

## The Empirical Research of the Impact of GDP and Exchange Rate on Foreign Exchange Reserve Scale in China-Based on Quantile Regression Model

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**Abstract:** Based on the relevant data from 1985 to 2010, this thesis uses a quantile regression model to make an empirical research about the effect of GDP and exchange rate on foreign exchange reserve. The findings show that: Both GDP and exchange rate have a remarkable influence on the size of foreign exchange reserve and the effect of exchange rate on foreign exchange reserve is higher than GDP at mean place and middle and lower quantile, smaller than GDP at higher quantile. At all the examined quantiles elastic coefficients of GDP and exchange rate are positive and among them, the elastic coefficients of GDP present us a reverse "V" model with the conditional distribution altering from low to high, that is, the impact of GDP on foreign exchange reserve shows an increasing trend when the latter is smaller, but begins to decrease when the latter reaches to a certain level; the elastic coefficients of exchange rate at lower quantiles are bigger than that of higher quantiles.

**Keywords:** Exchange rate, foreign exchange reserve scale, GDP, quantile regression model

### INTRODUCTION

Foreign exchange reserve refers to the foreign convertible currency that a country monetary authority's hold and that is used for the foreign payments. By the end of September 2011, China's foreign exchange reserve was \$ 3.201683 trillion with the increment of \$ 553.38 billion and the growth of 20.9%. Compared with the same period last year, China's foreign exchange reserve owns a big scale and high growth, which has become an important factor that influences the development of the national economy and draws more and more concern. It has an important actual meaning that understanding the factors that influence the foreign exchange reserve and measuring the affection degree between them, which can also provide reliable basis for country to run and manage foreign exchange reserve and control the scale of it.

A country's economic size affects its scale of foreign exchange reserve, so the influence of GDP is self-evident; the changes of the exchange rate of a country will cause the fluctuation of foreign trade and then cause the imbalance of the international balance of payments, thus exchange rate also influences the scale of the foreign exchange reserve. The scholars at home and abroad conduct a wide study of the impact of GDP and exchange rate on the foreign exchange reserve. Beyond seas, the parameter model designed by Frenkel (1978) constituted a reserve demand function by regression and correlation analysis of all kinds of factors that influence the demand of foreign exchange reserve of one country including GDP to determine the

reserve demand. Philip and Burke (2001) considered the influence of relative factors such as the per capita GDP to the foreign exchange reserves. Dooley *et al.* (2005) thought that the foreign exchange reserve of some countries with a rapid increase is the by-product of the undervalued real exchange rate policy carried out by them aiming at promoting the export, not that these national monetary and financial authorities are intended. Jeanne and Ranciere (2011) also researched the influence of the actual exchange rate to the optimal reserve. At certain conditions, the underestimated exchange rate theory led to the trade surplus, which increases a country's foreign exchange reserve. At the same time, in order to maintain the undervalued exchange rate, the central bank intervenes in the foreign exchange market, which also led to the increase in foreign reserves. If the correction of the undervalued exchange rate was expected by the international speculative capital, same result will be made by the inflows of hot money through the trade items and the capital items. At home, there are many literatures related to the influence of GDP to foreign exchange reserve scale, such as Liang (2001), Wang (2003a, b), Guo and Cai (2006), Wang (2008) and Yang (2009), who conduct theory and empirical analysis from different angles of the influences of GDP and related factors on the foreign exchange reserve. Wang and Wang (2010) estimated the lower and upper limit interval of foreign moderate scale exchange reserve of China in 1985-2008 by using the relevant data such as GDP. In the field of exchange rate affecting foreign exchange reserve scale, Jin (2000) conducted dynamic

analysis of RMB exchange rate and the actual practical spreads between China and America with the monthly data sample in 1981-1999 by using embedded co-integration relationship of vector regression model and the results showed that, the actual effective exchange rate and currency reserve have a co-integration relationship and the appreciation of RMB will accelerate the growth of the foreign exchange reserve. Ma (2004) found out the measurement model of China foreign exchange reserve scale through empirical analysis and confirmed that exchange rate influences China foreign exchange reserve scale, but because of the management of floating exchange rate system in our country, the foreign exchange reserve scale and the exchange rate can't show effective linear correlation, its affection on foreign exchange reserve mainly accomplish indirectly through various factors such as operation in the interbank foreign exchange market of the central bank to ensure the stable exchange rate. Yi (2007) conducted a detail empirical research on China's foreign exchange reserve demand function with monthly data in 1996-2004, finding that the RMB actual effective exchange rate index and its volatility have a significant effect on our country's foreign exchange reserve demand (Wang, 2008). Based on the day of exchange rate system reform, Ba ShuSong and Zhu (2007) conducted a new measure of RMB actual effective exchange rate, finding that the RMB actual effective exchange rate and trade surplus possess long-term co-integration relationship and the devaluation of actual effective exchange rate is one of the reasons leading to China's trade surplus increment, the increment of flexibility of the exchange rate will ease the extent of pin of exchange rate on the foreign exchange reserve. Shi (2008) focused on the affect on foreign exchange reserve scale because of the changes of exchange rate system by linking the foreign exchange reserve scale and exchange rate system. Luo (2010) researched the affect of currency appreciation in different countries on the foreign exchange reserve scale, taking 13 countries in 2003-2007 as the research objects. The empirical results show that, exchange rate fluctuations determine the foreign exchange reserve scale to a certain extent and the appreciation of domestic currency was an important factor which caused the fast growth of foreign exchange reserve scale of the emerging market countries after 2002 with inverse proportion between the RMB appreciation and foreign exchange reserve scale.

Although scholars both at home and abroad generally agree that GDP and exchange rate have positive effect on foreign exchange reserve scale through large number of empirical research. But previous empirical analysis, which mainly uses the least square method to conduct regression analysis, has some

shortcomings. On one hand, estimate is vulnerable to exceptional value because the least square method gets the estimated parameters by making minimum error square. On the other hand, the least square method gives only the dependent variable mean information and a lot of valuable data only gets a regression curve. A curve provides limited information and can't depict the influence of the independent variable on the dependent variable in different level conditions. This study conducts an empirical research on the influences of GDP and exchange rate to foreign exchange reserve scale according to the relative data in 1985-2010 by using the point's digits regression model. Compared with the least square method, quantile regression get estimation of parameter by weighted sum of absolute value of minimum error and the estimation will be more robust for estimator is not vulnerable to the influence of the abnormal values. Quantile regression takes all kinds of local information of distribution function into account to show conditional distribution information.

## MODEL CONSTRUCTION

We select the 1985-2010 annual data for a sample and set up following Bi-logarithm regression model, taking FER (Foreign currency Reserves) as explained variables and GDP and ER (direct Exchange Rate) as explaining variables:

$$\ln FER_i = \alpha_0 + \alpha_1 \ln GDP_i + \alpha_2 \ln ER_i + \varepsilon_i \quad (1)$$

To illustrate the validity of the model (1), it's necessary to unit root test and co integration test on variables including LNFER, LNGDP and LNER. There are usually 5 kinds of methods for the unit root test of time series data, among which, the ADF test, DFGLS inspection, PP inspection appeared early and are common used. But the application of these 3 methods attach certain inconvenience because they all need to be tested for sequence which may contain a constant assumption, but the KPSS inspection and ERS inspection overcome the inconvenience by tectonic statistics to test whether there are root of unity in sequence, used conveniently. Unit root test on the LNFER, LNGDP and LNER with Eviews 6.0 and Table 1 is the result.

From Table 1, it is known that the unit root test results show that LNFER, LNGDP and LNER are all one order single whole variable, so we can conduct co integration test on them. The co-integration relationship inspection results of variable LNFER, LNGDP and LNER are as shown in Fig. 1.

From Table 2, there is co-integration relationship among the variable LNFER, LNGDP and LNER, so the model (1) is appropriate.

Table 1: Unit root test results

Variables	Level		First order difference	
	KPSS inspection	ERS inspection	KPSS inspection	ERS inspection
LNFER	-0.521164	-1.339834	0.066292**	-3.422074**
LNGDP	0.171295	0.681106	0.499201*	-4.217188**
LNER	0.520300	-1.339834	0.651375*	-3.891769**

\* and \*\* were said in 5% and 1% parameter estimation of significant level

Table 2: Johansen co-integration test results

Hypothesized No. of CE(s)	Eigen value	Trace test		
		Trace statistic	0.05 critical value	Prob.**
None*	0.549115	38.59581	35.19275	0.0207
At most 1*	0.448294	19.47877	20.26184	0.0638
At most 2*	0.194970	5.205003	9.164546	0.2617

Table 3: Results of model parameters estimation

Methods	Explain variables and regression results	
	LNGDP	LNER
OLS	1.918380** (0.0000)	2.009882** (0.0000)
Points sites		
Points	0.2 1.897653** (0.0000)	2.120171** (0.0000)
digits	0.3 1.990900** (0.0000)	2.049845** (0.0000)
regression	0.4 1.986462** (0.0000)	2.060465** (0.0000)
	0.5 2.002819** (0.0000)	2.034986** (0.0000)
	0.6 1.981387** (0.0000)	2.131471** (0.0000)
	0.7 1.951763** (0.0000)	1.694520** (0.0001)
	0.8 1.965219** (0.0000)	1.719652** (0.0000)

\* and \*\* were said that parameter estimation is significant in the level of 5% and 1%; The digital in the brackets is probability

### EMPIRICAL ANALYSIS

Through the points digits regression model, in examining the GDP and exchange rate of foreign exchange reserve scale effect, we can better find the direction, size and trend of influence of GDP and exchange rate to foreign exchange reserves in different places of conditional distribution. According to the model (1), results of point's digits regression and least-squares regression are as shown in Table 3.

The "XY" line of points and LNGDP coefficient are as shown in Fig. 2, the "XY" line of points and LNER coefficient are as shown in Fig. 1. Through the Table 3, Fig. 1 and 2, we can see that the symbols of coefficients got by the points digits regression method and the least square method analysis model are consistent, both positive, but, as the foreign exchange reserve scale changes in different positions of the conditional distribution, the elastic coefficient of GDP and exchange rate show some of change rule.

GDP and exchange rate significantly influence the exchange reserve scale. Their elastic coefficients have an important characteristic, that is, the elastic coefficient of GDP is less than that of exchange rate in 0.2, 0.3, 0.4, 0.5, 0.6 etc., low points, adversely only in 0.7, 0.8 etc., high points. It can be concluded that: the influence of exchange rate on foreign exchange reserve scale is greater than that of GDP in the mean and low points, less than that of GDP in high points.

The elastic coefficient of GDP is positive in all quantiles investigated and changes from low-end to

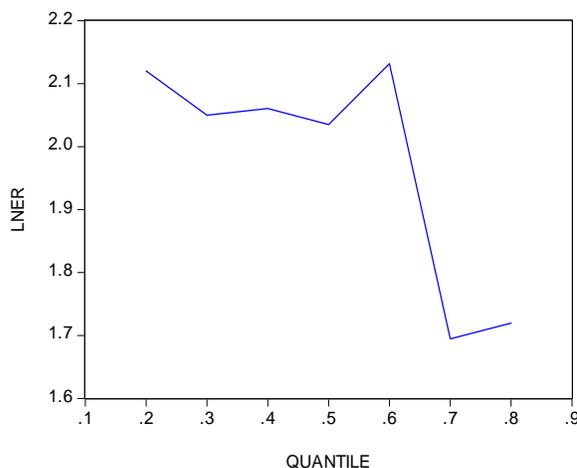


Fig. 1: "XY" line of points and LNGDP coefficient

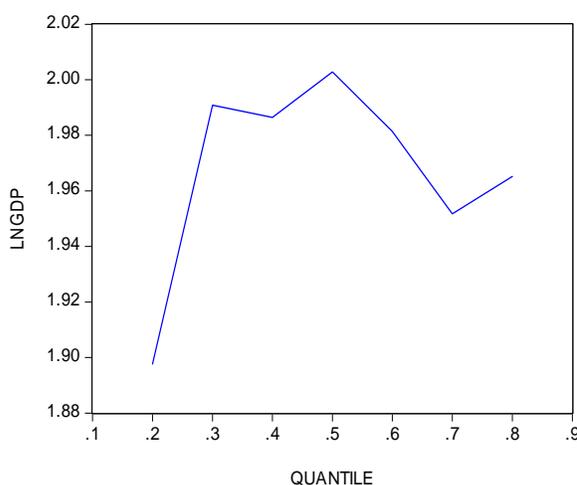


Fig. 2: "XY" line of points and LNGDP coefficient

high-end as conditional distribution. Its elastic coefficient presents inverted "v", such as low grade in 0.2 in 1.897653 sites for, in 0.5 peak in 2.002819, 0.8 high marks in place for 1.965219 sites. This suggests that, when the conditional distribution of China foreign exchange reserve scale lays 0.5 in low grade

Table 4: FER/GDP

Year	1985	1986	1987	1988	1989	1990	1991
FER/GDP	0.009	0.007	0.009	0.008	0.012	0.028	0.053
Year	1992	1993	1994	1995	1996	1997	1998
FER/GDP	0.040	0.035	0.092	0.101	0.123	0.147	0.142
Year	1999	2000	2001	2002	2003	2004	2005
FER/GDP	0.143	0.138	0.160	0.197	0.246	0.316	0.363
Year	2006	2007	2008	2009	2010		
FER/GDP	0.393	0.437	0.430	0.481	0.454		

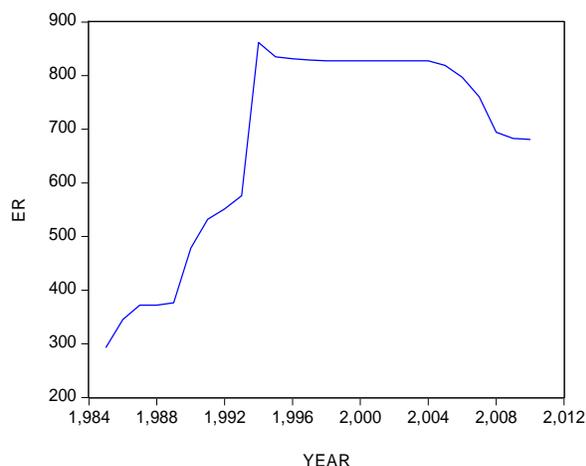


Fig. 3: Chart of china's exchange rate movements in 1985-2010

sites, GDP's influence is most significant, while in the other point's site, the effect of GDP is relatively weak. A country's economic size affect a country's foreign exchange reserve scale, so when economic scale is bigger, GDP is more, the demand for foreign exchange is also bigger, corresponding foreign exchange reserve scale is bigger, that is, the GDP has positive effect on foreign exchange reserve. From the results of regression analysis, we can see that, when Chinese foreign exchange reserve scale is small, influence of GDP to foreign exchange reserve scale increases; but when the foreign exchange reserve scale come to a certain extent, the influence begin to decline. This is because the reasonable interval of the rate of foreign exchange reserve to GDP should be 10-30% according to international experience; Table 4 lists the FER GDP ratio in part year in our country.

From Table 4, we can see that the proportion of China foreign exchange reserve scale to GDP keeps a reasonable range (30%) before and in 2003. Increasing of the export supply will stimulate domestic a full use of production resources and production capacity, which enlarge foreign trade and make foreign exchange reserve scale in the speed of higher than ever expanding, namely the GDP of foreign exchange reserves at this time of increasing scale has positive effect; But the proportion is beyond the reasonable scope since 2004. The foreign exchange reserve scale was too large, will inevitably reduce the efficiency in the use of resources, harm economic growth potential

and bring the macroeconomic many negative effects, restrain export supply and exports enthusiasm at a certain extent, thus weaken the speed of the development of foreign trade, which gradually reduce the rate of growth of foreign exchange reserve scale, namely GDP has digressive positive effect on foreign exchange reserve.

The elasticity coefficient of exchange rate is positive at all the investigated quantiles. However, with the conditional distribution changing from the low-end to high-end, the positive effect of the coefficient at low quantiles is bigger than that at high quantiles. For example, the coefficient is 2.120171 at the quantile of 0.2, 2.049845 at the quantile of 0.3 and it are 1.694520 and 1.719652 at the quantiles of 0.7 and 0.8 respectively. Generally speaking, increase of exchange rate will cause the devaluation of domestic currency and appreciation of foreign currency and stimulate exports and curb imports, therefore foreign exchange reserve will increase. Thus, the size of foreign exchange reserve enlarges along with the increase of exchange rate. From the result of regression analysis, the increase of exchange rate can enlarge the size of foreign exchange reserve and when the size is smaller, the positive effect of exchange rate on foreign exchange reserve size is bigger; when the size is bigger, the positive effect will be smaller. Since 1994, China has implemented regulated floating exchange rates. Exchange rate mainly affects foreign exchange reserve in three ways: import and export trade, the central bank intervention in the exchange market and foreign direct investment. When the foreign exchange reserve size is smaller, the increase of exchange rate will stimulate export and curb import and increase foreign exchange reserve. The Central Bank will also purchase dollars and paying out RMB on the foreign exchange market in order to maintain a low exchange rate of RMB (indirect rate). Besides, higher exchange rate will attract substantial foreign investment to China. For the time being, exchange rate has a strong positive effect on the size of foreign exchange reserve. But in recent years, along with the rapid expanding of China's foreign exchange reserve and the continuous decline of exchange rate, as shown in Fig. 3.

On one hand, increase of exchange rate will still stimulate export and curb import and increase foreign exchange reserve and the Central Bank will still purchase dollars and paying out RMB on the foreign

exchange market in order to maintain a low exchange rate of RMB (indirect rate); on the other hand, the generally lower exchange rate and the appreciation of RMB will weaken the degree of the increase in exports and decrease in imports, reduce China's regular trade surplus and combat foreign investment enthusiasm as well, thus the aggregate amount of direct foreign investment which is an important part of China's foreign exchange reserve will decrease. Under the combined influence of the above two aspects, the facilitation of exchange rate on the size of foreign exchange reserve will be significantly reduced and the positive effect of exchange rate on the size of foreign exchange reserve will be smaller than before.

### CONCLUSION

Based on the statistics of China's foreign exchange reserve, GDP and exchange rates from 1985 to 2010, this study estimates the influence level of GDP and exchange rate on foreign exchange reserve size by using the quantile regression model so as to reveal the influence level's distribution features and variation laws at each quantile. Based on empirical estimation results, the following conclusions could be drawn:

- Both GDP and exchange rate have a significant influence on the size of foreign exchange reserve. The influence of exchange rate on foreign exchange reserve size is bigger than that of GDP at the point of mean value or a medium/low quantile and it is smaller at the point of a high quantile.
- Both the elasticity coefficient of GDP and that of exchange rate are positive at all the investigated quantiles, while with the conditional distribution changing from the low-end to high-end, the elasticity coefficient of GDP generally presents an inverted "V" type.

That is, when China's FER size is smaller, the influence of GDP on it will gradually increase and when the size reaches a certain level this increase trend will turn to a gradual decrease trend. The elasticity coefficient of exchange rate at a low quantile is bigger than that at a high quantile: when the size of FER is smaller, the positive effect of exchange rate on it is bigger, while when the size is bigger, the positive effect will be smaller.

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