China's Profits and Losses from Currency Intervention, 1994-2011

Hailong Jin and E. Kwan Choi
Iowa State University

1. Introduction

- Due to China's mounting currency reserves since the 1990s, its currency policy has been under intense scrutiny.
- 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, 2012; McKinnon and Schnabl, 2004)
- Most major currencies are free-floating vis-à-vis other currencies, except the renminbi.
- Gylfason and Schmid (1983) showed that devaluation has positive output effects in a study of ten countries.

- Any foreign currency reserve must be used up eventually, and sold at different exchange rates.
- Hence, the central bank may incur losses from such intervention.
- There are two main differences between speculation by private investors and the PBC, China's central bank.
  (i) unlike private speculators, PBC simply prints yuan notes to buy foreign currencies, and hence does not pay interest.
  (ii) no forward currency market for yuan exists due to its regulated status.

- The purpose of this paper is to investigate China's profits and losses from currency intervention since 1994 when China began to merge the exchange rates in the swap market and official exchange rates.
- McKinnon and Schnabl (2009) note that renminbi was inconvertible before 1994. Also, China's trade surplus was negligible in 1994.
- utilize the accounting profit concept from currency intervention in a multi-period framework (Ghosh, 1997).
- while profits from currency intervention were positive in the 1990s, China has lost a phenomenal sum since 2007.

Recent Trend

- China's trade surplus was $595 billion in 2015.
- China's capital outflow was $750 billion in 2015, which reduced China's reserve by $375 billion.
- China seems to have decided to increases its FDI in other countries, thereby reducing its FX reserve.
- We show that China's losses are even greater with financial outflow.
- Capital outflow is a temporary means of avoiding reserve accumulations, and hence requires buying the dollar at high prices.
- When foreign assets are liquidated and the yuan proceeds are returned to China, yuan is bought at high prices.
- In 1985, Japanese yen appreciated 100%, $\Rightarrow$ the yen revenue from the sale of Japanese assets in the US was roughly 50% of their original investment.

2. How not to use trade surplus ($500 billion) each year

- Two ways to spend trade surplus: (a) spend on imports, or (b) invest in the US.
- Dollar balances are usable only in the US.
- Cannot be used to buy China's domestic consumption goods.

For option (a),

- Decide when to spend the $.

- A. Never. Keep accumulating trade surpluses forever $\Rightarrow$
  This means in effect the trade surplus is being robbed by foreign countries, or dollar bills being burned each year.

- B. Use them a decade later.
  It may help the US economy a little if in a recession. If the US economy is at the full employment level, additional demand for American goods by Chinese firms or government cannot stimulate more output. Only inflation follows. (Hence, the real value of the trade surplus plummets.)

- C. Use it now. $\Rightarrow$ Trade will be balanced.
- Invest. $\Rightarrow$ Capital outflow temporarily delays yuan appreciation and complicates the process, but raises China's losses further.
- Principal + dividends are repatriated later, but the yuan appreciated. If dividends = 0, a sure loss ensues.

3. Effects of Yuan Appreciation on China's Trade Surplus

- 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 ε denote the dollar price of yuan.
- $x(P, \varepsilon, Y^*)$ = China's export in dollars, where P = yuan price,
- Y^* = GDP of the United States.
- China's GDP, expressed in yuan:

$$Y = C + I + G + \left(x/\varepsilon - q\right),$$

$q(P, \varepsilon, Y)$ = China's import,

China is free to choose its dollar peg ε.

- China's trade surplus S_i is measured in dollars

$$S_i \equiv x(P_i, \varepsilon_i, Y_i^*) - \varepsilon_i q(P_i, \varepsilon_i, Y_i), \qquad (1)$$

$\varepsilon_i = P_i^* / P_i$ = dollar price of yuan

P^* = dollar price per unit of output

Y_i = China's GDP measured in yuan

Y_i^* = U.S. GDP measured in dollars in period i,

- a yuan devaluation immediately affects domestic price, $P_i = P_i^* / \varepsilon_i$.
- yuan depreciation does not affect U.S. GDP, $Y_i^* = Y^*$.

$$S_i \equiv x(P_i^* / \varepsilon_i, \varepsilon_i, Y_i^*) - \varepsilon_i q(P_i^* / \varepsilon_i, \varepsilon_i, Y_i) = X(P_i^*, \varepsilon_i, Y^*) - \varepsilon_i Q(P_i^*, \varepsilon_i, Y_i).$$

- $F(r)$ be capital or financial *outflow* in dollars, including direct investment, portfolio investment and short-term capital flow, excluding reserve account activities.

  - A balance of payments surplus is written as

$$S_i = X(\varepsilon_i, Y^*) - \varepsilon_i Q(\varepsilon_i, Y_i) - F_i(r). \quad (2)$$

  - two-period Model
  - While a country may have a trade surplus in one period, it subsequently must be used up.

- exchange rate also may be expressed as a function of balance of payments surplus,

$$\varepsilon_i = g(S_i + F_i, Y^*). \quad (3)$$

Since *Y** is assumed as fixed:

$$\varepsilon_i = f(S_i + F_i), \qquad (4)$$

Differentiating (2) with respect to ε and suppressing *i* gives:

$$S_\varepsilon = X_\varepsilon - \varepsilon Q_\varepsilon - Q, \qquad (5)$$

- Given that the Marshall-Lerner condition holds, the trade surplus function is negatively sloped ($S_\varepsilon < 0$).

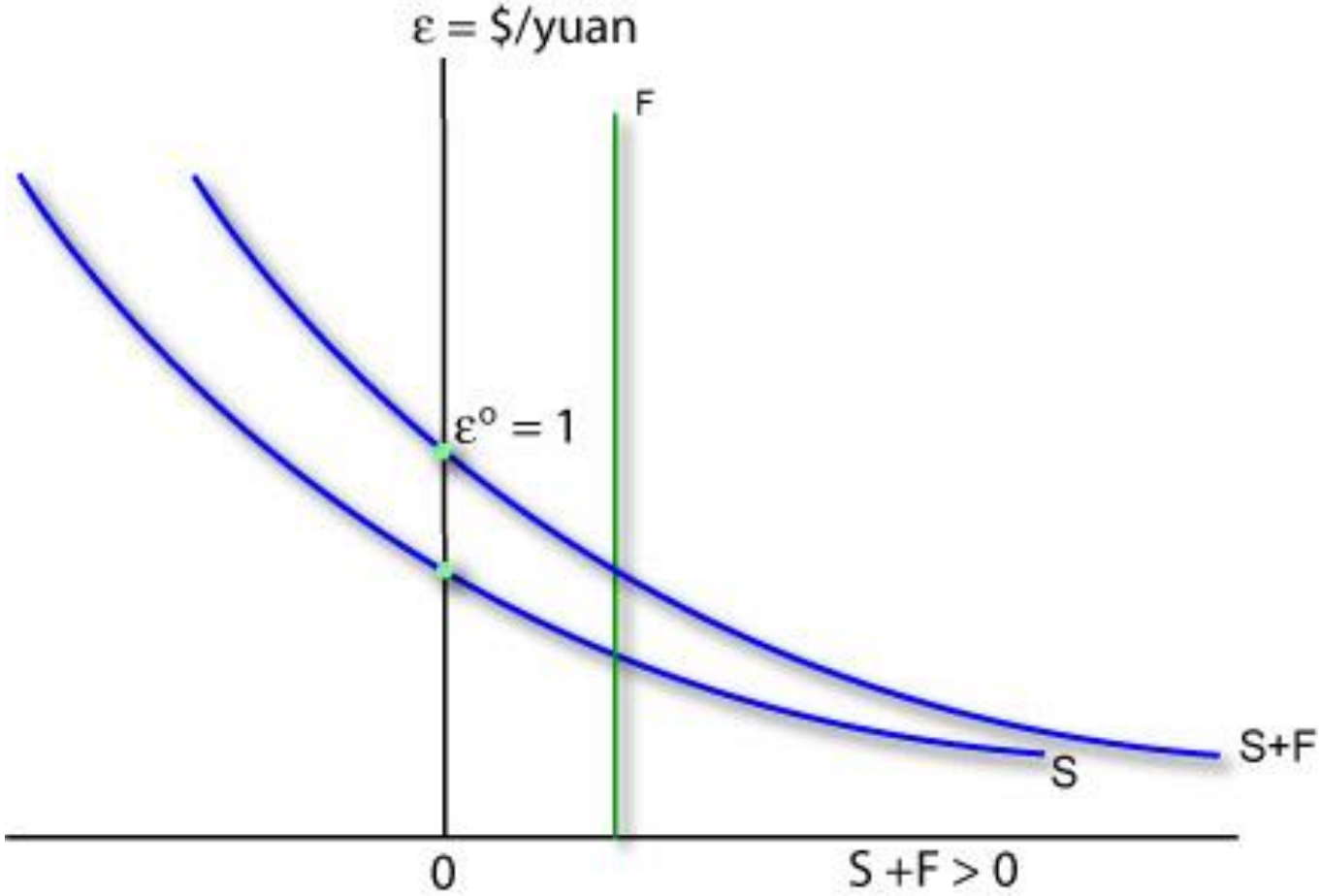

Figure 1: Exchange Rate and Balance of Payments Surplus

4. Annual Profits from Currency Intervention

- China may choose to devalue yuan below the equilibrium and invest the resulting trade surplus in the United States.

- Proceeds from foreign investment eventually will be used up in subsequent periods.

- two period model.

China is assumed to incur a trade surplus in the first period, which is invested in dollar assets in the United States, and the proceeds are used in the second period.

- $S_1 = S$ is China's trade surplus in the first period.
- yuan cost = S / ε_1,
- S_1 dollars are invested in US Treasury bills, and grows to $S_1(1+r)$ at the end of the second period

- We assume $r = r^*.$
- China's net foreign investment in dollars is $F \equiv K - K^*.$

- revenue in renminbi is $(S+F)(1+r)/\varepsilon_2$

- profit realized from currency intervention is:

$$\pi(S+F) = \frac{(S+F)(1+r)}{\varepsilon_2} - \frac{S+F}{\varepsilon_1}$$

$$= (S+F)\left(\frac{1+r}{f\left(-(S+F)(1+r)\right)} - \frac{1}{f\left(S+F\right)} \right). \qquad (6)$$

- Multiperiod Model

Annual Accounting Profits (measured in yuan)

- C_i = cumulative foreign currency invested in the U.S. Treasury bills in period i.
- stock of foreign currency reserve at the beginning of period 1 is zero ($C_0 = 0$), and hence $C_1 = S_1$.

- accounting profit in the first period, which is to be known in the second period

$$\pi_1(C_1, r_1, \varepsilon_1, \varepsilon_2) = \frac{(S+F)(1+r_1)}{\varepsilon_2} - \frac{S+F}{\varepsilon_1} = \frac{C_1(1+r)}{\varepsilon_2} - \frac{C_1}{\varepsilon_1}. \quad (7)$$

- The market value of the current reserve at the end of period 2 is

$$\frac{C_2(1+r_2)}{\varepsilon_3}.$$

When calculating profits, the exchange rates are assumed to be given, even though China's action affects them.

- accounting profit in the second period is:

$$\pi_2(C_2, r_2, \varepsilon_2, \varepsilon_3) = \frac{C_2(1+r_2)}{\varepsilon_3} - \frac{C_2}{\varepsilon_2}. \quad (8)$$

- annual profit in period *N* is

$$\pi_N\left(C_N, r_N, \varepsilon_N, \varepsilon_{N+1}\right) = \frac{\left(C_{N-1}(1+r_{N-1}) + S_N + F_N\right)(1+r_N)}{\varepsilon_{N+1}} - \frac{\left(C_{N-1}(1+r_{N-1}) + S_N + F_N\right)}{\varepsilon_N}$$

$$= C_N\left(\frac{1+r_N}{\varepsilon_{N+1}} - \frac{1}{\varepsilon_N}\right) = C_N\left(\frac{(1+r_N)\varepsilon_N - \varepsilon_{N+1}}{\varepsilon_N \varepsilon_{N+1}}\right). \qquad (9)$$

Properties of Annual Accounting Profits

$$\frac{\partial \pi_N}{\partial r_N} = C_N\left(\frac{1}{\varepsilon_{N+1}} + \frac{1}{\varepsilon_N^2}\frac{\partial \varepsilon_N}{\partial r_N}\right)\frac{C_N}{\varepsilon_{N+1}} + F_N^{'}\left(\frac{1+r_N}{\varepsilon_{N+1}} - \frac{1}{\varepsilon_N}\right). \qquad (10)$$

The first term is positive. The sign of the second term on the RHS is indeterminate. However, if ε_i is a random variable, independently and identically distributed, then $E\varepsilon_{N+1} = \varepsilon_N$ and hence $\left(\frac{1+r_N}{E\varepsilon_{N+1}} - \frac{1}{\varepsilon_N}\right) > 0.$ Since $F_N^{'} > 0,$ the second term on the RHS is positive on average.

- an increase in the foreign interest rate increases China's annual profits from currency intervention. (US has lowered the interest rate)

$$\frac{\partial \pi_N}{\partial \varepsilon_N} = \frac{C_N}{(\varepsilon_N)^2} > 0, \qquad (11)$$

$$\frac{\partial \pi_N}{\partial \varepsilon_{N+1}} = -\frac{C_N(1+r_N)}{(\varepsilon_{N+1})^2} < 0. \qquad (12)$$

Thus, as yuan appreciates, other things equal, annual profit increases. On the other hand, as the future value of yuan rises, current profit declines, because a given amount of dollar assets fetches a smaller sum in yuan.

- The elasticity of annual profit with respect to the future exchange rate is:

$$\eta_{\pi\varepsilon_{N+1}} \equiv \frac{\varepsilon_{N+1}}{\pi_N}\frac{\partial \pi_N}{\partial \varepsilon_{N+1}} = -\frac{\varepsilon_{N+1}}{\pi_N}\frac{C_N(1+r_N)}{(\varepsilon_{N+1})^2}$$

$$= -\frac{\varepsilon_{N+1}}{C_N\left(\frac{(1+r_N)\varepsilon_N - \varepsilon_{N+1}}{\varepsilon_N \varepsilon_{N+1}}\right)}\frac{C_N(1+r_N)}{(\varepsilon_{N+1})^2} = -\frac{\varepsilon_N(1+r_N)}{(1+r_N)\varepsilon_N - \varepsilon_{N+1}}. \quad (13)$$

- Suppose the interest rate were .1 percent (as in 2011) and yuan were undervalued by 10 percent. Then a 1 percent yuan appreciation (from ε =.9 to .91) reduces profits by

$$\eta = -\frac{.9 \times 1.001}{1.001 \times .9 - .91} = 99.$$

- Suppose the interest rate is 5 percent and yuan was undervalued by 25 percent. In this situation, a 1 percent yuan appreciation (from ε = .9 to .91) reduces profit by 27 percent.
  - These examples suggest that profits from currency intervention are very sensitive to exchange rate appreciation, especially when the interest rate is near zero.

Data

- China’s foreign exchange reserve data were obtained from the State Administration of Foreign Exchange and are shown in Table 1.
- Six-month interest rates on U.S. Treasury bills were used as the annual interest rates.

Annual Accounting Profits without Financial Flow

- the current account deficit was about $12 billion in 1993.
- Few economists argue that China’s intervention started before 1993.

- profits and losses from subsequent attempts to moderate exchange rate changes can be computed from 1994.
- Table 1 shows annual profits in yuan from currency intervention, which rose to 81 billion yuan in 2000, equal to approximately 1/10 of 1 percent of U.S. GDP, but fell to zero in 2006.

- Since 2006, China began to incur huge losses, which rose to 546 billion yuan in 2007, 824 billion yuan ($122 billion) in 2010, and 537 billion yuan ($83 billion) in 2011. This amount should be compared to the actual current account surplus of $305 billion in 2010.

Table 1. China's Annual Profits from Currency Intervention, 1994-2011

	Exchange Rate	U.S. TB interest	China FX	Annual Profit	
	($/RMB)	%	$Billion	Billion Yuan	$ Billion
1994	0.1160	4.64	52.9	6.0	0.7
1995	0.1198	5.56	75.4	32.2	3.9
1996	0.1203	5.08	107.0	42.9	5.2
1997	0.1206	5.18	142.8	59.3	7.1
1998	0.1208	4.83	149.2	59.7	7.2
1999	0.1208	4.75	146.2	57.5	6.9
2000	0.1208	5.90	165.6	80.9	9.8
2001	0.1208	3.34	212.2	58.7	7.1
2002	0.1208	1.68	286.4	39.8	4.8
2003	0.1208	1.05	403.3	35.1	4.2
2004	0.1208	1.58	609.9	29.3	3.5
2005	0.1220	3.39	818.9	39.4	4.8
2006	0.1254	4.81	1066.3	2.1	0.3

2007	0.1314	4.44	1528.2	-546.4	-71.8
2008	0.1440	1.62	1946.0	-6.2	-0.9
2009	0.1464	0.28	2399.2	-98.8	-14.5
2010	0.1477	0.20	2847.3	-823.5	-121.6
2011	0.1546	0.10	3181.1	-536.8	-83.0
2012	0.1589				

Annual Accounting Profits without Financial Flow

Estimated Interest Rates and FX

	US TB interest (%)	Estimated interest rate (%)	China FX ($billion)	Estimated China FX ($ billion)
1994	4.64	0.04	52.9	53.6
1995	5.56	0.30	75.4	77.8
1996	5.08	0.07	107.0	111.0
1997	5.18	-0.02	142.8	148.2
1998	4.83	-7.71	149.2	156.6
1999	4.75	6.05	146.2	164.9

2000	5.90	-0.44	165.6	163.7
2001	3.34	-0.62	212.2	222.7
2002	1.68	-0.04	286.4	294.8
2003	1.05	0.06	403.3	408.2
2004	1.58	-6.82	609.9	613.9
2005	3.39	-4.55	818.9	870.1
2006	4.81	0.11	1066.3	1131.4
2007	4.44	-4.04	1528.2	1578.3
2008	1.62	2.82	1946.0	2075.7
2009	0.28	-0.98	2399.2	2375.9
2010	0.20	-1.90	2847.3	2877.6
2011	0.10		3181.1	3240.8

- Financial flows are made to take advantage of different interest rates between countries. The presence of the financial flows indicates that there are temporary differences in the financial returns or profitability of investment between the two economies.

- Without financial flows

$$\pi_N\left(C_N, r_N, \varepsilon_N, \varepsilon_{N+1}\right) = \frac{\left(C_{N-1}(1+r_{N-1}) + S_N\right)(1+r_N)}{\varepsilon_{N+1}} - \frac{\left(C_{N-1}(1+r_{N-1}) + S_N\right)}{\varepsilon_N}$$

$$= C_N\left(\frac{1+r_N}{\varepsilon_{N+1}} - \frac{1}{\varepsilon_N}\right) = C_N\left(\frac{(1+r_N)\varepsilon_N - \varepsilon_{N+1}}{\varepsilon_N \varepsilon_{N+1}}\right). \qquad (14)$$

- Table 2 shows that the annual accounting profits without the financial flows also were near zero in 2006, and have since increased to $92.6 billion in 2010. This is somewhat less than $121.6 billion when the financial flow is included. As expected, if the interest rate differential is negligible, accounting profits should be roughly equal, whether financial flows are included or not.

Table 2. China's Annual Profits from Currency Intervention without Financial Flow,
1994-2010

	Current Account ($ Billion)	Foreign Reserve from Trade Surplus ($ Billion)	Annual Profit (Billion Yuan)	Annual Profit ($ Billion)
1994	7.7	7.7	22.9	0.1
1995	1.6	9.6	20.9	0.5
1996	7.2	17.4	24.1	0.8
1997	37.0	55.3	-1.2	2.8
1998	31.5	89.6	-25.0	4.3
1999	21.1	115.0	-12.6	5.5
2000	20.5	141.0	-10.0	8.3
2001	17.4	166.7	29.9	5.6
2002	35.4	207.7	40.1	3.5
2003	45.9	257.1	71.1	2.7

2004	68.7	328.5	137.7	1.9
2005	134.1	467.7	116.5	2.7
2006	232.7	716.3	52.0	0.2
2007	354.0	1,104.8	106.7	-51.9
2008	412.4	1,566.2	67.2	-0.7
2009	261.1	1,852.7	137.3	-11.2
2010	305.4	2,163.3	166.3	-92.4
2011	201.7	2,369.3	186.1	-61.8

5. Cumulative Profits from Currency Intervention

Cumulative Accounting Profit to be realized in period 2 is defined as:

$$\Pi_2 = \frac{C_2(1+r_2)}{\varepsilon_3} - \left(\frac{S_2}{\varepsilon_2} + \frac{S_1}{\varepsilon_1} \right). \qquad (15)$$

Market Value of Foreign Exchange Reserve

- If the country does not liquidate the existing foreign exchange reserve in period 2, its cumulative reserve balance is

$$C_2 = C_1(1+r_1) + S_2,$$

- the cumulative foreign exchange reserve at the terminal period N is:

$$\frac{C_N(1+r_N)}{\varepsilon_{N+1}}. \qquad (16)$$

Cumulative Accounting Profits

- the cumulative accounting profit in yuan is:

$$\Pi_3 = \frac{C_3(1+r_3)}{\varepsilon_4} - \left(\frac{S_3}{\varepsilon_3} + \frac{S_2}{\varepsilon_2} + \frac{S_1}{\varepsilon_1} \right). \qquad (17)$$

Likewise, the total yuan cost up to the terminal period *N* is:

$$F_N = \sum_{i=1}^{N} \frac{S_i}{\varepsilon_i}. \qquad (18)$$

- Cumulative accounting profit in period *N* is the market value of the currency reserve less cost, i.e.,

$$\Pi_N = \frac{C_N(1+r_N)}{\varepsilon_{N+1}} - \sum_{i=1}^{N} \frac{S_i}{\varepsilon_i}. \qquad (19)$$

- we have

$$\Pi_N = \frac{C_N(1+r_N)}{\varepsilon_{N+1}} - \sum_{i=1}^{N} \frac{S_i}{\varepsilon_i} = \frac{C_1(1+r_1)}{\varepsilon_2} - \frac{C_1}{\varepsilon_1} + \frac{C_2(1+r_2)}{\varepsilon_3} - \frac{C_2}{\varepsilon_2} + ... = \pi_1 + \pi_2 + ... = \sum_{i=1}^{N} \pi_i .$$

- Table 3 displays the cumulative accounting profits since 1994. It shows that in the early years of currency intervention, cumulative profits in yuan from currency intervention steadily increased, reaching 543 billion yuan in 2006.

- PBC began to lose money in 2007 when its cumulative profit was completely wiped out. It has since found it difficult to recover from the mounting losses, which reached 1,469 billion yuan (or about $227 billion) in 2011, and are expected to rise further as the yuan appreciates.

Table 3. China's Cumulative Profits from Currency Intervention, 1994-2011

	Cumulative Profit	
	Billion Yuan	$ Billion
1994	6.0	0.7
1995	38.3	4.6
1996	81.1	9.8
1997	140.4	16.9
1998	200.0	24.2
1999	257.5	31.1
2000	338.4	40.9
2001	397.1	48.0
2002	436.9	52.8
2003	472.0	57.0
2004	501.3	60.6
2005	540.7	66.0
2006	542.7	68.1
2007	-3.7	-0.5
2008	-9.9	-1.4

2009	-108.7	-15.9
2010	-932.2	-137.7
2011	-1,469.0	-227.1

• Table 4 shows the cumulative accounting profits without the financial flow. In 2010, the cumulative accounting loss rose to $115.2 billion, or close to $137.7 billion without the financial flow. Again, inclusion of the financial flow does not make much difference in the cumulative accounting profits.

Table 4. Cumulative Accounting Profits without Financial Flow

	Cumulative Profit (Billion Yuan)	**Cumulative Profit ($ Billion)**
1994	0.9	0.1
1995	5.0	0.6
1996	12.0	1.4
1997	34.9	4.2

1998	70.7	8.5
1999	116.0	14.0
2000	184.8	22.3
2001	230.9	27.9
2002	259.8	31.4
2003	282.2	34.1
2004	298.0	36.0
2005	320.5	38.7
2006	321.8	38.9
2007	-73.2	-13.0
2008	-78.2	-13.7
2009	-154.5	-24.9
2010	-780.2	-117.3
2011	-1,180.0	-179.1

6. Concluding Remarks

- Throughout the 1990s, China's profits from currency markets were negligible and China did not intentionally speculate in the currency market.

- In 1994, China merged the official and swap markets, effectively adopting the exchange rates from the swap market. Initially, the exchange rate rose to the equilibrium level.

- However, after 1994, the currency peg apparently was below the equilibrium level and China began to accumulate trade surpluses.

  - Such intervention yielded profits until 2006, but the continued appreciation of the yuan resulted in the ballooning of the cumulative losses. This result does not change whether or not the financial flow is included.

The cumulative profits of about 543 billion yuan in 2006 were wiped out completely the next year, and the mounting losses from currency intervention rose to 1,469 billion yuan (or $227 billion) in 2011. Current account surpluses since 2007 hovered around $300 billion, and are expected to be above this level, despite the continued appreciation of yuan. If this trend continues, China's losses will continue to mount.

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.