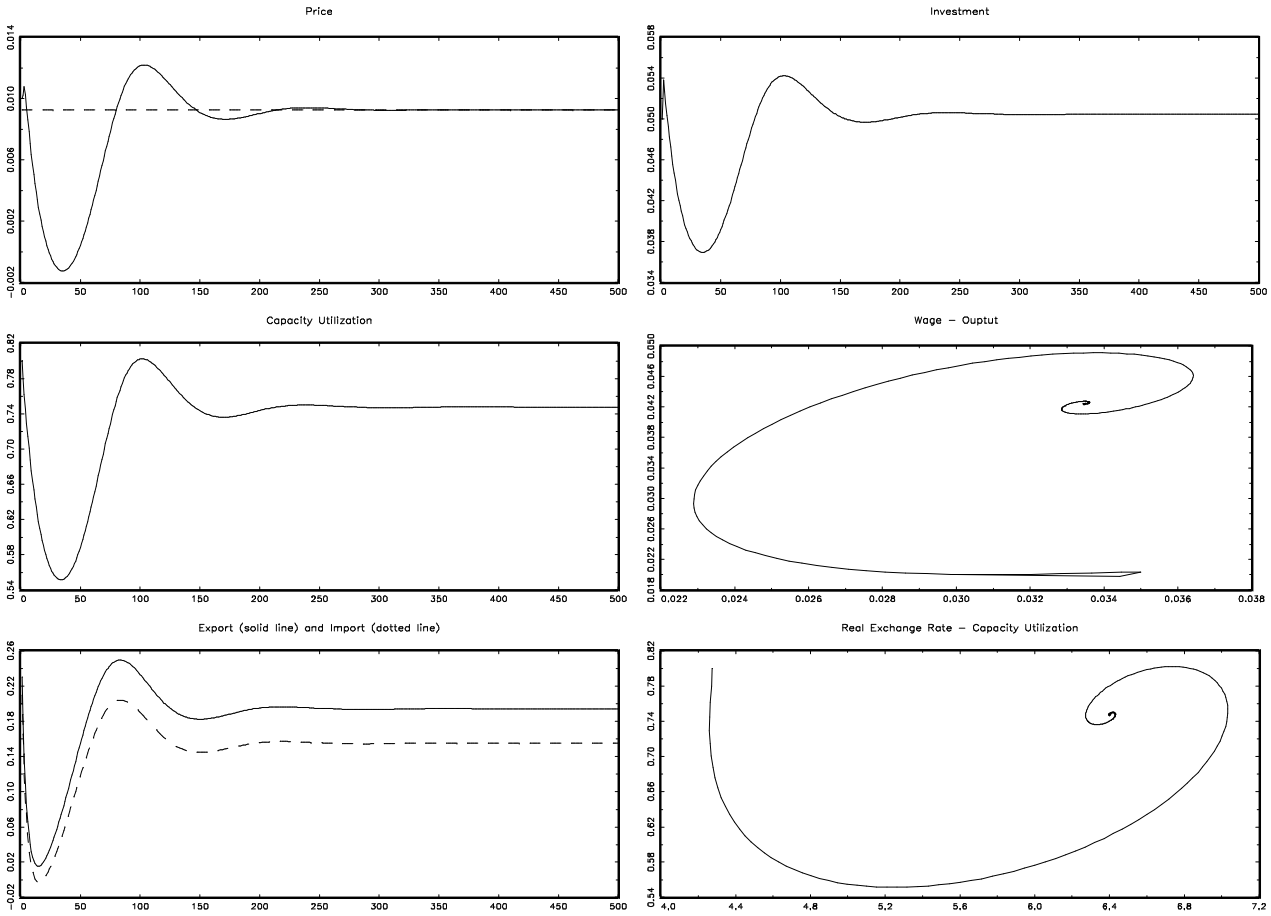

Figure 6: Absence of Monetary Policy Rule (31): Open Economy with Fixed Exchange Regime

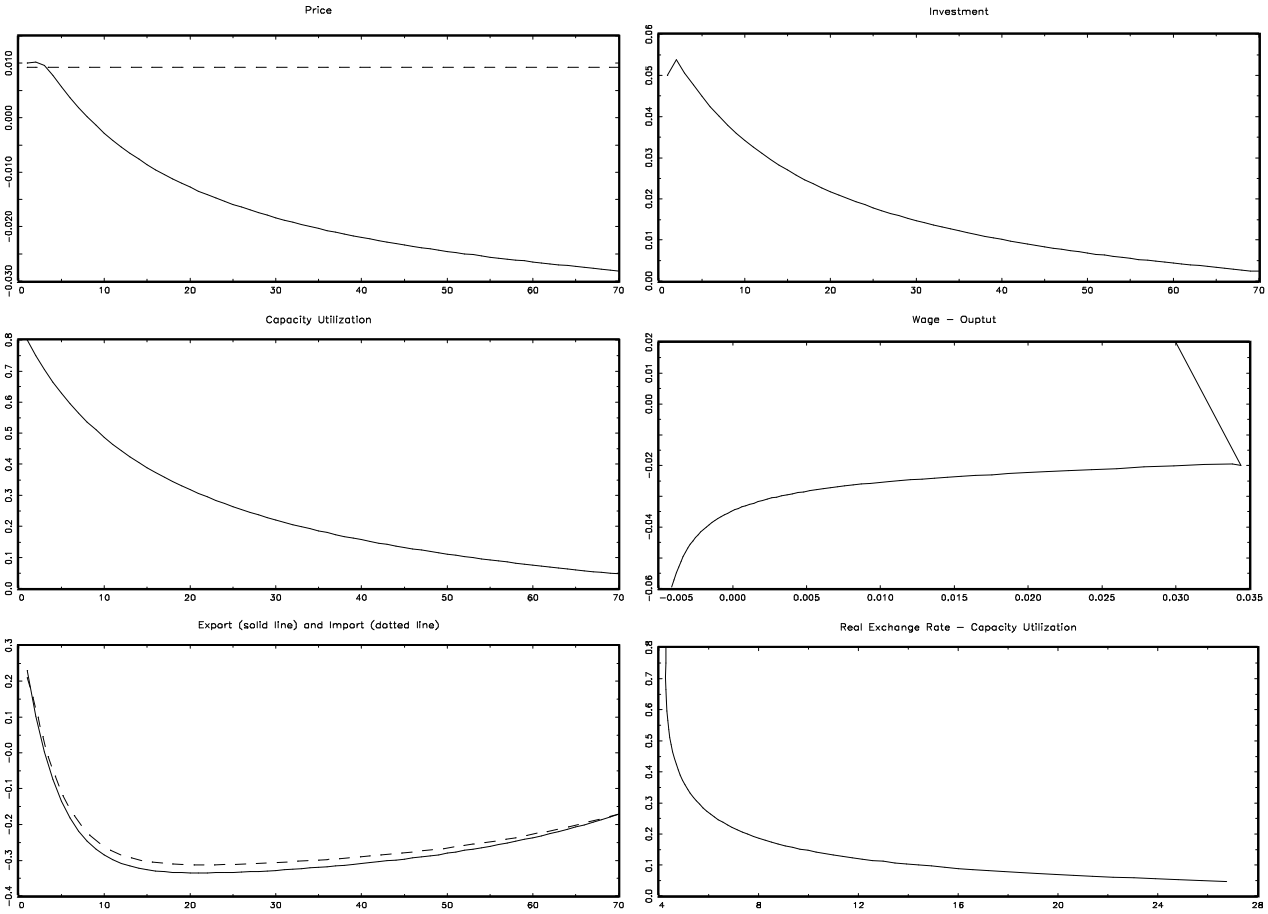

Figure 7: Absence of Monetary Policy Rule (31) with Insufficient Stabilization Effect of Price: Open Economy with Fixed Exchange Regime, ζ_γ and ς_γ are adjusted down

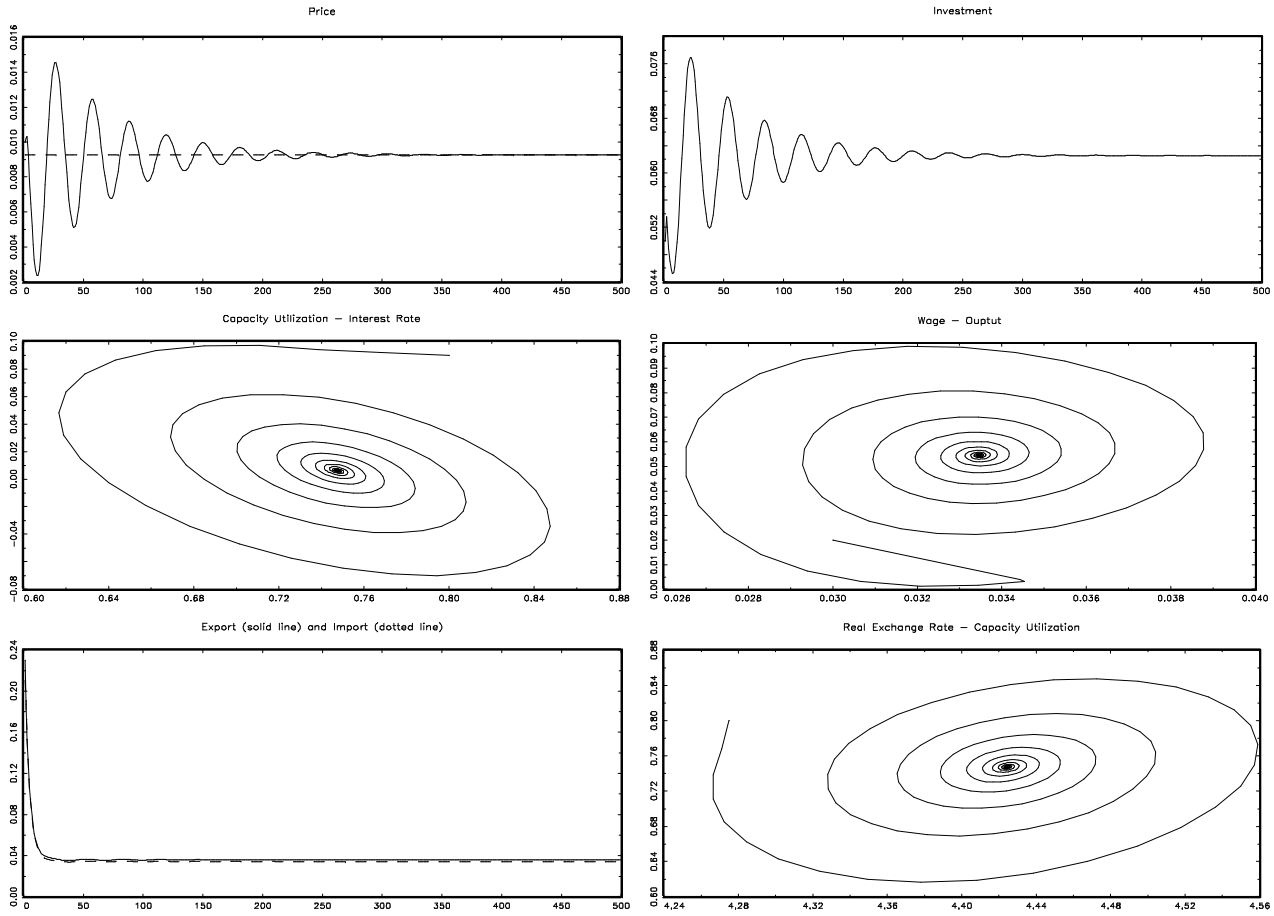

Figure 8: The Effective Monetary Policy Rule (31) when Stabilization Effect of Price is Insufficient: Open Economy with Fixed Exchange Regime, $\theta = 2.5$ and ζ_γ and ς_γ are adjusted down

We thus demonstrate our argument 1: under our three institutional arrangements, the monetary policy (31), though it may not be needed as in the case of figure 6, can be effective independently even if the exchange rate is fixed and the capital market is open.

4.5 Monetary Policy in Open Economy with Flexible Exchange Regime

Next we shall discuss our argument 2. We have already found that under the fixed exchange regime, there exists a stabilization mechanism as expressed in (58). When this stabilization effect is sufficient, there is even no need for monetary policy rule (31) to stabilize the economy. This seems to suggest that the fixed exchange regime may bring the benefit in terms of macroeconomic stability. However, for a more rigorous argument, we should also investigate what could occur if the monetary authority does not adopt the second monetary policy rule (32) so that the exchange rate can be floating. Should in this case the price effect from the stabilization mechanism (58) will be weaken by the exchange rate variation?

To answer this, we shall first compute the exchange rate x_t under the flexible exchange regime via the following balanced condition at the foreign exchange market:

$$(1+p_t)\left[n_t(x_t,...)-e_t(x_t,...)\right]=f_{m,t} \tag{59}$$

This balanced condition is derived from (17) when both sides are divided by $P_{t-1}Y_{t-1}$ while ΔF_t, $\Delta F_{o,t}$ and $\Delta F_{g,t}$ are all settled to 0. Here setting ΔF_t and $\Delta F_{o,t}$ to 0 is by assumption. $\Delta F_{g,t}=0$ indicates no government intervene in the foreign exchange market so that the exchange rate is floating. Also note from (7) that $\Delta F_{m,t}$ in this case is equivalent to $\Delta F_{w,t}$, and therefore $f_{m,t}$ should be understood as the normalized net capital inflow. Using (47), (48) and (27), we find

$$\begin{aligned} n_t-e_t &= \varsigma_0-\varsigma_\gamma\gamma_t+(\varsigma_e-1)(\tilde{\zeta}_0+\zeta_\gamma\gamma_t+\zeta_e e_{t-1}) \\ &= \pi_0+\pi_\gamma\frac{P_t^f}{P_t}x_t+\pi_e e_{t-1} \end{aligned}$$

where $\pi_0=\varsigma_0+(\varsigma_e-1)\tilde{\zeta}_0$, $\pi_\gamma=(\varsigma_e-1)\zeta_\gamma-\varsigma_\gamma$, $\pi_e=(\varsigma_e-1)\zeta_e$. Substituting the above into (59), we obtain the solution to x_t:

$$x_t=\left(\frac{f_{m,t}}{1+p_t}-\pi_0-\pi_e e_{t-1}\right)\frac{P_t}{\pi_\gamma P_t^f} \tag{60}$$

where $f_{m,t}$ is given by (52). Given the nominal exchange rate determined in (60), the real exchange rate γ_t is given by

$$\gamma_t = \left(\frac{f_{m,t}}{1+p_t} - \pi_0 - \pi_e e_{t-1} \right) \frac{1}{\pi_\gamma} \tag{61}$$

We have now seen that $f_{m,t}$, which should be understood as the capital inflow in this case, can have impact on the real side of the economy via exchange rate. We therefore, for dynamic simulation, need to specify the functional form of $\lambda(\cdot)$, which is appeared in $f_{m,t}$ (see equation (52)). For this, we assume

$$\lambda(r_t - r^*) = \begin{cases} 1 & \text{if } r_t > r^* \text{ and } (1+p_{t-1})(1+y_{t-1}) > 1 \\ 0.5 & \text{if } r_t = r^* \text{ and } (1+p_{t-1})(1+y_{t-1}) > 1 \\ 0 & \text{if } r_t < r^* \text{ and } (1+p_{t-1})(1+y_{t-1}) > 1 \\ 0 & \text{if } r_t > r^* \text{ and } (1+p_{t-1})(1+y_{t-1}) < 1 \\ 0.5 & \text{if } r_t = r^* \text{ and } (1+p_{t-1})(1+y_{t-1}) < 1 \\ 1 & \text{if } r_t < r^* \text{ and } (1+p_{t-1})(1+y_{t-1}) < 1 \end{cases} \tag{62}$$

This functional form is consistent with restriction that have discussed in section 3.1. Meanwhile it satisfies the maximization principle if the risk premium of assets are not considered. Note that the condition $(1+p_{t-1})(1+y_{t-1}) > 1$ indicates the increased money demand, i.e., $f_{m,t} + d_t > 0$ while $(1+p_{t-1})(1+y_{t-1}) < 1$ indicates $f_{m,t} + d_t < 0$

Given γ_t as expressed in (61) and $\lambda(\cdot)$ as expressed in (62), we are now able to simulate the model with the floating exchange rate. Figure 9 and 10 provides a simulation which resembles the economy in figure 6 except γ_t here is replaced by (61) and $f_{m,t}$ is provided by (52) with $\lambda(r_t - r^*)$ to be given by (62).[18] As we can see, the economy in this case is again unstable. This is consistent with our argument that the fluctuation in exchange rate will have negative impact on the economy in terms of macroeconomic stability. Since the stable exchange rate in domestic country is also applied to the country of its trader partner, we find that the benefit from the fixed exchange rate in terms of macroeconomic stability can also be shared by the country of its trade partner.

When the economy is unstable due to the floating exchange rate, the monetary policy rule (31) can be adopted to stabilize the economy. In figure

[18]Here we adjust parameters ζ_e and ζ_0 down to the 50% of their estimates. This is again to avoid the negative export and import when the economy is at the steady state. Note that here we have changed the model and therefore the adjustment is necessary. The initial condition for $f_{m,t}$ and x_t are settled respectively to 0.1 and 7.5. The other initial condition is the same as before.

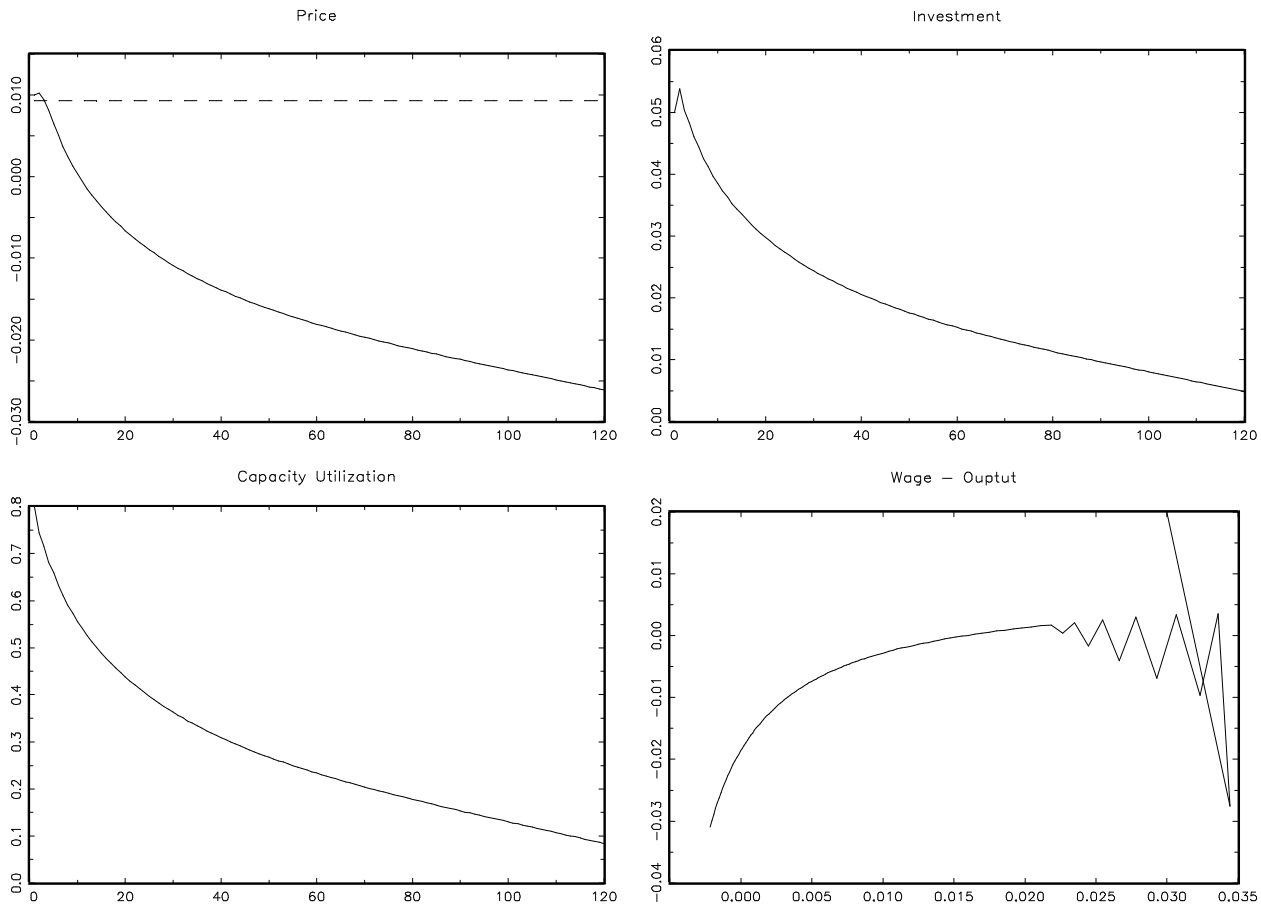

Figure 9: Absence of Monetary Policy Rule (31): Open Economy with Flexible Exchange System, Part a

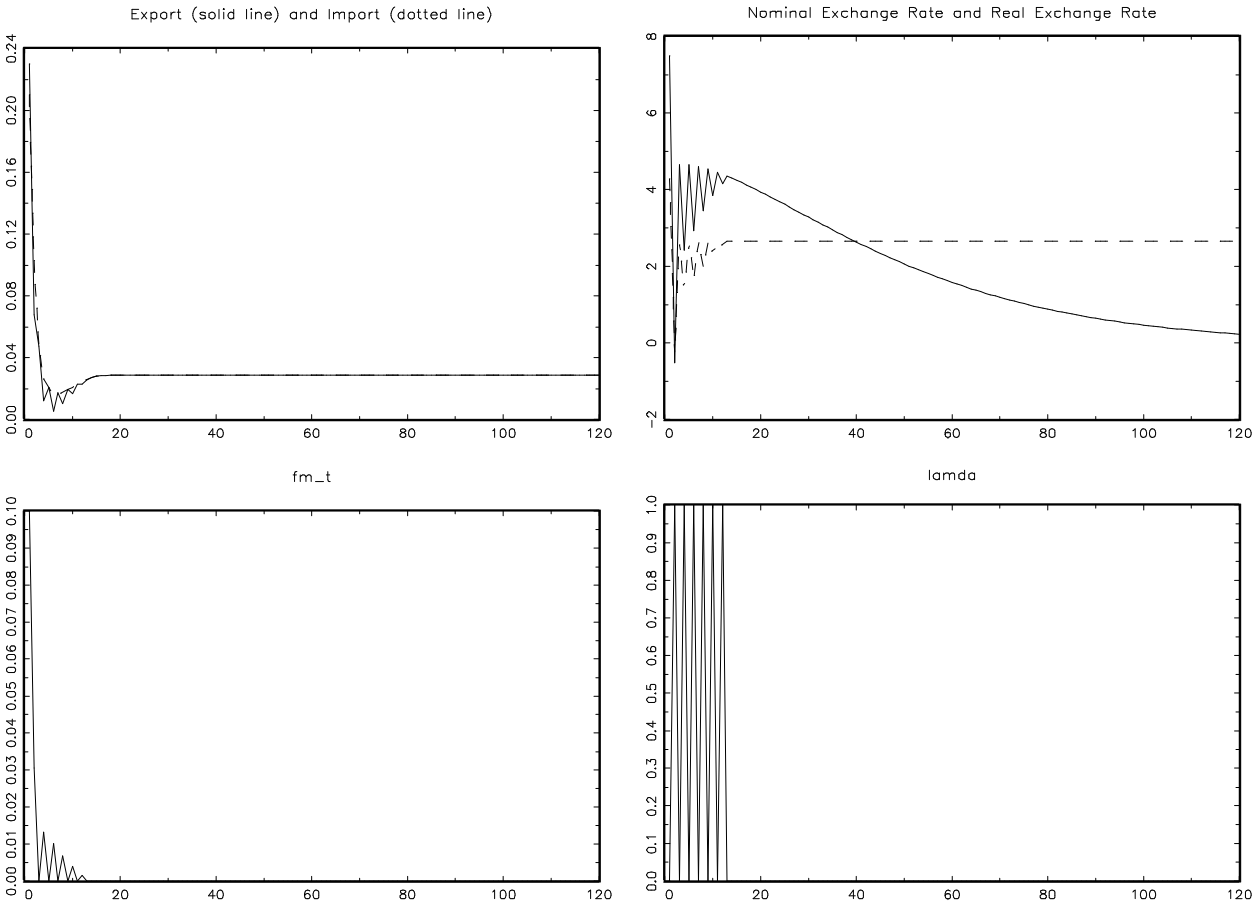

Figure 10: Absence of Monetary Policy Rule (31): Open Economy with Flexible Exchange System, Part b

11 and 12, we provides a simulation to the economy that is resemble to the economy in figure 9 and 10, except the interest rate r_t is replaced by the monetary policy rule (31).

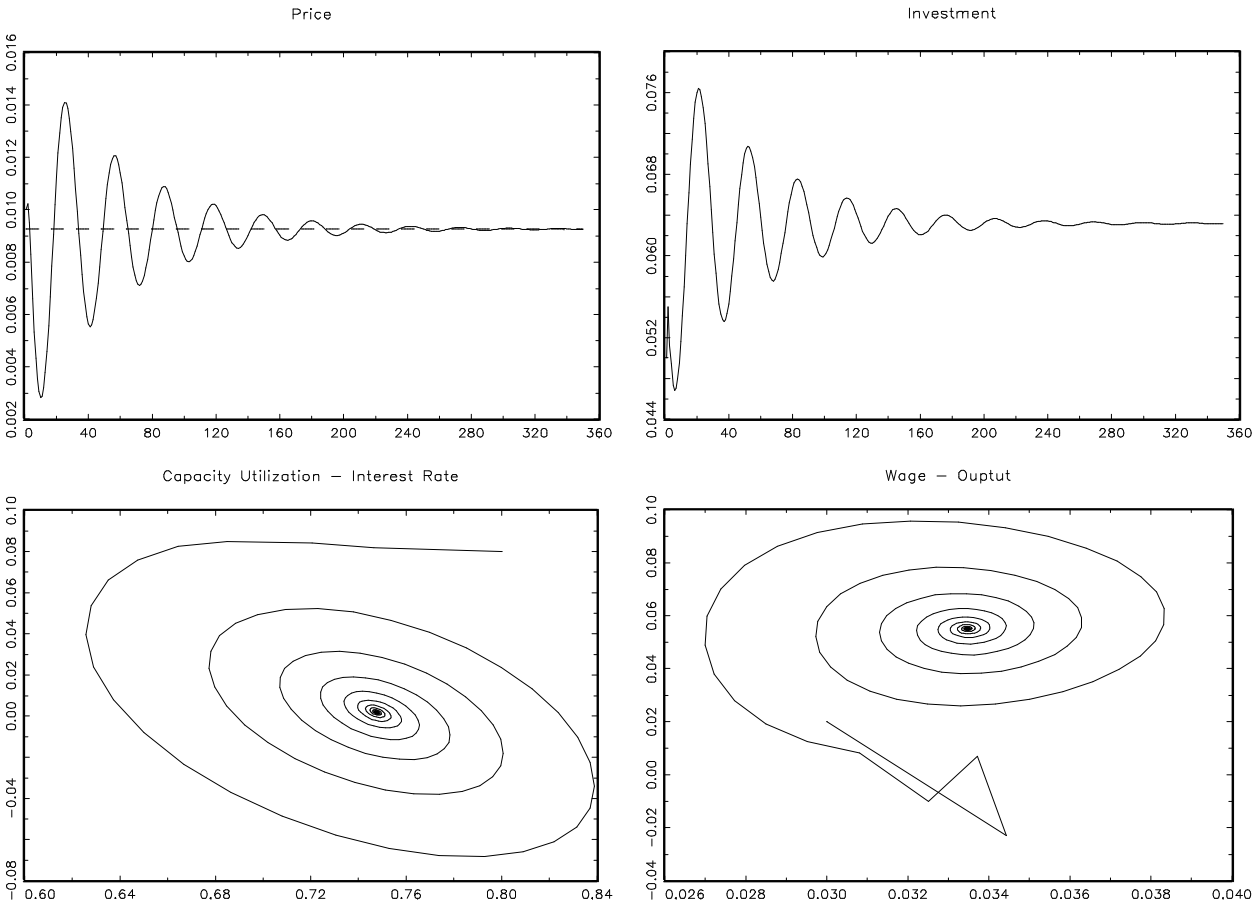

Figure 11: The Effective Monetary Policy Rule (31): Open Economy with Flexible Exchange System, Part a

4.6 The Sustainability

Next we shall discuss the sustainability of the target exchange rate, which leads to our argument 3. Since the central bank has limited foreign exchange

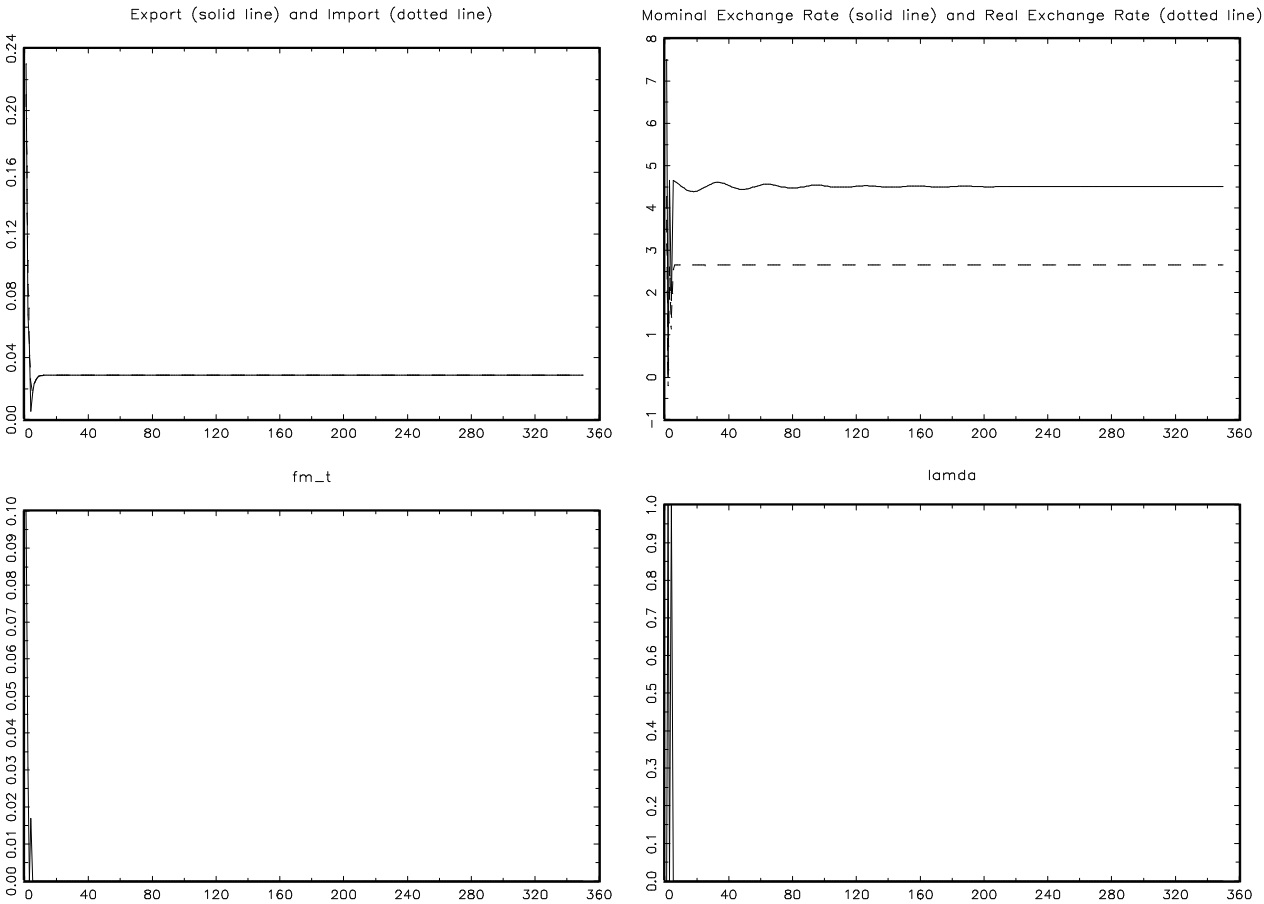

Figure 12: The Effective Monetary Policy Rule (31): Open Economy with Flexible Exchange System, Part b

reserve, we expect that it can not always use its foreign exchange to intervene the foreign exchange market. In other words, it cannot keep negative $f_{g,t}$ all the times. In other words, for the fixed regime to be sustainable, we should set the target exchange rate to the level that results a nonnegative steady state of $f_{g,t}$. Of course, it will be better to have the positive steady state. From equation (60), this further indicates that

$$x^* \geq \left(\frac{\bar{f}_m}{1+\bar{p}} - \pi_0 - \pi_e \bar{e} \right) \frac{P_T}{\pi_\gamma P_T^f} \tag{63}$$

where P_T and P_T^f are defined in (55). This equation indicates that at period 0 it is quite difficult to define equilibrium exchange rate, the exchange rate which is equal to the right side of equation (63) when evaluated at the steady state. Since the sustainable target exchange rate x^* should be at least as high as the equilibrium exchange rate, we find that it will be more appropriate at period 0 to set the target exchange above the equilibrium exchange rate. In order to avoid the financial crises, that is, the occurrence of the foreign exchange reserve to be negative,[19] a Monte Carlo simulation (by adding the variety stochastic shocks to the system) might be needed to help the determination of target exchange rate. Although this will be an interesting research in the future, we have already the following conjectures on the sustainability of the target foreign exchange rate:

- The higher is the current foreign exchange reserve, the higher is the possibility for a given target exchange rate, which satisfies (63), to be sustainable.
- The higher is the target exchange rate (or the more is the RMB undervalued), the higher is the possibility for the exchange rate to be sustainable.

5 Conclusion and Discussion

This paper studies the monetary policy for the future possible Chinese economy when capital market is open and the commercial banks are shareholding with strategical partnership. We suggest that in such an open economy, money is most likely to be endogenous and therefore the current credit plan mechanism of monetary policy will not be effective as it has currently been

[19] Here the change in foreign exchange reserve (normalized) should be equal to $e_t + f_{m,t} - n_t$.

working. Another serious challenge for the managerial mechanism of macroeconomic policy in China is that whether China should actually give up the the current fixed exchange rate regime. According to the open economy tri-lemma, this seems to be the only choice if China want to keep the independence of monetary policy for stabilizing the domestic economy.

However, the open economy tri-lemma may be effective only under the restrictions of certain institutional arrangements. For this, we suggest three institutional arrangements for the future Chinese economy. Given the three institutional restrictions, we study the monetary policy rule in a model of open economy constructed for the future Chinese economy. We find that the open economy tri-lemma will not hold under our three institutional restrictions. Therefore the monetary policy will not lose its independence even if the capital market is open and the exchange rate is fixed. The dynamic analysis of the model further shows that the fixed exchange rate system will strengthen the stability of the macroeconomy. Meanwhile, in order for the target exchange rate to be sustainable, the exchange rate in RMB should be set in such a way that RMB are under-valued. Indeed, the more RMB is under-valued, the more secure for the target exchange rate to be sustainable.

6 Appendix

6.1 The Proof of Proposition 2

Equation (43) is simply from (31) and (14) when equation (42) hold and the two discount rates are merged. Equation (44) and (45) are trivial from (30) and (29) by assuming $a_t = \bar{a}$. To prove (46), we divide both sides of (27) by γ_{t-1} while in the left side using definition $\gamma_{t-1} = \frac{x_{t-1}}{P_{t-1}} P^f_{t-1}$:

$$\frac{\gamma_t}{\gamma_{t-1}} = \frac{x_t P^f_t / P_t}{x_{t-1} P^f_{t-1} / P_{t-1}}$$

Note that here $x_t = x_{t-1} = x^*$, $P_t = (1 - p_{t-1}) P_{t-1}$ and $P^f_t = P^f_{t-1}(1 + \bar{p}_w)$. We thus find (46).

Given the equation (46), the proof of the export and import function, (47) and (48) is trivial from (26) and (28) when $y_{w,t}$ is replaced by y^*_w. The proof of investment function (49) is also trivial from (23). Next, we prove the output function (50). For doing this, we first divide both sides of equation (18) by Y_{t-1}

$$\frac{Y_t}{Y_{t-1}} = \frac{c(Y_{t-1} - T_{t-1})}{Y_{t-1}} + \frac{I_t}{Y_{t-1}} + \frac{gY_{t-1}}{Y_{t-1}} + \frac{E_t}{Y_{t-1}} - \frac{N_t}{Y_{t-1}}$$

so that

$$1 + y_t = c(1-\tau) + g + e_t - n_t + \frac{I_t}{Y_{t-1}} \tag{64}$$

where

$$\frac{I_t}{Y_{t-1}} = \frac{I_t/K_{t-1}}{AY_{t-1}/(AK_{t-1})} = \frac{i_t}{AU_{t-1}} \tag{65}$$

Substituting the above into (64), we obtain (50).

To prove (51), we use the definition (24) and (25). We find

$$U_t = \frac{Y_t/Y_{t-1}}{AK_t/Y_{t-1}} = \frac{1+y_t}{\frac{A(1-\delta)K_{t-1}}{Y_{t-1}} + \frac{AI_t}{Y_{t-1}}}$$

Expressing I_t/Y_{t-1} in terms of (65) and AK_{t-1}/Y_{t-1} in terms of $1/U_{t-1}$, we obtain (51) as in the proposition.

Next, we prove (52). From (1) - (3) when $r_{b,t}$ is replaced by r^*, we first finds that

$$\Delta F_{m,t} + \Delta D_t = h(r^*)\left(\hat{P}_t\hat{Y}_t - \hat{P}_{t-1}\hat{Y}_{t-1}\right) \tag{66}$$

Dividing both sides of (66) by $P_{t-1}Y_{t-1}$ while using assumption (40) and normalization (38), we obtain from the above

$$\begin{aligned} f_{m,t} + d_{m,t} &= h(r^*)\left[\frac{P_{t-1}(1+p^*)Y_{t-1}(1+y^*)}{P_{t-1}Y_{t-1}} - \frac{P_{t-2}(1+p^*)Y_{t-2}(1+y^*)}{P_{t-2}(1+p_{t-1})Y_{t-2}(1+y_{t-1})}\right] \\ &= \kappa\left[1 - \frac{1}{(1+p_{t-1})(1+y_{t-1})}\right] \end{aligned}$$

where κ is expressed in the proposition. From (4), we find

$$f_{m,t} = \lambda_t\kappa\left[1 - \frac{1}{(1+p_{t-1})(1+y_{t-1})}\right]$$

Expressing λ_t in terms of (5), we get (52). The similarity can also be found in proving (53).

Finally, we prove (54) by relying on (32). We first note that when $B_t = 0$ as assumed in (39), $\Delta F = 0$ as from (11). Now dividing both sides of (32) by $P_{t-1}Y_{t-1}$, we obtain

$$\begin{aligned} f_{g,t} &= \frac{E(x^*,...)P_t}{P_{t-1}Y_{t-1}} - \frac{N(x^*,...)P_t}{P_{t-1}Y_{t-1}} + \frac{\Delta F_{m,t}}{P_{t-1}Y_{t-1}} \\ &= e_t(1+p_t) - n_t(1+p_t) + f_{m,t} \end{aligned}$$

This is indeed (54).

6.2 The Proof of Proposition 3

Equation (43) indicates that at the steady state $\bar{p} = p^*$. Further from (46), if the steady state $\bar{\gamma}$ does exist (so that γ_t equals γ_{t-1} at the steady state), then we must request that p_t at steady state equals $\bar{p}_w$. We thus prove $\bar{p} = p^* = \bar{p}_w$ as in the proposition.

Using equation (27), the definition on γ_t, with x_t to be replaced by x^*, we further derive $\bar{\gamma}$ as in the proposition. Given the steady state $\bar{\gamma}$, we can obtain $\bar{e}$ and $\bar{n}$ from (47) and (48) respectively. Given the steady state of $\bar{p}$, $\bar{w}$ can be obtained from (45) and then $\bar{U}$ can be resolved from (44)

To prove the steady state $\bar{y}$, we first write (51) at the steady state:

$$\bar{U} = \frac{(1+\bar{y})\bar{U}}{1-\delta+\bar{i}}$$

This allow us to obtain

$$\bar{i} = \bar{y} + \delta \tag{67}$$

as in the proposition. On the other hand, (50) implies that at the steady state

$$\bar{y} = \tilde{c} + \bar{e} - \bar{n} + \frac{\bar{i}}{A\bar{U}}$$

Expressing $\bar{i}$ in terms of (67), we obtain from the above

$$\bar{y} = \tilde{c} + \bar{e} - \bar{n} + \frac{\bar{y}+\delta}{A\bar{U}}$$

Solving this equation for $\bar{y}$, we obtain the steady state $\bar{y}$ as expressed in the proposition.

Given the steady state $\bar{y}$, we obtain $\bar{i}$ from (67). This further allows us to derive $\bar{r}$ from (49) when evaluated at the steady state. Finally, the steady states $\bar{f}_m$, $\bar{d}_m$ and $\bar{f}_g$ are directly computed from (52), (53) and (54) when evaluated at the steady state.

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