

Empirical Study on the Optimal Scale of China's Foreign Exchange Reserves

-- Based on the Modified Agarwal Model

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Abstract – This paper does an empirical study on China's optimal scale of foreign exchange reserves in 1994-2010, by using the modified Agarwal model which is in accordance with China's specific national conditions. The results show that the actual size of China's foreign exchange reserves has been significantly excessive. According to the present situation of China's foreign exchange reserves, this paper puts forward the following advices to effectively suppress the excessive growth of China's foreign exchange reserves: (1) Improve trading structures and expand domestic demands; (2) Increase imports and support foreign investments; (3) Pay attention to the quality of GDP and promote rational economic growth; (4) Strictly implement foreign company access system and change the introducing structures of foreign company; (5) Increase the flexibility of RMB exchange rate.

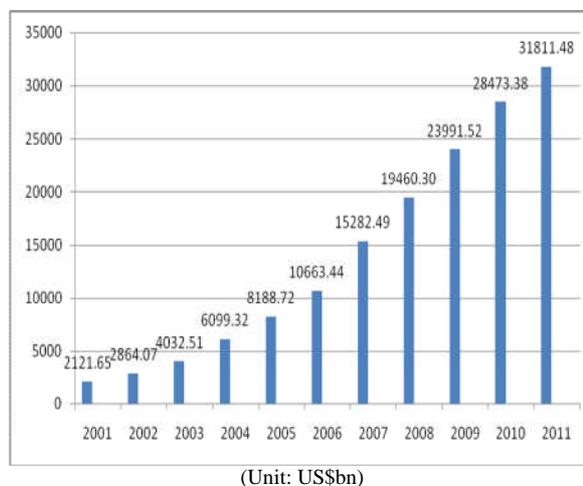
Keywords – Foreign exchange reserves; Optimal scale; Modified Agarwal model

1. Introduction

In recent years, China's foreign exchange reserves have achieved spectacular growth, attracting wide attention both at home and abroad. Since 2001, China's foreign exchange reserves have been growing rapidly. By the end of February 2006, China's official foreign exchange reserves had reached \$ 853.60 billion, which surpassed Japan's \$ 850.1 billion for the first time, becoming the world's largest holder of foreign exchange reserves. By the end of 2006, China's foreign exchange reserves had reached \$ 1.0663 trillion, becoming the first country whose national foreign exchange reserves was over one trillion U.S. dollars. China's foreign exchange reserves have been ranked first in the world for five consecutive years. It can be seen from Figure 1 that China's total foreign exchange reserves had increased from \$ 212.17 billion by the end of 2001 to \$ 3,181.15 billion by the end of the year 2011. The total amount of foreign exchange reserves has increased about 14 times just in ten years. The substantial increase of China's foreign exchange reserves has aroused a discussion of domestic scholars on its management.

This paper chooses the Agarwal model to analyze the optimal scale of china's foreign exchange reserves as it is a special model for developing countries. In particular, the demands of foreign exchange reserves were modified in the model, according to China's economic situation and the basic national conditions, taking into account China's foreign exchange reserves demands as fully as possible. By applying the modified Agarwal model, this paper worked out the optimal scale of foreign exchange reserves in China. Through the comparison between the results and the actual scale of foreign exchange reserves, it figured out whether China's foreign exchange reserves were insufficient, optimal or excessive. Moreover, on the basis of the analysis of the

calculated results and the status quo of China's economic development, it puts forward suggestions on China's foreign exchange reserves management.



(Unit: US\$bn)
Figure 1. China's foreign exchange reserves 2001-2011
Sources: State Administration of Foreign Exchange

2. The modified Agarwal model

2.1 Agarwal model and its modification

Agarwal put forward that the economic status and economic characteristics of the developing countries have decided that developing countries need more foreign exchange reserves, as their foreign exchange reserves should not only just pay for the unexpected international payment deficit under the fixed exchange rate facility during its planned period, but also keep the benefits and costs of the country's foreign exchange reserves equivalent. On the basis of Heller's model, Agarwal established a model mainly used to estimate the optimal scale of foreign exchange reserves of developing

countries. The model fully considers the characteristics of the developing countries, and its research on the relevant factors is more comprehensive and realistic. Assumptions in the model:

- (1) Due to the recurrent changes of the imports and exports, the country is prone to a foreign exchange balance of payments deficit.
- (2) If there were no necessary imports and exports, there would be a lot of idle resources in the country.
- (3) When unable to provide financing for the balance of payments deficit, the country often directly controls the imports through administrative means.
- (4) The country has a weak financing capacity in the international market. ^[1]

Agarwal developed the model for developing countries to estimate the optimal scale of foreign exchange reserves:

$$R = W(\ln k + \ln q_2 - \ln q_1) / \ln p_1 \quad (1)$$

In the Agarwal model, whether a country's foreign exchange reserves is optimal or not is determined by the changes of current account in the international balance of payments, and it treats the foreign exchange reserves as the only means to adjust the balance of payments. Therefore, the model just considers the transaction demands and regulatory demands of foreign exchange reserves, neglects other demands. According to the actual situation in China, in this paper we consider China's foreign exchange reserves demands mainly consist of seven parts: The transaction demands R1, the regulatory demands R2, the interventionist demands R3, the debt repayment demands R4, the FDI profit export demands R5, the personal demands R6 and the supplementary demands R7. According to the above sources of foreign exchange reserves demands, the optimal scale of China's foreign exchange reserves can be defined as:

$$R^* = R1 + R2 + R3 + R4 + R5 + R6 + R7 \quad (2)$$

The transaction demands R1 and the regulatory demands R2 can be determined by the traditional Agarwal model:

$$R1 + R2 = W(\ln k + \ln q_2 - \ln q_1) / \ln p_1 \quad (3)$$

The interventionist demands:

$$R3 = M(\ln r + \ln q_2) / \ln P_2 \quad (4)$$

The debt repayment demands:

$$R4 = D \cdot r_D (\ln r + \ln q_2) / \ln P_3 \quad (5)$$

The FDI profits export demands:

$$R5 = FDI \cdot r_{FDI} (\ln r + \ln q_2) / \ln P_4 \quad (6)$$

The personal demands:

$$R6 = \varepsilon \cdot GDP \quad (7)$$

The supplementary demands:

$$R7 = \theta (R1 + R2 + R3 + R4 + R5 + R6) \quad (8)$$

According to the analysis above, the modified Agarwal model to estimate the optimal scale of China's foreign exchange reserves can be defined as:

$$R^* = (1 + \theta)(R1 + R2 + R3 + R4 + R5 + R6) \\ = (1 + \theta) [W(\ln k + \ln q_2 - \ln q_1) / \ln p_1 + M(\ln r + \ln q_2) / \ln P_2 + D \cdot r_D (\ln r + \ln q_2) / \ln P_3 + FDI \cdot r_{FDI} (\ln r + \ln q_2) / \ln P_4 + \varepsilon \cdot GDP] \quad (9)$$

W stands for the scale of international balance of payments deficit. k stands for the reciprocal of the capital-output ratio. q_1 stands for the proportion of imports account in the supplemental capital goods. q_2 stands for the ratio of imported productive goods and the total output. P1 stands for probability of balance of

payments deficit. M is the amount of foreign exchange to stabilize the foreign exchange market. P_2 is the probability of the occurrence of financial crisis. r stands for the rate of international investment return. D denotes the external debt balance. r_D denotes the rate of external debt servicing. p_3 denotes the probability of a debt crisis. FDI stands for the foreign direct investment cumulative balance. r_{FDI} stands for foreign direct investment profit repatriation. p_4 stands for the probability of an economic crisis. ε stands for the proportion of personal demands of foreign exchange reserves in GDP. θ is the proportion of extra foreign exchange reserves and normal foreign exchange reserves which is held by a country to prevent possible economic and financial crisis.

2.2 Description of variables and sample interval

China introduced the exchange rate reform in 1994, and the statistical caliber of foreign exchange reserves has changed. Therefore, in this paper we use the statistics from 1994 to 2010. By calculating the seven parts of China's foreign exchange reserves demands: the transaction demands R1, the regulatory demands R2, the interventionist demands R3, debt repayment demands R4, FDI profit export demands R5, personal demands R6 and supplementary demands R7. We work out an optimal scale of China's foreign exchange reserves during the period of 1994 to 2010.

From 1978 to 2010, China's trade balance deficit appeared 11 times, and the largest deficit was appeared in 1985, which was \$ 14.9 billion. Therefore, we can assume that $W=149$, at the same time, it can be concluded that the probabilities of the balance of payments deficit $p_1=11/33=0.33$. K can be represented by the ratio of the total investment in fixed assets to GDP. q_1 can be denoted by the ratio of imported primary products to new investment in fixed assets. q_2 can be denoted by the ratio of imported primary products to GDP. r can be denoted by United States Treasury Bond yields. According to international experience, the rate of external debt servicing r_D is generally defined at 12% -18%, and the foreign direct investment profit repatriation r_{FDI} is defined at 10% -15%. The ratio of the amount of foreign exchange used to intervene the foreign exchange market M to the total foreign exchange transactions T is defined at 8% -18%. The ratio of personal foreign exchange demands account in the gross national income is defined at 1% -4%. As China is still a developing country, whose economic activities have been expanding, and with a special foreign exchange reserves formation mechanism, it is necessary to establish a Risks and Development Fund, which requires 5% -10% more foreign exchange reserves than the normal demands of foreign exchange reserves, so $5\% \leq \theta \leq 10\%$. In the 33 years from 1978 to 2010, China experienced the Asian financial crisis which began in 1997 and the 2007 global financial crisis, both of which lasted for about two years, thus we can get the probability of financial crisis $p_2 = 4/33 = 0.1212$. Since 1978, China's economic development has been growing rapidly and does not have the sign to occur a debt crisis. However, China had experienced two debt crises caused by other countries in the worldwide, which had certain influence on the development of China. It is a total of four years, so

China's debt crisis probability of occurrence $p_3 = 4/33 = 0.1212$. Also, the probability of occurrence of the economic crisis $p_4 = 4/33 = 0.1212$.

2.3 Empirical analysis

According to the modified Agarwal model and the variables, we can get an optimal scale interval of China's foreign exchange reserves, and the upper and lower limits of the interval respectively are:

The upper limit:

$$R^* = (1 + 10\%) [W(\ln k + \ln q_2 - \ln q_1) / \ln p_1 + 18\% T(\ln r + \ln q_2) / \ln p_2 + D \cdot 18\% (\ln r + \ln q_2) / \ln p_3 + FDI \cdot 15\% (\ln r + \ln q_2) / \ln p_4 + 4\% \cdot GDP] \quad (10)$$

The lower limit:

$$R^* = (1 + 5\%) [W(\ln k + \ln q_2 - \ln q_1) / \ln p_1 + 8\% T(\ln r + \ln q_2) / \ln p_2 + D \cdot 12\% (\ln r + \ln q_2) / \ln p_3 + FDI \cdot 10\% (\ln r + \ln q_2) / \ln p_4 + 1\% \cdot GDP] \quad (11)$$

$$W = 149 \quad \ln p_1 = -1.0986 \quad \ln p_2 = -2.8034$$

$$\ln p_3 = \ln p_4 = -2.1102$$

We get the statistics of China's GDP, foreign direct investment (FDI), the turnover of foreign exchange market (T) 1994-2010, from the 2010 *China Statistical Yearbook*, the National Bureau of Statistics, then calculate the related values. The results can be seen in table 1.

Table 1. The values of $\ln k$, $\ln q_1$, $\ln q_2$, $\ln r$ (Unit: US\$bn)

Year	$\ln k$	$\ln q_1$	$\ln q_2$	$\ln r$
1994	-0.2756	-1.0275	-3.524	-2.6593
1995	-0.4633	-0.3782	-3.395	-2.7269
1996	-0.7916	-0.3136	-3.516	-2.7507
1997	-1.1628	-0.1571	-3.5051	-2.7608
1998	-1.6548	-0.6009	-3.7938	-2.9492
1999	-1.7334	-0.4281	-3.6976	-2.8788
2000	-1.2388	-0.2337	-3.2442	-2.8045
2001	-1.271	-0.1263	-3.366	-3.0106
2002	-1.4046	-0.4327	-3.3846	-3.1118
2003	-1.2774	-0.6964	-3.1158	-3.2675
2004	-1.0749	-0.4293	-2.8017	-3.1937
2005	-1.2649	-0.4135	-2.7268	-3.1601
2006	-1.2544	-0.3526	-2.6742	-3.0403
2007	-1.0205	-0.3909	-2.6659	-3.0813
2008	-1.2762	-0.3441	-2.5239	-3.3788
2009	-2.1386	-0.9613	-2.8449	-3.5291
2010	-1.5768	-0.9438	2.9498	-3.5638

Sources: *China Statistical Yearbook*, the National Bureau of Statistics of China, Federal Reserve System

According to the values showed in table1, and by using the modified Agarwal model, we estimate the optimal scale of China's foreign exchange reserves over the years, come to the upper and lower limits of the optimal scale of China's foreign exchange reserves 1994-2010, and make a comparison with the actual foreign exchange reserves.

Table 2. The optimal scale of China's foreign exchange reserves and the actual scale 1994-2010 (Unit: US\$bn)

Year	Upper limit	lower limit	Actual
1994	1846.93	1171.25	516.2
1995	2380.67	1492.68	735.97
1996	2799.72	1762.42	1050.29
1997	3305.78	2100.28	1398.9
1998	3745.34	2384.16	1449.59
1999	4015.62	2612.96	1546.75
2000	3885.78	2448.72	1655.74
2001	4780.73	2952.88	2121.65
2002	5246.22	3196.29	2864.07
2003	5685.28	3380.14	4032.51
2004	6367.56	3689.15	6099.32
2005	7339.39	4167.60	8188.72
2006	8511.84	4707.18	10663.44
2007	10405.86	5559.73	15282.49
2008	13031.33	6725.69	19460.3
2009	17230.73	8761.51	23991.52
2010	22799.72	11316.99	28473.38

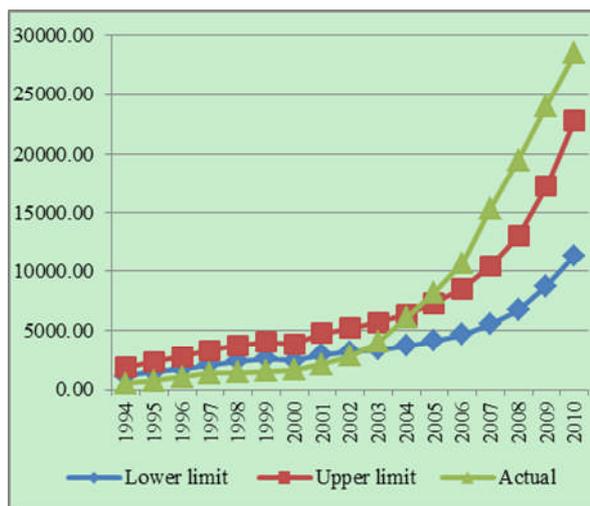


Figure 2. The Optimal scale and the actual size of China's foreign exchange reserves (Unit: US\$bn)

According to Table 2 and Figure 2, we can see clearly that from 1994 to 2003, China's actual foreign exchange reserves were lower than the lower limit of the optimal scale of the foreign exchange reserves. China was at the stage of insufficient foreign exchange reserves. However, the gap was becoming smaller year by year. This indicates that from the 1990s to the early 20th century, in terms of the rapid economic development, China's foreign exchange reserves were obviously insufficient. Whereas, due to the development of foreign trade, the increased foreign direct investment and other reasons, the gap between China's actual size of foreign exchange reserves and the optimal scale had become smaller year by year. Since 2003, China's foreign exchange reserves have entered into the rapid growth period. The actual size of the foreign exchange reserves continued to increase and was gradually closer to the optimal scale. By the end of 2005, the actual size of china's foreign exchange reserves had

exceeded the upper limit of the optimal scale, which indicated that since 2005, the benefits of China's foreign exchange reserves cannot cover its holding costs. After 2005, the gap between the actual size of China's foreign exchange reserves and the upper limit of the optimal scale is increasing year by year, and the situation has been worsening. In 2010, according to the modified Agarwal model, the optimal scale of China's foreign exchange reserves should be from \$ 11,316.99 billion to \$ 2,279.97 billion. Nevertheless, the actual size of china's foreign exchange reserves was up to \$ 2,847.34 billion, exceeding the maximum optimal scale as much as \$ 567.37 billion.

3. Conclusion and policy suggestions

In this paper, we estimate the optimal scale of china's foreign exchange reserves of 1994-2010 with the modified Agarwal model, and the results show that from 1994 to 2002, China's foreign exchange reserves were in the stage of relatively insufficient; In 2003 and 2004, China's foreign exchange reserves were optimal; From 2005 to 2010, china was in the phase of excessive foreign exchange reserves. Although the growth rate of China's foreign exchange reserves has slowed down, the foreign exchange reserves continue to grow. Therefore, in order to effectively inhibit the excessive growth of china's foreign exchange reserves, so as to cope with the scale risk brought by the high foreign exchange reserves, China's foreign exchange reserves management authorities need to take more rational foreign exchange reserves management measures. Therefore it can effectively use the current excessive foreign exchange reserves, improve the management level of foreign exchange reserves assets and promote the harmonious development of China's foreign exchange reserves, national economy and foreign trade.

China should adopt the following policy measures:

(1) Improve the trade structure and expand the domestic demand. On the one hand, China should highly develop the strategic high-tech industries, promote the export of hi-tech products. On the other hand, china should vigorously expand the domestic demand to speed up the economic restructuring.

(2) Increase the imports and support the foreign investment. China should attach importance to strengthen the rational use of foreign exchange reserves, increase the imports of energy, advanced technology and equipment, transfer the excessive foreign exchange reserves into the material and technical reserves. At the same time, China should actively explore the key areas

of overseas markets, and encourage those powerful domestic enterprises to enter the world market to make the mergers and acquisitions of those companies and enterprises with resources and core technologies.

(3) Pay attention to the quality of the GDP, and promote the sustainable economic growth. Make sure that the GDP growth is on the healthy and stable track. Focus on the quality of the development of GDP, and change the concept and method of economic development to ensure a stable and healthy development of the national economy.

(4) Strictly carry out the foreign company access system and change the foreign company introducing mode. Those foreign investments of low-tech, high energy, high-polluting industries should be limited, reduce the introduction of labor-intensive industries, and regulate the investment promotion behavior to shift the introduction of foreign investment in China from quantity-oriented to quality-oriented.

(5) Strictly control the scale of foreign debt and adjust the structure of foreign debt, reduce the size of short-term foreign debt indicators of the domestic institutions, and expand the range of RMB bonds placement institution within the country.

(6) Enhance the flexibility of RMB exchange rate and reduce the pressure on the central bank to stabilize the exchange rate.

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