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Balance of Payments Surplus and Renminbi Revaluation Pressure

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Abstract

Based on a simple theoretical exchange rate model, this paper shows how persistent balance of payments surpluses build up appreciation pressure on a fixed exchange regime in a partially-open economy such as China. A deregulated market interest rate may work as an automatic stabilizer to release some of the appreciation pressures, but it cannot fully eliminate the appreciation pressure because of the zero interest rate floor. Strategic options for the government include improving the quality of domestic assets by reducing the non-performing loans of the banking sector, so that the substitutability of domestic and foreign assets will rise and the exchange rate will be stabilized. Secondly, more foreign currency loans may be issued through the state-owned banking sector to promote economic growth and increase income while at the same time reducing the level of foreign reserves.

Keywords: exchange rate model, revaluation pressure, government intervention, China.

JEL classification: E58, F31.

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1. Introduction

There is an abundant literature on currency crises under pegged exchange rate regimes, including the European exchange-rate-mechanism (ERM) crisis in 1993 (Obstfeld, 1996; Ma and Kanas, 2000) and the Asian financial crisis in 1997 (Burnside, Eichenbaum, and Rebelo, 2001; Tsang and Ma, 2002). However, these models are only concerned with *devaluation* crises. Especially, they fail to explain the current revaluation pressure on the Chinese renminbi (RMB) in an economy with strong growth and persistent balance of payment surpluses (Ma, 2001).

Pressure to revalue the RMB stems from both outside and inside China, and has important political as well as economic ramifications. Some authors argue that the real exchange rate of the RMB is undervalued on the order of 15 to 25 percent, and that undervaluation is the root cause of China's current account surpluses (Goldstein and Lardy, 2003). At least in some media, China is blamed for the gloomy economy and the decline of jobs in some of its trading partners (*Economist*, 2003). Rightly or wrongly, these circumstances have created external pressures for revaluation of the RMB.

There are also internal pressures within China for the revaluation of the RMB. Under the *de facto* pegged exchange rate, the surplus in the overall balance of payments results in an increasing money supply, which may create a bubble in the capital market or in the long run result in inflation. The People's Bank of China (PBOC), the Chinese central bank, attempts to sterilize international reserve growth by issuance of central bank bills and controls on bank lending. In any case, international monetary theory and the experiences of other countries suggest that such operations tend to work only in the short term at best (Caramazza and Aziz, 1998). If the stock of central bank bills persistently rises faster than the domestic market's ability to absorb them, then the sterilization will be self-defeating: higher interest rates attract yet more capital inflows. These inconsistencies in the targets of monetary policies and the balance of payments increase appreciation pressure in the Chinese economy.

China is accumulating foreign currency reserves at an astonishing rate: in 2001, reserves were \$212.2 billion. At the end of 2003, these had reached \$403.3 billion,¹ up \$116.8 billion since the end of 2002. This represents a 40.8 percent surge on an annual basis. The growth of M1 was 19.6 percent in 2003. Bank lending increased by 21 percent in 2003, as compared to about 16 percent in 2002. Inflation is still running very low but is rising. The year-on-year change in the CPI has risen from -0.4 percent in December 2002 to 3.2 percent in December 2003 (The People's Bank of China, 2004). Interest rates are also low but are rising as the authorities sell more and more domestic bonds to sterilize. There is some evidence that the economy is overheating (*Economist*, 2004a).

¹ In addition US\$45 billion was utilized by the Chinese government during 2003 to bail out two of the four large state-owned banks.

China's government may withstand international pressures to revalue the RMB because the current account surplus is declining. In the first quarter of 2004 the current account was actually in deficit: \$-8.4 billion. China's government may ignore the internal revaluation pressures just described, but still fear an appreciation of the RMB because of three other factors. First, the unemployment rate has been rising since 1980, and at the end of 2003 the registered unemployment rate was at an all time high of 4.3% (National Bureau of Statistics of China, 2004).² The export sector absorbs a significant portion of the enormous number of underemployed people, because most Chinese exports are labour intensive goods. Second, if the consequence of revaluation is either a current account deficit or a capital outflow, China may face banking crises as happened in Korea and Japan. Greenspan (2004) pointed out that "many in China, however, fear that an immediate ending of controls could induce capital outflows large enough to destabilize the nation's improving, but still fragile, banking system. Others believe that decontrol, but at a gradual pace, could conceivably avoid such an outcome." Third, since most foreign exchange reserves held by the PBOC are US dollar-denominated securities, the losses from a falling US dollar would be significant (Cargill, Guerrero, and Parker, forthcoming). So there is not much room to revalue the RMB at present. But the questions must be answered: how long can China hold the pegged rate? What are the policy options to deal with revaluation pressure?

In this paper, we use a continuous time model to examine the effects of balance of payment surpluses on a pegged exchange rate regime. Although this model demonstrates that the peg could not permanently endure revaluation pressure, we find that a deregulated market interest rate may work as an automatic stabilizer to release some of the appreciation pressure. In addition, there are some strategic options provided by the analysis of our theoretical model which can be used to extend the lifetime of the pegged regime (see Sections 3 and 4).

The remainder of the paper is organized as follows. Section 2 builds a sticky-price monetary model with imperfect capital mobility and imperfect asset substitution; the variable definitions are summarized in Appendix A. Section 3 provides the model solution. Finally, Section 4 concludes.

² It is the ratio of the number of the registered unemployed persons to the sum of the number of employed persons and the registered unemployed persons in urban areas. Between 1998 and 2002, state-owned enterprises closures resulted in job losses for 24 million workers, or about 10 percent of the urban labor force (Economist, 2004b)

2. A Sticky-Price Monetary Model with Imperfect Capital Mobility and Imperfect Asset Substitution

Real money demand is positively related to income and negatively related to the interest rate:

$$M^d(t)/P(t) = \theta_0 Y(t) - \theta i(t) \quad (1)$$

where M^d is nominal money demand, and $P(t)$ is the domestic price level which is normalized to unity, i.e., $P(t)=1$. Similar to other currency crisis models, real income $Y(t)$ is assumed to be fixed, $Y(t)=Y$.³ Both θ_0 and θ are positive parameters (See Appendix A for the variable definitions of the model).

The nominal money supply is an identity of the central bank's balance sheet, which can be decomposed as follows:

$$M^s(t) = \eta [D + \Phi(t)] \quad (2)$$

where η is the money multiplier, D is domestic credit created by the central bank, and $\Phi(t)$ is the stock of foreign reserves held by the central bank. The assumption for D in our model is different from that in the first-generation models of currency crisis (Krugman, 1979; Flood and Garber, 1984), which usually assume that D grows along with the fiscal deficit (Sun, 2000). In this paper we assume that D is constant, which allows us to focus on the problem created by the external factors. When there are balance of payment surpluses, the stock of foreign reserves, $\Phi(t)$, will increase. But domestic credit remains unchanged under the pegged exchange rate regime if the central bank doesn't sterilize.

When the domestic money market is in equilibrium, $M^d(t) = M^s(t)$, we have:

$$i(t) = [\theta_0 Y - \eta D - \eta \Phi(t)] / \theta \quad (3)$$

Since we assume Y and D are fixed, $i(t)$ will be determined by $\Phi(t)$.⁴ The sterilization operated by the PBOC shores up the interest rate, but we ignore this operation because it prevents domestic interest rates from falling in response to the inflows and, hence, may result in the attraction of even greater capital inflows (Caramazza and Aziz, 1998). The fiscal deficits in China are huge but they are financed by long-term treasury bonds, so that they have little effect on the money market interest rate.

³ If we relax the constant real income assumption, then Y is a function of interest rate i . Substituting this IS-curve into the money demand function (1) we will get a reduced money demand function which still has a functional form similar to (1).

⁴ Although the primary lending rate and deposit rate are fixed by the PBOC, money market rates are determined by the market forces. Between January, 2001 and July, 2002, when the PBOC did not operate sterilization, the 7-day interbank rate, one of the major money market rates, dropped in response to the increase in foreign exchange reserves. Thus, there is evidence that the Chinese interest rate responds to the change of foreign exchange reserves.

Following Dornbusch and Krugman (1976), we formally distinguish the two concepts of imperfect capital mobility and imperfect asset substitution. Imperfect asset substitution implies that the desired stock of net assets, $K^*(t)$, is a function of the uncovered interest differential:

$$K^*(t) = s[i(t) - i^*(t) - \dot{e}(t)] + u_k t \quad (4)$$

where $\dot{e}(t)$ is the expected change of the spot exchange rate $e(t)$. The spot rate is defined as the price of foreign currency in terms of domestic currency, i.e., an *increase* in $e(t)$ indicates a *depreciation* of domestic currency. The term $i^*(t)$ is the foreign interest rate, and s is a positive parameter which measures the degree of asset substitutability. Finally, the term u_k is a constant representing an exogenous permanent shock to the capital account. The stock of the cumulated capital account shocks up to time t is $u_k t$.

In a world of perfect asset substitutability ($s \rightarrow +\infty$), domestic and foreign assets are perfect substitutes and uncovered interest parity holds, i.e., $i(t) - i^*(t) = \dot{e}(t)$, provided that u_k is a finite number. However, with capital control (see eq. (5) below), this is not likely to be the case for China. Under the situation of imperfect asset substitution, $0 < s < +\infty$, the premium paid to domestic assets over foreign assets is defined as $i - i^* - \dot{e}$.

Equation (4) implies that the net demand for domestic assets depends on both economic fundamentals as well as other exogenous international factors. For example, China's economic reform and open door policy produced a higher growth rate than other countries in the last two decades. Therefore, China has attracted a large amount of foreign direct investment (Tsang and Ma, 1997), although the nominal interest rate in China has been consistently lower than that in overseas market. Thus, we assume $u_k > 0$.

The net inflow of foreign capital, $dK(t)/dt$, depends upon the degree of capital mobility, m :

$$\begin{aligned} dK(t)/dt &= m [K^*(t) - K(t)], \\ &= m s [i(t) - i^* - \dot{e}(t)] + m u_k t - m K(t), \quad 0 \leq m \leq +\infty, \end{aligned} \quad (5)$$

where m is the capital adjustment coefficient. To a certain extent, the authority controls capital mobility. If $m \rightarrow +\infty$, there is perfect capital mobility and there is no capital control. This implies investors are able to adjust their investment portfolio to the desired level *instantaneously*. If $m = 0$, it means capital is under complete government control and there is no capital mobility, even if $K(t)$ is different from $K^*(t)$. For China, it is likely that $0 < m < +\infty$: Capital is under partial control and capital mobility is imperfect.⁵ In any finite period, the capital stock adjustment is only a portion of the difference between $K(t)$ and $K^*(t)$.

⁵ China imposes restrictions on both capital outflows and inflows according to current laws and rules. In equation (5) a change in capital mobility (m) affects both inflows and outflows. But in practice the regulations on capital outflows are stricter than that on capital inflow. A decrease in m is interpreted as tightening controls on inflows because controls on outflows have been tighter than that on inflows; and an increase in m is interpreted as loosening controls on outflows because controls on inflows have been looser than that on outflows (see Sections 3.4.1 and 3.4.2).

Both parameters of substitution, s , and capital mobility, m , depend on the available technology, institutional arrangements of the market, and government regulations. For example, in countries like China and some other developing countries where capital is controlled by the government, both the capital mobility and asset substitutability are probably low. On the other hand, capital mobility and asset substitutability are high among most developed countries, since there are few restrictions on capital movements. For middle-income countries with liberalized capital accounts, capital mobility could be high but asset substitutability probably remains low due to insolvency risk. A formal treatment of imperfect capital mobility and imperfect asset substitution can be found, for example, in Ma, Meredith and Yiu (2002) in a discrete-time model of the currency board arrangements in Hong Kong.

For simplicity, we assume that the economic system is initially at steady state with no shocks to the capital or current accounts. The initial values are:

$$K(0)=K^*(0)=0, \quad i_0 = i^*, \quad i_0 = [\theta_0 Y - \eta D - \eta \Phi_0] / \theta \quad (3)'$$

where i_0 is initial domestic nominal interest rate for $t=0$, and Φ_0 is the initial foreign exchange reserves level.

To close the model, we also need the balance of payments identity, which consists of the current account and the capital account. If the stock of foreign exchange reserves in level terms is $\Phi(t)$, then the balance of payments identity is:

$$\mu(t) \equiv d\Phi(t)/dt = dK(t)/dt + u_c \quad (6)$$

where u_c is the current account surplus and is assumed to be constant for simplicity.

The stock of the foreign reserves held by the central bank can be obtained by integrating (6):

$$\Phi(t) = \Phi_0 + K(t) + u_c t \quad (7)$$

where Φ_0 is the initial level of foreign reserves.

Substituting (4) and (3) into (5), and with the assumption $\dot{e}(t) = 0$, we have:

$$\frac{dK(t)}{dt} = m s \left[\frac{\theta_0 Y - \eta D - \eta \Phi(t)}{\theta} - i^* \right] + m u_k t - mK(t) \quad (8)$$

Substituting (7) and (3) into (8):

$$\frac{dK(t)}{dt} = m s \left[\frac{-\eta K(t) - \eta u_c t}{\theta} \right] + m u_k t - mK(t) \quad (9)$$

Therefore,

$$dK(t)/dt + \rho K(t) = -w t \quad (10)$$

where

$$\rho = m s \eta / \theta + m > 0$$

$$w = m[s \eta u_c / \theta - u_k]$$

We can solve $K(t)$ out as follows:

$$K(t) = (1 - e^{-\rho t}) \frac{w}{\rho^2} - t \frac{w}{\rho} \quad (11)$$

Hence:

$$\frac{dK(t)}{dt} = -(1 - e^{-\rho t}) \frac{w}{\rho}, \quad (12)$$

Substituting (12) into (6):

$$\mu(t) = u_c \frac{1 + e^{-\rho t} s \eta / \theta}{1 + s \eta / \theta} + u_k \frac{1 - e^{-\rho t}}{1 + s \eta / \theta} \quad (13)$$

Equation (13) indicates that if there is a capital inflow ($u_k > 0$), and a current account surplus ($u_c > 0$), then we have a balance of payments surplus:

$$\mu(t) > 0. \quad (13a)$$

Based on (3) and (5), we can identify two coordinated automatic stabilizing mechanisms of the market interest rate in our model. The first one is the domestic money market adjustment mechanism. If the increase in the foreign exchange reserves causes the domestic currency supply to rise, the domestic interest rate $i(t)$ will be adjusted downwards to stimulate the demand for money [cf. (3)]. This will maintain the equilibrium of domestic money supply and demand. The second stabilizing mechanism is international capital flow adjustment. The fall in the domestic interest rate will prompt a foreign capital outflow. This implies that a market-determined interest rate mechanism allows foreign exchange reserves to run down which eases the strain of exchange rate revaluation.

However, the effect of the interest rate adjustment mechanism is limited. Under a persistent surplus shock to the balance of payments, the foreign exchange reserves will rise continuously. Accordingly, the money supply will increase [cf. eq.(2)]. The nominal interest rate then will fall constantly [cf. eq.(3)] until it reaches the zero floor, say, at time t_r . Then it will destabilize the pegged exchange rate.

Information on t_r may induce extra pressure on appreciating the RMB similar to the findings of the first-generation models of currency crisis (Krugman, 1979; Flood and Garber, 1984). However, capital controls on short-term capital inflows are very tight in China. Thus the likelihood that there will be a huge short-term capital inflow to trigger a speculative attack on the RMB is weak.

However, even if the domestic credit supply is sound, the domestic interest rate adjustment mechanism itself is not sufficient to defend the pegged exchange rate system forever if there is a persistent shock to the current and/or capital accounts. Although the interest rate adjustments may help the foreign reserves correction to offset the impact of capital inflow on the exchange rate, these adjustments are limited and therefore cannot eliminate completely the impact of the surplus in the balance of payments. As a result, official foreign reserves will have to continuously rise and the nominal interest rate eventually will have to fall down to the zero floor. The exchange rate parity will ultimately be abandoned.

3. The Implications of the Model Solution: Revaluation Occurrence and its Postponement

Suppose the time the interest rate hits the zero floor, namely the life of the pegged exchange rate system, is t_r . We have $\dot{i}(t_r)=0$ and from equation (3), the foreign reserves reach the maximum level given as follows:

$$\Phi(t_r) = (\theta_0/\eta) Y - D \quad (14b)$$

This shows the limit of the automatic stabilizer effect of interest rate adjustment during the exchange rate revaluation pressure. When the interest rate falls down to the zero floor, it cannot help to fix the pegged exchange rate anymore. Under this circumstance, it requires government intervention to stabilize the exchange rate.

To find t_r , first substitute (11) into (7):

$$\Phi(t) = \Phi_0 - e^{-\rho t} \left[\frac{w}{\rho^2} \right] - t \frac{w}{\rho} + \frac{w}{\rho^2} + u_c t \quad (14a)$$

Then substitute (14b) into (14a) at time t_r :

$$\Phi_0 - e^{-\rho t_r} \left[\frac{w}{\rho^2} \right] + \frac{w}{\rho^2} - \left(\frac{w}{\rho} - u_c \right) t_r = (\theta_0/\eta) Y - D \quad (14)$$

This equation shows that t_r is an implicit function⁶ of the initial level of foreign reserves Φ_0 , the exogenous shocks to the capital account (u_k) and to the current account (u_c), international asset substitutability (s),

⁶ From (10), we know that w is itself a function of m , s , u_k , and u_c , and ρ is itself a function of both m and s .

capital mobility (m), real income (Y) and domestic credit (D). By (14), we can find out the derivatives of t_r with respect to all of these variables. Thus we may analyze the effects of these variables on t_r .

3.1 The Relationship Between Initial Foreign Exchange Reserves, Φ_0 , and t_r

From (14) and (13), we obtain:

$$\frac{dt_r}{d\Phi_0} = \frac{-1}{u_c \frac{1+e^{-\rho t_r} s\eta/\theta}{1+s\eta/\theta} + u_k \frac{1-e^{-\rho t_r}}{1+s\eta/\theta}} = \frac{-1}{\mu(t_r)} \quad (15)$$

where $\mu(t_r)$ is the balance of payments surplus at the time that revaluation occurs, and t_r is the time when revaluation occurs. We assume that the balance of payments continue to be in surplus. This is the situation that China has experienced since the 1994 exchange rate reform. From (13a), if the balance of payments continues to be in surplus, i.e., $u_k > 0$ and $u_c > 0$, then $\mu(t_r) > 0$. This implies $\frac{dt_r}{d\Phi_0} < 0$. In other words, a reduction in the initial value of foreign reserves may lengthen the life of the pegged exchange rate. In some economies like Hong Kong, about half of the money supply is in terms of foreign currency (Tsang and Ma, 2002).

At the end of 2003, the PBOC utilized US\$45 billion of foreign reserves to bail out two of the big four state-owned banks, the China Construction Bank and the Bank of China. According to our model, that reduces the initial value of foreign reserves and lengthens the life of the peg.

3.2 The Current Account Shock

Based on (14) and (13), we have

$$\frac{dt_r}{du_c} = \frac{\frac{t_r \theta}{s\eta + \theta} + (1 - e^{-\rho t_r}) \frac{s\eta}{m\theta(s\eta/\theta + 1)^2}}{-\mu(t_r)} \quad (16)$$

If the balance of payments is in surplus, we have $\mu(t_r) > 0$, hence $\frac{dt_r}{du_c} < 0$. This means that a reduction of the current account surplus may delay the rise of reserves and slow the fall of the interest rate to the zero floor. Therefore the pegged exchange rate system can be maintained for a longer period. The policy measures that may help to reduce the current account surplus include reductions in tariffs and other import barriers, and a revamp of export tax rebates such as that recently implemented by the Chinese government (Dickie, 2003).

3.3 The Capital Account Shock

According to (14) and (13), we have:

$$\frac{dt_r}{du_k} = \frac{-\frac{m}{\rho} \left[t_r - \frac{1}{\rho} (1 - e^{-\rho t_r}) \right]}{\mu(t_r)} \quad (17)$$

where t_r represents the time when revaluation occurs.

Define the function in the bracket of the numerator as $q(t) = t - \frac{1}{\rho}(1 - e^{-\rho t})$, with $q(0)=0$ and $dq(t)/dt = 1 - e^{-\rho t} > 0$ ($t > 0$). Thus, $q(t)$ is a positive monotonic increasing function with respect to t . Hence, $[t_r - \frac{1}{\rho}(1 - e^{-\rho t_r})] > 0$.

If the balance of payments is in surplus, we have $\mu(t_r) > 0$, so $\frac{dt_r}{du_k} < 0$. This shows that a fall in the positive shocks to the capital account will prolong the life of the pegged exchange rate system. Policy options to encourage domestic capital outflow such as the initiative of the Qualified Domestic Institutional Investor (QDII) will offset the large capital inflow and reduce the positive u_k shocks.

3.4 The Influence of Capital Mobility

Based on (14) and (13), we obtain:

$$\frac{dt_r}{dm} = \frac{\frac{w}{m\rho} \left[\frac{1 - e^{-\rho t_r}}{\rho} - t_r e^{-\rho t_r} \right]}{\mu(t_r)} \quad (18)$$

Define the function in the bracket of the numerator as $h(t) = \frac{1 - e^{-\rho t}}{\rho} - t e^{-\rho t}$, with $h(0)=0$, and $dh(t)/dt = t \rho e^{-\rho t} > 0$ ($t > 0$), namely $h(t)$ is a positive monotonic increasing function with respect to t . Hence, $\left[\frac{1 - e^{-\rho t_r}}{\rho} - t_r e^{-\rho t_r} \right] > 0$.

The impact of capital mobility m on the time of revaluation occurrence can be analyzed according to the following two cases.

3.4.1 Only the capital inflows shock $u_k > 0$ but no current account shock, $u_c = 0$.

In this case, we have:

$$w = -m u_k < 0, \mu(t_r) > 0, \text{ and } \frac{dt_r}{dm} < 0.$$

If the root cause of currency revaluation pressure is from the capital inflow, then strengthening the control of capital *inflow* (namely m decreases⁷) may enhance the robustness of the pegged exchange rate to the exogenous shocks.

3.4.2 Only current account surplus shock $u_c > 0$ but no capital account shock $u_k = 0$.

In this case, $w = m s \eta u_c / \theta > 0$, and $\mu(t_r) > 0$. This implies that $\frac{dt_r}{dm} > 0$.

Thus if the root cause of currency revaluation stress is from the current account surplus, then relaxing capital controls (namely m increases⁸) will allow more capital outflow and thus stabilize the pegged exchange rate system.

3.5 A Change in the Degree of Asset Substitution

According to (14) and (13), we have:

$$\frac{dt_r}{ds} = \frac{t_r \frac{m\eta}{\theta} e^{-\rho t_r} \left(\frac{w}{\rho^2}\right) + \frac{m^2\eta}{\theta\rho^3} [u_c - u_c \frac{s\eta}{\theta} + 2u_k](1 - e^{-\rho t_r}) - t_r \frac{m^2\eta}{\theta\rho^2} (u_c + u_k)}{-\mu(t_r)} \quad (19)$$

where t_r is the time when revaluation occurs.

Theorem 1 of Appendix B shows that no matter if it is the capital account inflow shock $u_k > 0$, or if it is the current account surplus shock $u_c > 0$, we always have $\frac{dt_r}{ds} > 0$.

This implies that if the balance of payment is in surplus, an increase in the degree of asset substitution degree s may delay the foreign reserves increase and slow the fall of the nominal interest rate to the zero floor. It is advantageous to the pegged exchange rate parity.

The degree of asset substitution s is mainly determined by the heterogeneity in financial systems and the macroeconomic environments among domestic and foreign countries. For example, if a developing

⁷ In this case a decrease in m is interpreted as tightening controls on inflows because controls on outflows have been tighter than that on inflows in practice.

⁸ In this case, an increase in m is interpreted as loosening controls on outflows because if $u_k = 0$ then according to the model there is no capital inflows but only capital outflows induced by $i < i^*$.

country liberalizes its domestic financial market while maintaining stable economic development, substitution between domestic and foreign assets will probably increase. Based on our model's analysis, this will enhance the stability of the exchange rate system.

3.6 Domestic Credit (D)

According to (14) and (13), we have

$$\frac{dt_r}{dY} = \frac{\theta_0}{\eta \mu(t_r)} \text{ and } \frac{dt_r}{dD} = \frac{-1}{\mu(t_r)} \quad (21)$$

Equation (21) indicates that when there is balance of payment surplus, $\mu(t_r) > 0$, then we have $dt_r/dY > 0$ and $dt_r/dD < 0$. It implies that an increase of real income and a contraction of domestic credit will stabilize the fixed exchange rate regime. An increase of real income will increase the demand for money, which will offset the rise of money supply generated from the expansion of foreign reserves. This in turn will slow down the fall of the nominal interest rate. In contrast, the contraction of domestic credit will counteract the rise of money supply, which also will prevent the nominal interest rate reaching the zero floor. Consequently both measures prolong the life of the official parity. This is consistent with recent Chinese policies of sales of central bank bills and increases in reserves requirement of the banking sector (McGregor, 2003).

4. Conclusion

In this paper, we present a monetary model that focuses on the external factors that may destabilize a pegged exchange rate system. It is shown that a pegged exchange rate system still faces total destruction under persistent external shocks even when the fundamentals of the economy are strong and domestic economic policy is also sound. This conclusion indicates that the pegged exchange rate system is intrinsically vulnerable. However, despite its weakness, our analysis shows that there are policies that may prolong the life of the pegged exchange rate to a certain extent, although not permanently.

We find that a deregulated market interest rate may work as an automatic stabilizer to release some of the appreciation pressure. One policy implication of our finding is that China should accelerate liberalizing the interest rate. This will not only help China to make the banking system more efficient but also support the existing fixed exchange rate regime to a certain extent.

Another policy implication of our analysis is that China should improve the quality of her domestic assets, such as reducing non-performing assets and injecting more capital into the banking sector (Lardy, 1998). That will increase the substitutability of the domestic assets with the foreign ones, reduce the vulnerability of the banking sector, and consequently enhance the stability of the exchange rate system. Recently two of China's four biggest state-owned commercial banks received foreign exchange reserves from the PBOC to bolster their capital adequacy ratios and move from total state ownership to become joint-stock holding banks. This action may extend the lifetime of a pegged regime in two ways: first, it reduces the initial level of foreign exchange reserves; second, it increases the substitutability

between Chinese capital and foreign capital. On the other hand, improving the quality of Chinese assets makes them more attractive and therefore may increase capital inflows and pressure to revalue.

Our model suggests that there is still room for maneuver in the short run for China, if she does not rush into opening up her capital account (Liu, et al., 2002, 2004; Cargill, Guerrero and Parker, forthcoming). However, China has to change the current foreign exchange controls that regulate capital outflows more tightly than inflows. That is, China should encourage more domestic capital outflow. At present, about 70 percent (State Administration of Foreign Exchange of China, 2003) of the change of China's official foreign exchange reserves comes from the capital account. According to the analyses in Section 3.4.1 and 3.4.2, the policy options under this circumstance are to strengthen capital control to reduce the external shock and allow more capital outflow to ease the pressure of revaluation.

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Appendix A. Variable definitions

- D domestic credit extended by the central bank, constant
 e spot exchange rate, defined as the price of foreign currency in terms of domestic currency
 \dot{e} the expected change of the spot exchange rate e
 $i(t)$ domestic nominal rate of interest
 i^* foreign interest rate, constant
 $K^*(t)$ the desired net demand for domestic assets
 $K(t)$ the actual net demand for domestic assets
 m the degree of capital mobility
 $M^d(t)$ nominal money demand
 $M^s(t)$ nominal money supply
 $P(t)$ domestic price level which is normalized to unity, i.e., $P(t)=1$
 s a parameter which measures the degree of asset substitutability
 t time variable
 t_r the time when the revaluation occurs, i.e., the fixed exchange rate collapses
 u_c exogenous permanent shock to the current account
 u_k exogenous permanent shock to the capital account
 w variable ($=m[s\eta u_c / \theta - u_k]$)
 $Y(t)$ real income, assumed to be fixed, $Y(t)=Y$
 η money multiplier
 $\Phi(t)$ stock of foreign exchange reserves held by the central bank
 Φ_0 initial values of foreign reserves
 $\mu(t)$ balance of payments ($=d\Phi(t)/dt$)
 ρ parameter ($=m s \eta / \theta + m$)
 θ_0, θ parameters in money demand equation

Appendix B

The influence of the degree of assets substitution (s) on the life of the pegged exchange rate system (t_r)

Lemma 1.

For any positive parameters of $m, x > 0$, let $\pi(t) \equiv -1 + (t m x + t m + 1) e^{-t(x+1)m}$. Then for any $t > 0$, $\pi(t) < 0$.

Proof.

Since $\pi(0)=0$, $d\pi(t)/dt = -t m^2(x+1)^2 e^{-t(x+1)m} < 0$, namely $\pi(t)$ is a negative monotonic decreasing function with respect to t . Therefore for any $t > 0$, we have $\pi(t) < 0$. **QED.**

Lemma 2.

For any positive parameters of $m, x > 0$, let

$$\psi(t) \equiv -t m (x+1) (1 + e^{-t(x+1)m}) + 2(1 - e^{-t(x+1)m}).$$

Then for any $t > 0$, $\psi(t) < 0$.

Proof.

Since $\psi(0)=0$,

$$\begin{aligned} d\psi(t)/dt &= -m(x+1)(1 + e^{-t(x+1)m}) + t m^2(x+1)^2 e^{-t(x+1)m} + 2m(x+1) e^{-t(x+1)m} \\ &= m(x+1)[-1 + (t m x + t m + 1) e^{-t(x+1)m}] \\ &= m(x+1) \pi(t) < 0 \text{ (by lemma 1)} \end{aligned}$$

Namely $\psi(t)$ is a negative monotonic decreasing function with respect to t . Therefore for any $t > 0$, we have $\psi(t) < 0$. **QED.**

Lemma 3.

For any positive parameters of $m, x > 0$, let

$$\xi(t) \equiv t m (x^2 e^{-t(x+1)m} - 1) + (1 - x - t m x)(1 - e^{-t(x+1)m}).$$

Then for any $t > 0$, $\xi(t) < 0$.

Proof.

Since $\xi(0)=0$,

$$d\xi(t)/dt = -m(x+1)[(1 - e^{-t(x+1)m}) + t x m (x+1) e^{-t(x+1)m}] < 0.$$

Namely $\xi(t)$ is a negative monotonic decreasing function with respect to t . Therefore for any $t>0$, we have $\xi(t)<0$. QED.

Theorem 1.

For any $t_r>0$, $u_k > 0$, and $u_c > 0$, we have:

$$\frac{dt_r}{ds} = \frac{\eta m^2}{-\mu(t_r)\theta\rho^3} [\xi(t_r)u_c + \psi(t_r)u_k] > 0.$$

Proof.

According to (19), we have:

$$\frac{dt_r}{ds} = \frac{t_r \frac{m\eta}{\theta} e^{-\rho t_r} \left(\frac{w}{\rho^2}\right) + \frac{m^2\eta}{\theta\rho^3} [u_c - u_c \frac{s\eta}{\theta} + 2u_k](1 - e^{-\rho t_r}) - t_r \frac{m^2\eta}{\theta\rho^2} (u_c + u_k)}{-\mu(t_r)}$$

To simplify the notations, define

$$x \equiv s\eta/\theta.$$

Then the parameter ρ and variable w can be rewritten as follows:

$$\begin{aligned} \rho &= m s\eta/\theta + m = m(x+1) > 0, \\ w &= m[s\eta u_c/\theta - u_k] = m(x u_c - u_k). \end{aligned}$$

Hence

$$\frac{dt_r}{ds} = \frac{\eta m^2}{-\mu(t_r)\theta\rho^3} [\xi(t_r)u_c + \psi(t_r)u_k] > 0$$

where $\psi(t)$ and $\xi(t)$ are defined in Lemmas 2 and 3, respectively. From Lemmas 2 and 3, together with $t_r>0$, we have $\psi(t_r)<0$ and $\xi(t_r)<0$. This implies that no matter if it is the capital inflow shock $u_k > 0$, or the current account surplus shock $u_c > 0$, we always have

$$\mu(t_r) > 0 \text{ and } \frac{dt_r}{ds} > 0. \text{ QED.}$$