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Profits and losses from currency intervention

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ABSTRACT

This paper investigates the possible gains from currency intervention by central banks using a two-period framework in which a trade surplus in one period must be offset by a trade deficit in the next period. It is shown that when the interest rate is zero, the optimal policy is nonintervention. If the interest rate is positive, a country may earn positive profits by incurring a trade surplus in the first period. However, there is an upper bound for optimal trade surplus. A country actually may lose money if the rate of devaluation below the equilibrium is greater than the interest rate. The limiting surplus share model suggests that China may have been losing money from excessive devaluation of renminbi since 2002.

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1. Introduction

Due to mounting currency reserves since the 1990s, China's currency policy has been under intense scrutiny. The People's Bank of China (PBC) closed the currency swap market,¹ and began to regulate renminbi on January 1, 1994 by moving the official rate to the then prevailing swap market rates (Goldstein & Lardy, 2009, page 6). According to the State Administration of Foreign Exchange of PBC, China's foreign exchange reserve, which excludes gold, was \$22 billion in 1993. China's foreign exchange reserve has since increased steadily, reaching \$166 billion in 2000. However, during the first decade of this century, China's foreign exchange reserve rose dramatically to \$3.3 trillion as of December 2011.² Such a meteoric rise in China's cumulative trade surplus has provoked much debate concerning China's currency valuation and misalignment. The common view is that "China has intentionally depressed the value of its currency, the renminbi (RMB), to gain unfair advantages in the global market." (Cheung, in press).

Most major currencies are free floating vis-à-vis other currencies, except renminbi.³ There might possibly be some gains or losses from currency intervention in the foreign exchange market. For example, Gylfason and Schmid (1983) show that devaluation has positive output effects in a study of ten countries. Thus, a Keynesian open economy may devalue its currency during a recession in order to stimulate its economy. Currency devaluation raises a country's trade surplus temporarily. However, any foreign currency reserve so accumulated must eventually be used up, and sold at different exchange rates.

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¹ Goldstein and Lardy (2009, pp. 5–6) noted that before 1994, the swap market was sanctioned by the Chinese government to settle trade transactions. It helped the Chinese government find the equilibrium exchange rate.

² Of this amount, current account surplus was \$2.2 trillion and the remaining \$1.13 trillion was capital and financial flow.

³ Prior to the Asian financial crisis of 1997, most Asian exchange rates were de facto pegged to the U.S. dollar. See Patnaik, Shah, Sethy, and Balasubramaniam (2011).

Ghosh (1997) argued that a sharp trader can make profits in currency trading by utilizing the forward contracts on foreign currency. In his model a speculator invests in a foreign currency for a given period and sells the anticipated sum in the forward market.

Ghosh and Arize (2003) use the present value concept to compute profits of speculators who do not necessarily liquidate the existing balances. The speculator borrows money at the domestic interest rate and sells the anticipated proceeds in the forward currency market.

Gains from currency intervention by the central bank have not received any attention in the literature.⁴ There are two main differences between speculation by private investors and the PBC, China's central bank. First, unlike private speculators, PBC simply prints yuan to buy foreign currencies, and hence does not pay interest. Second, no forward currency market for yuan exists due to its regulated status.⁵ PBC keeps track of the fund to purchase foreign currencies.

The purpose of this paper is to investigate gains from currency intervention by a central bank. We utilize the profit concept from currency intervention (Ghosh, 1997). Since no forward renminbi market exists when it is regulated, we use the concept of anticipated profits from currency intervention in a two-period model. The primary intent of currency intervention may be to stimulate outputs and exports. Nevertheless, PBC may earn profits or incur losses from such intervention attempts. Thus, any benefits from expanded exports should be weighed against the possible losses from currency intervention.

Section 2 considers the effects of yuan appreciation on China's trade surplus. Section 3 examines optimal trade surplus and the associated exchange rate in a two-period framework. Section 4 illustrates the main proposition for a linear model of exchange rate. Section 5 investigates a realistic upper bound for currency depreciation and the associated trade surplus share of GDP. Section 6 contains concluding remarks.

2. Effects of yuan appreciation on China's trade surplus

Assume that China is an open Keynesian economy and trades only with the United States. Due to price rigidity some unemployment exists in its domestic market, and changes in the exchange rate affect its gross domestic product (GDP). Let $X(\varepsilon/P, Y^*)$ be China's exports in dollars and $q(\varepsilon/P^*, Y)$ be its imports in yuan, where ε is the dollar price of yuan. Let P be the yuan price and P^* the dollar price per unit of output, and Y^* be GDP of the United States. Assume that no financial flow occurs in the private sector between the two countries.⁶ China's GDP, expressed in yuan, is given by:

$$Y = C + I + G + (X/\varepsilon - q),$$

where C , I , and G are China's domestic consumption, investment, and government spending, all expressed in yuan. Since prices are fixed in the Keynesian economy, we may normalize Chinese price so that $P = P^*$. However, China is free to choose its dollar peg ε .

China's net export S_i measured in dollars is defined as

$$S_i \equiv X(\varepsilon_i, Y_i^*) - \varepsilon_i q(\varepsilon_i, Y_i). \quad (1)$$

Since China is an open Keynesian economy, its GDP depends on its trade surplus in renminbi, $Y = y(S/\varepsilon)$. China's trade surplus in dollars $S(\varepsilon)$ is defined by:

$$S \equiv X(\varepsilon, Y^*) - \varepsilon q(\varepsilon, y(S/\varepsilon)). \quad (2)$$

At the equilibrium exchange rate, ε^0 , for balanced trade, $S(\varepsilon^0) = X(\varepsilon^0, Y^*) - \varepsilon^0 q(\varepsilon^0, y(S/\varepsilon^0)) = 0$.

We adopt a two-period framework to investigate the gains from currency intervention. While a country may have a trade surplus in one period, it must be used up subsequently because trade must be balanced in the long run.

The exchange rate may also be expressed as a function of trade surplus,

$$\varepsilon_i = g(S_i, Y_i^*). \quad (3)$$

The U.S. economy is assumed to be stationary, i.e., $Y_i^* = Y^*$. Since Y^* is fixed, we may write the exchange rate as:

$$\varepsilon_i = f(S_i), \quad (4)$$

where trade surplus or deficit is expressed in dollars.

⁴ Hsiao, Pan, and Wu (2012) observe that the renminbi–euro rate is not an appropriate intervention object for China.

⁵ Because of recent internationalization attempts, China is allowing the offshore market for the RMB denominated assets.

⁶ The financial flow was relatively insignificant until 2009, and accounts for roughly one third of China's foreign exchange reserve as of 2011.

2.1. Effect of yuan appreciation on trade surplus

We now explore the effect of a yuan devaluation from the equilibrium rate on trade balance. Note that a change in the exchange rate affects China's trade surplus, which in turn affects its GDP, $Y = y(S(\varepsilon)/\varepsilon)$. Since income depends on the exchange rate, China's imports may be written as: $Q(\varepsilon) \equiv q(\varepsilon, y(S(\varepsilon)/\varepsilon))$. Thus, Eq. (2) now reduces to

$$S = X(\varepsilon, Y^*) - \varepsilon Q(\varepsilon). \quad (5)$$

Differentiating Eq. (5) with respect to ε and suppressing i gives:

$$S_\varepsilon = X_\varepsilon - \varepsilon Q_\varepsilon - Q, \quad (6)$$

where subscripts denote partial derivatives. Let $\eta_{X\varepsilon} \equiv (\partial X / \partial \varepsilon)(\varepsilon/X)$ and $\eta_{Q\varepsilon} \equiv -(\partial Q / \partial \varepsilon)(\varepsilon/Q)$ denote the elasticity of exports and imports with respect to the exchange rate ε , respectively. Eq. (6) can be rewritten as:

$$S_\varepsilon = \eta_{X\varepsilon}(X/\varepsilon) + \varepsilon \eta_{Q\varepsilon}(Q/\varepsilon) - Q. \quad (7)$$

As yuan appreciates, China's trade surplus is assumed to decrease, i.e., $S_\varepsilon < 0$. When trade is balanced, $X = \varepsilon Q$, and

$$S_\varepsilon \frac{\varepsilon}{X} = \eta_{X\varepsilon} + \eta_{Q\varepsilon} - 1.$$

Thus, China's trade surplus in dollars decreases as yuan appreciates if, and only if

$$\eta_{X\varepsilon} + \eta_{Q\varepsilon} < 1. \quad (8)$$

This is another way of expressing the Marshall–Lerner condition, under which the U.S. trade surplus in dollars increases as dollar price of yuan rises. We assume that the Marshall–Lerner condition holds. This implies $S_\varepsilon < 0$ and $f'(S) < 0$.

Fig. 1 illustrates that exchange rate ε is decreasing in S .

3. Optimal trade surplus

Consider the base scenario in which China refrains from currency intervention and trade is balanced at the equilibrium exchange rate ε^0 in both periods. Without loss of generality, assume further that the equilibrium exchange rate is unity, $\varepsilon^0 = f(0) = 1$. We now explore whether China can profit from currency intervention. For this purpose we relax the condition that trade must be balanced each period, but we allow a trade surplus in the first period. However, trade must be balanced over two periods. Thus, when China incurs a trade surplus in one period, it must have a trade deficit in the next period so that its trade is balanced over the two periods.

Assume that China pegs yuan below the equilibrium rate in the first period, and it incurs a trade surplus $S_1 = S > 0$. PBC buys dollar reserve with its renminbi, and hence does not incur any interest expense.⁷ The yuan cost of obtaining net export of S dollars is: S/ε_1 . However, the value of China's investment in dollar assets increases to $S(1+r)$ dollars, where r is the interest rate on U.S. assets, e.g., Treasury bills.

In the second period, China sells its foreign exchange reserve, $S(1+r)$. When this amount is sold in the second period, yuan revenue is $S_1(1+r)/\varepsilon_2$, where $\varepsilon_2 = f(-S(1+r))$ is the exchange rate in the second period. Recall that yuan devaluation below the equilibrium rate in period 1, equal to unity, necessarily causes an appreciation of yuan above unity.

We now explore whether China's currency intervention is motivated by profits. The total profit in yuan realized in the second period from currency intervention is:

$$\pi(S) = \frac{S(1+r)}{\varepsilon_2} - \frac{S}{\varepsilon_1} = S \left(\frac{1+r}{f(-S(1+r))} - \frac{1}{f(S)} \right) \quad (9)$$

Consider the special case where the interest rate is zero. In this case, profit in Eq. (9) reduces to

$$\pi(S) = S \left(\frac{1}{f(-S)} - \frac{1}{f(S)} \right). \quad (10)$$

If $S = 0$, then $\pi(S) = 0$. This means that nonintervention in the foreign exchange market yields zero profit.

⁷ This constitutes an increase in money supply to affect the yuan–dollar exchange rate. PBC issues a certain amount of new money each year. Some of it is used to buy foreign exchange from commercial banks, and is called the “Funds outstanding for foreign exchange” by PBC.

If China chooses to have a trade surplus in the first period, then $\varepsilon < 1$ and $S > 0$. Since $\varepsilon = f(S)$ is a decreasing function of S and S is positive in the first period, we have $f(-S) > f(0) > f(S)$, or $\varepsilon_2 > 1 > \varepsilon_1$, and

$$\frac{1}{f(-S)} - \frac{1}{f(S)} < 0, \text{ if } S > 0.$$

Thus, $\pi(S) < 0$ for all $S > 0$. Alternatively, if $S < 0$, then $f(S) > f(-S) > 0$, or $\varepsilon_1 > 1 > \varepsilon_2$, and

$$\frac{1}{f(-S)} - \frac{1}{f(S)} > 0, \text{ if } S < 0.$$

Thus, $\pi(S) < 0$ for all $S < 0$. Therefore, zero trade surplus is the *global* optimal solution to the profit maximization problem in Eq. (10). This result is summarized below:

Proposition 1. *If $r = 0$, then the optimal trade surplus is zero. That is, neither a trade surplus nor a deficit in the first period is optimal.*

Next, consider the general case where the interest rate is positive. Note that since the exchange rate cannot be zero, as depicted in Fig. 1, $\varepsilon = f(S)$ approaches the horizontal axis asymptotically as S increases. Differentiating Eq. (9) with respect to S gives

$$\pi'(S) = \frac{1+r}{f(-S(1+r))} - \frac{1}{f(S)} + S \left(\frac{(1+r)^2 f'(-S(1+r))}{f^2(-S(1+r))} + \frac{f'(S)}{f^2(S)} \right). \quad (11)$$

Evaluating Eq. (11) at $S = 0$, we get

$$\pi'(0) = \frac{1+r}{f(0)} - \frac{1}{f(0)} = \frac{r}{f(0)} = r > 0. \quad (12)$$

This implies that profit is increasing in S when evaluated at $S = 0$. Thus, the optimal profit must be positive, $\pi(S^{opt}) > \pi(0) = 0$. However, when $S < 0$, note that $\varepsilon_2 < \varepsilon_1$ and

$$\pi(S) = S \left(\frac{1+r}{\varepsilon_2} - \frac{1}{\varepsilon_1} \right) = S \left(\frac{(1+r)\varepsilon_1 - \varepsilon_2}{\varepsilon_1 \varepsilon_2} \right) < S \left(\frac{(1+r)\varepsilon_1 - \varepsilon_1}{\varepsilon_1 \varepsilon_2} \right) < 0,$$

Thus, $\pi(S) < 0$ for all $S < 0$. Therefore, the globally optimal policy must be a trade surplus.

Proposition 2. *If $r > 0$, then an optimal policy is a trade surplus $S > 0$ and the optimal exchange rate ε_1 in the first period is below unity, i.e., $\varepsilon_1 < 1$.*

4. The limiting surplus share model

We now consider a model that imposes limits to the trade surplus share. The reduced form exchange rate equation in Eq. (3) indicates that China's trade depends on the exchange rate and U.S. GDP. Let a be the upper physical limit of China's trade surplus share of U.S. GDP. For instance, if $a = .1$, then China's trade surplus can never exceed 10% of U.S. GDP.

Fig. 1. Exchange rate and trade surplus.

Fig. 2. Profit and trade surplus.

The yuan–dollar exchange rate function $\varepsilon=f(S)$ takes a specific form:

$$\varepsilon_i = 1 - \frac{S_i}{a}, \quad (13)$$

where $s_i = S_i/Y^*$ is China's trade surplus share of U.S. GDP. Profit from currency intervention is

$$\pi = \frac{S(1+r)}{\varepsilon_2} - \frac{S}{\varepsilon_1} = saY^* \left(\frac{ar - 2s(1+r)}{(a+s+sr)(a-s)} \right). \quad (14)$$

Recall that $s < a$. If $r = 0$, then

$$\pi = saY^* \left(\frac{-2s}{(a+s)(a-s)} \right) = \frac{-2s^2 a Y^*}{a^2 - s^2} \leq 0 \quad (15)$$

which is nonpositive. Thus, if $r = 0$, nonintervention is optimal as indicated by Proposition 1.

Next, assume $r > 0$. If $s = 0$, then $\pi = 0$, and if $0 < s < \frac{ar}{2(1+r)}$, then $\pi(s) > 0$. Thus, a small trade surplus can yield positive profit, as indicated by Proposition 2.

In Fig. 2, profit on the vertical axis is expressed as a function of S on the horizontal axis. To determine an appropriate value of a in Eq. (13), we choose the year with trade balance. In 1995, China's trade surplus was the lowest (\$1.6 billion) and hence China should be deemed to have achieved trade balance. Also, China's GDP was 9.9% of U.S. GDP that year. Hence, we set $a = .1$ in our simulation.

Given $Y^* = \$10$ trillion and $r = 0.05$, optimal trade surplus is approximately \$10 billion, i.e., $s = 0.001$, and the intervention profit is about .29 billion yuan, which amounts to about \$.29 billion when evaluated at the equilibrium exchange rate.

5. Practical limits to devaluation

How high is the optimal trade surplus? Recall that the market clearing yuan–dollar exchange rate in each period is assumed to be unity, i.e., $\varepsilon^o = 1$. From Proposition 2, we know optimal trade surplus S in the first period is positive. Recall that $\pi(S) = 0$ at $S = 0$, and profit is increasing in S at $S = 0$ ($\pi'(0) > 0$). Thus, an optimal trade surplus S_1 and profit $\pi(S_1)$ in the first period are both positive. From the profit function in Eq. (9), profit for the optimal level of trade surplus S is positive, i.e.,

$$\pi(S_1) = S_1 \left(\frac{1+r}{f(-S_1(1+r))} - \frac{1}{f(S_1)} \right) > \pi(0) = 0. \quad (16)$$

Let $A(S) \equiv \frac{1+r}{f(-S_1(1+r))} - \frac{1}{f(S_1)}$ denote per unit or average profit of holding a trade surplus in the first period. Since $S_1 > 0$, this implies unit profit is positive, i.e.,

$$A(S) = \frac{(1+r)f(S_1) - f(-S_1(1+r))}{f(-S_1(1+r))f(S_1)} > 0. \quad (17)$$

Thus,

$$(1+r)f(S_1) > f(-S_1(1+r)) > f(0), \quad (18)$$

Fig. 3. China's trade surplus share of U.S. GDP and interest rate. Source: World Development Indicators online database, World Bank, and Board of Governors of the Federal Reserve System.

since $f(S)$ is a decreasing function of S . Thus, $(1+r)f(S_1) > f(0)$. Since $\varepsilon^0 = f(0) = 1$ by assumption, we get

$$\varepsilon_1 > \frac{1}{1+r}. \quad (19)$$

That is, the optimal exchange rate in the first period is less than unity by Proposition 2, but Eq. (19) implies that there is a lower bound for the optimal exchange rate.⁸

Proposition 3. If $r > 0$, then the optimal exchange rate has a lower bound, $\varepsilon_1^{opt} > \frac{1}{1+r}$, which is independent of trade surplus.

Note that $\frac{1}{1+r} = \frac{1-r}{1-r^2} > 1-r$. Let ε represent δ percent depreciation from the equilibrium exchange rate, $\varepsilon = 1$, i.e., $\varepsilon = 1 - \delta$. Then $1 - \delta > \frac{1}{1+r}$, or

$$r > \frac{r}{1+r} > \delta. \quad (20)$$

Thus, the optimal exchange rate must be greater than $(1-r)$. Note that if the devaluation rate below the equilibrium was equal to the interest rate, profit is already negative, i.e., if $r = \delta$, $\pi(S_1) < 0$. Thus, for example, if the interest rate is 5%, the optimal depreciation rate is below 5%, and $\varepsilon_1^{opt} > 0.95$. That is, the exchange rate should be devalued no more than 5% from the equilibrium value.

We now consider a practical upper bound for trade surplus. In the limiting surplus share model, from Eq. (18), we get $(1+r)\varepsilon_1 > 1$. Since $\varepsilon_1 > \frac{1}{1+r}$ and $r > \frac{r}{1+r}$, we have

$$\varepsilon_1 > 1-r. \quad (21)$$

In the limiting surplus share model, from Eq. (13) we get $s_1/a = 1 - \varepsilon_1$. Thus, Eq. (21) reduces to $r + 1 - s_1/a > 1$, or

$$s_1 < ar. \quad (22)$$

This means that when a conservative limit $a = .1$ is chosen, China's surplus share of U.S. GDP must be below one-tenth of the interest rate on U.S. Treasury bills.

Fig. 3 shows that China's trade surplus share of U.S. GDP has been below one-tenth of the interest rate on U.S. Treasury bills until 2002, but has since diverged greatly. In 2008, an upper limit of China's trade surplus share of U.S. GDP should have been about 0.16%, but China's actual trade surplus share rose to 2.88%, and the actual trade surplus amounted to \$412 billion dollars in 2008, and U.S. GDP was \$14.30 trillion. These mounting trade surpluses clearly are outside the profitable range, suggesting that China's currency policy is not motivated by profit considerations.

⁸ Note that in Fig. 1, the exchange rate is a decreasing function of S , and an optimal trade surplus is positive, so we have $f(0) > f(S_1)$. Thus, $(1+r)f(0) > (1+r)f(S_1) > f(1 - S_1(1+r))$. Thus, Eq. (18) implies $(1+r) > \varepsilon_2^0 > 1$, where ε_2^0 is the exchange rate in the second period resulting from the optimal exchange rate in the first period.

Since China's economy has been steadily growing, a more liberal limit of $a = 40\%$, which was the ratio of $\varepsilon Y/Y^*$ in 2010, might be chosen. Again, the gigantic divergence of China's trade surplus share and 40% of interest rate on US treasury bills after 2006 indicates that China's currency intervention policy was undertaken despite the mounting losses.

6. Concluding remarks

We have explored the gains from currency intervention for an open Keynesian economy. In a two-period framework, if a country incurs a trade surplus, it is invested in the US treasury bills earning some interest income. Such foreign assets eventually must be used up in the subsequent period at a different exchange rate. Thus, there exists the possibility for China either to make profits or incur losses.

We have shown that if the interest rate is zero, the optimal trade surplus is zero. If the interest rate is positive, then a small country can make profits from devaluing its currency below the equilibrium rate in the first period. In this case, the associated optimal trade surplus is positive. However, there is a lower bound for the optimal exchange rate, and hence an upper bound for a trade surplus. If the interest rate is 5%, then the optimal exchange rate requires a devaluation of not more than 5% from the equilibrium exchange rate for balanced trade.

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