Does a correlation exist between the foreign exchange reserves and the exchange rate?

An empirical study of China

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ABSTRACT

The main purpose of this study is to investigate relationship between foreign exchange reserves and RMB exchange rate. In order to obtain a precise result, foreign trade situation and GDP are also considered. The monthly data is collected over period 1994 to 2011, and processed through ADF test, Johansen test, and Granger causality test. Final results indicate that there is a long-term equilibrium relationship existing between foreign exchange reserves and RMB exchange rate. Moreover, any changes of foreign exchange reserves would lead to the fluctuation of RMB exchange rate but not vice versa. At last, the dummy variables are added into regression model to test influence from the reform of RMB exchange rate regime. Results suggest that regime reform not only increase flexibility of RMB exchange rate, but also slow down the accumulation of foreign exchange reserves.

Key words: Foreign exchange reserves, Foreign exchange rate, Gross domestic product, Total volume of import and export trade, RMB
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CHAPTER 1

INTRODUCTION

In this chapter, both of us are prone to deal with questions which are related to our topic such as research background, problem statement, purpose of study, limitation, structure of research etc. They are regularly considered as bricks to support researchers to build their own pillars. We therefore hope this part guides our study to get a good start.

1.1 The research background

According to the data from China State Administration of Foreign Exchange (SAFE), the amount of foreign exchange reserves in China has increased up to 2.85 trillion dollar at the end of 2010 which was 40 times of that in 1995. On August 13th 2007, the SAFE decided to terminate compulsory regime of exchange settlement and allowed domestic institutions keeping foreign currency as their required. However, under the expectation of RMB appreciation, inland institutions have no intention for holding foreign currency. As the result, foreign exchange reserves still accumulated rapidly. Foreign exchange reserves are crucial to open economics and play the vital role in keeping stability of macro-economy. Accumulation of reserves could help enhance control ability of national macroeconomic, increase currency intervention efficiency, and defuse international financial crisis. However, in the composing of China’s reserves, the US dollar occupied more than 70 percent and the main purpose of reserves is still purchasing T-bills. Therefore, with the huge accumulation of foreign exchange reserves, the central bank People's Bank of China (PBC) has to improve supplement of base currency. Concerning of the RMB appreciation, China foreign exchange reserves face the enormous risk.

Another problem related foreign exchange reserves accumulation is RMB appreciation. In the context of economic globalization and financial liberalization, many countries regard the exchange rate as a key method to maintain balance in international payments. In addition, it also could be used to adjust amount of money in circulation and develop national economy. Since 2003, the international public opinion required appreciation of RMB for many times. In response, China implemented floating exchange rate regime on 21st July 2005 which was a unitary and well-managed system based on market supply and demand. But this exchange rate regime reform did not eliminate stress on RMB appreciation fundamentally. On the contrary, a new wave of appreciation expectations was coming. In recent years,
with the growing amount of foreign exchange reserves, some countries accused that RMB exchange rate was underestimated badly and caused global imbalance of international payments. Then they unrealistically required a faster appreciation of the RMB. In 2010, the United States insisted on appreciation of the RMB again; even accused that China was a “currency manipulator”.

The change of foreign exchange reserves reflects the situation of national capital flows and foreign trade activities. It is also the result of the exchange rate intervention implemented by government. Specially, the change of reserves is very closely related to exchange rate policy adjustments in China. On the other hand, foreign exchange reserve remarkable growth proven that China has great trade competitive advantage and economic growth potential. Some previous studies proved that huge accumulation of foreign exchange revers will lead to much appreciation of local currency exchange rate. For example, Pan (2006) found foreign exchange reserves have significant influence on exchange rate, and Hoshikawa (2012) declared a long-term relationship existing between foreign reserves and exchange rate. However, in term of China, the RMB exchange rate did not appreciate as fast as exchange reverse accumulation. More specific, the RMB exchange rate keeps stable in a long time and the fluctuating range was very small. Therefore, we have great interest on the relationship between foreign exchange reserves and foreign exchange rate in China. We try to find this relationship is same or different with that in other countries.

1.2 Problem Statement

As we stated above, China is a pretty interesting country to have remarkable growth of foreign exchange reserves in recent years. The truth we hold tight is that, some financial indexes as well as other economic indexes will be impacted when the amount of foreign exchange reserves increases overmuch.

Correspondingly, since the government of China adjusts the policy of exchange rate of RMB, the exchange rate reserves fluctuate significant following from that. Therefore, we have great interest in exploring the real relationship between foreign exchange reserves and RMB exchange rate. Our research trends to give all its attention on the different aspects of relationship between them:

 ✓ Research statement one: Does a long-term equilibrium relationship exist between foreign exchange reserve and RMB exchange rate?
 ✓ Research statement two: If the long-term equilibrium relationship exists between foreign exchange reserve and RMB exchange rate, what is the causal relationship between them?
 ✓ Research statement three: Did the reform of RMB exchange rate regime have the impact on foreign exchange reserve?
1.3 Purpose of Study

We intend to present our purposes from two sides. Briefly speaking, since the foreign exchange reserves increase overmuch year after year in China, the deviation of exchange rate system perhaps affects this economic index or perhaps is impacted by it. Therefore, we have tremendous interest in exploring certain relationship between foreign exchange reserves and RMB exchange rate.

In addition, both of us hope to accomplish this research by realizing gradually three research statements which are mentioned in 1.3. To be exact, we expect to obtain the necessary and general understanding by achieving the research statement one. Subsequently, a more detailed knowledge is explored and acquired through realizing research statement two. As authors, we therefore could summarize the reasonable proposal or suggestion to maintain the healthy economic development and orderly financial operation when the third research statement is reached. After fulfilling these three research statements, the task of our research is completed by coming up with the valuable results. Consequently, we hope that our findings could provide useful information for the following researchers as well as the creditable reference in this domain. The holistic description follows closely in order to bring the briefly understanding for readers (Figure 1):

1.4 Limitation

We intend to discuss the weaknesses of our research in this part as well. As we mentioned before, the main tree economic indexes that are taken into consideration depend on the real economic condition of China. These indexes are collected based on monthly basis, in order to keep our data as accurate as possible and also to enhance the credibility of our analysis. However, the data of GDP and exchange rate are not
available on monthly basis. We have to transform the quarterly GDP into monthly GDP by using the mathematical method. Although the professor who holds a post at economics department of Umeå University convinces us to adopt a reasonable mathematical method to obtain more detailed data, we still think it is hard to avoid the deviation during the calculating process. It may therefore affect the quality of the analysis. Homologically, the exchange rate of RMB has the same problem as GDP. It also requires us have to convert the daily exchange rate to monthly exchange rate. The deviation thus probably comes out again and influences the validity and reliability of our research.

Another disadvantage we have to point out is that this research is conducted at the basic level. We have not studied the question of optimal management of exchange reserves or the question of moderate size of exchange reserves. Our hope is that we can work on it in the further research.

1.5 Definitions

- **GDP**
  Called the gross domestic product, is the quite significant indicators applied to gauge the health of the economy of different counties. It is usually defined as “GDP is defined as the market value of all final goods and a service produced domestically in a single year and is the single most important measure of macroeconomic performance (Duffy, 1993, p. 31)”.

- **Foreign exchange reserves**
  The foreign exchange reserves represent that the total amount of gold holdings of every country, besides, it also indicates the volume of convertible foreign currencies grasped by its banks (Li, 2006, p. 171).

- **Exchange rate**
  “An exchange rate is the amount of a currency that one needs in order to buy one unit of another currency, or it is the amount of a currency that one receives when selling one unit of another currency (Sercu, 2009, p. 69)”.

- **The total volume of import and export trade**
  It is simply defined as the total amount of goods and services of import and export produced by a country. For the country, the total volume of import and export trade is the important economic index to reflect the scale of the international trade (Lu & Zhang, 2005, p. 7).

- **T-bills**
  “It calls U.S. treasury bills or just bills for short are the most marketable of all money market instruments. It represents the simplest form of borrowing: the
government raises money by selling bills to the public. Investors buy the bills at a
discount from the stated maturity value. At the bill’s maturity, the holder receives
from the government a payment equal to the face value of the bill (Bodie, Kane &
Marcus, 2009, p. 24)

- **RMB**
  RMB is the legal currency of the PRC mainland. According to the Law on ISO 42
  17 referred to as CNY (China Yuan), but more commonly used abbreviations is R
  MB (Ren Min Bi); The symbol of RMB is "¥" (Law of the people’s republic of

- **Currency intervention**
  In China currency intervention is that the central bank manipulates the price of a
certain currency by buying or selling currency in order to reach specific economic
goals (Hou, 2007, p. 19).

### 1.6 Structure of the Research

In order for us to provide clearly structure of research for readers, the entire procedure
of our study is raised as Figure 2:

![Figure 2: The structure of research (Source: Created by authors)](image-url)
CHAPTER 2

THEORETICAL POSITION

In this chapter, we are intended to do the overall introduction of our research methods and to state the related academic experience of authors as well. Then the emphasis switches to explicitly interpret each scientific perspectives and strategies which are close to the topic. In order to ensure our paper more reliable and valid, we are also prone to disclose the weakness of secondary resources at the end of this part.

2.1 Systemic Introduction

Research methods raises the basic guidance for all researchers on how to implement their own projects and presents readers to the main methods, concepts and suggestions involved in carrying out their studies. We therefore fairly believe this chapter lays the foundation for the rest of the work, and it could provide the valuable learning results as well. Since this part is the crucial tie for the subsequent researches, we are prone to do the explicit interpretations on research philosophy, research approach, research strategy and so on. The Figure 3 is designed to reveal how philosophic theories work in our paper, which strives to opening up the vivid description for readers (”√” means the methods we adopt in this thesis)

![Figure 3: Philosophic theories are employed in our paper](image)

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![Figure 3: Philosophic theories are employed in our paper](image)
2.2 Preconceptions

Before we made final decision, many different topics were considered by both of us. But choice of this topic was mainly impacted by our great interest in foreign exchange reserves as well as RMB exchange rate. Besides, in 2011 Chinese foreign exchange reserves increase nearly 40 times compare with the amount in 1995. Along with the central bank of China issued base currency rapidly at recent years, the foreign exchange reserves faced probably great risk. Both of them are considerable hot items currently. We are enthusiastically trying to know how they affect to each other, and whether the long-term equilibrium relationship exists between foreign exchange reserves and RMB exchange rate. As far as we aware this subject is tightly related to our major, we studies on some similar subjects within program of master at USBE and corresponding practical experiences build us the confidence to chase this work better. We also researched the arbitrage of stock index futures and the performance of open-funds at last year. Although did not directly study foreign exchange reserves and exchange rate of RMB, we still have much knowledge from previous researches and know how to establish the mathematical model by similar method. These theoretical knowledge and skill will promote us to analysis deeply.

However, we hesitated for a while to consider whether or not to pick this subject. As we state in chapter one, the relationship among many variables should be researched at the same time in this paper, but we have never done this work. The methodological consideration and the explanation of scientific issues will be influenced according to researchers own background and relative experiences to some extent. A large number of data have to be collected as well as the new and complicated model have to be built by our own. We therefore have tried hard to present all relative research contexts, research contents and to keep each methodological consideration in touch with this thesis as well. For the benefit of study, we have still been attempting to keep our data as accurate as possible and also to keep the entire research stay in transparency as large as we can.

We expect that the paper could sufficiently furnish useful and valuable information in this domain, and the readers could assess our results, or generate inspiration from them. We cordially hope they can not only pay attention on what we studied, but also how we studied them. In addition, we are interested in setting some innovative ideas in the part of empirical analysis when we come across a wide range of scientific articles and resources which are related to this subject.

2.3 Research Philosophy

Since the scientific perspectives play an important role in running the whole work, especially data collection and analysis, we have to seriously take them into account at
the beginning of research. Otherwise it seems like to throw the caution in the wind, which means the quality and the validity of result would largely be threatened. The research philosophy principally includes assumptions about ontology and epistemology. Their own sub-positions are involved in each assumption. Which sub-positions do we require for our study, positivism or interpretivism and objectivism or constructionism? It is tremendously in line with their scientific realities and ideals which are particularly characteristics of sub-positions themselves, rather than our personal beliefs.

2.3.1 Positivism & Objectivism

Based upon the characteristics of this topic, the positivism and objectivism are two optimal choices to be employed in our paper than other sub-positions under epistemological and ontological considerations. Our decision is highly affected by the nature of those sub-positions. We tend to examine the economic reality and something beyond it by utilizing the methods of the natural science. This property is in accordance with the nature of positivism which advocates that knowledge is gathered by the general facts and offer us the basis for laws (Bryman & Bell, 2007, p. 16). In order to realize which kind of relationship exists between foreign exchange reserves and RMB exchange rate, the economic variables such as GDP and other corresponding elements are pondered over. Apart from this, the regression models will be built to disclose the relationship that we deserve by combining those variables. Since variables exist objectively out there and are not influenced by our mind, what is more, these models possess largely positivist overtones as well. Those characteristics highlight a central concern in positivistic paradigms.

Do we build the target of research, or is this target objectively true in the world? The answer is yes if we, as explorers could generate hypotheses and test them. If the long-term equilibrium relationship exists between foreign exchange reserve and RMB exchange rate, the causal relationship between them then have to be estimated. We are probably necessary to raise hypotheses to figure out these economic realities. After that it would be better shift the emphasis on testing them in the light of empirical findings. These viewpoints are the shadow of positivism too when the previous scholars claim that: “the purpose of theory is to generate hypotheses that can be tested and that will thereby allow explanations of laws to be assessed (Bryman & Bell, 2007, p. 16)”.  

Scientific research must be carried out through the way is value free (Bryman & Bell, 2007, p. 16). From our standpoints, we exactly bring this policy into work. Value-free method to gather data and to do analysis largely reflects we are neutral within study. In addition to this, we have been trying so hard to dig out what the truth is and to implement what we are unaware of which highlights the central idea of positivism (Gummesson, 2000, p. 177).
Instead of positivistic beliefs, the interpretivism focus on using words to explain the world and help us to realize reality. It is the position that is associated with the subjective meaning of social action (Gummesson, 2000, p. 177). However, we are naive to believe that our research has little to with interpretivism since positivism position guides our work to be more scientific and objective.

The epistemology keeps essaying to explain how to know the real world for the scholars, whereas the ontology always hold the query of what the real world is. Differing from the positivism, the position of objectivism is inclined to emphasize that social phenomenon and meanings exists out of the minds of social actors (Bryman & Bell, 2007, p. 22). The aim of our paper is to explore some kind of relationship between economic indexes. From data collection to mathematics models creation, entire procedure is external to the explorers and is the entity of real world which is probable acquired and measured objectively. But is there any possible our research carries out with position of constructionism? Then the analogous question comes out and we think it should be answered first. Are the scientific data continually being accomplished by social actors? The reply is no if the data, as the reality being existed “out there” and independent of researchers’ mind. The same circumstance turns out when we make great efforts to explicate how much the mathematics models are pure and objective in this research. There is by no means is similar to the issue of “people create culture continuously” which means people have to resolve the problems in everyday and have to remake those solutions to ensure them get better life (Bryman & Bell, 2007, p. 23). Nevertheless, being scientific has to reveal the phenomenon or research in a reasonable and trustworthy way. We have to defecate that we hold tighter faith to adopt the position of objectivism in our research when the economic elements and phenomenon are reality that exist in the real world independently. There is nothing to do with the constructionism which claims that the reality is malleable and constructed all the time.

2.4 Research Approach

What is the most important issue when we are going to start with new project? The answer is absolutely to look for the best approach to reach the fixed goals maximally. Deductive approach fortunately fulfills this rule, which works as guidance to provide the theoretical framework for our research.

Based on the rule we mentioned above, both of us have reviewed great amount of relational theories and attempted to penetrate the conceptual contexts as well as previous studies deeply. It serves us theoretical basis and certain inspiration to gain clear ideas about how to illustrate long-term equilibrium relationship and causal relationship between two variables. The stationary test for variables has to be implemented when we carry out regression analysis of time-series data at second step. As far as we aware how much mean it is, the Johansen co-integration test will be introduced as yardstick before operating other tests later. The continue procedure then
shift towards to execute the Granger causality test when we are willing to make research compatible with China’s specific market environment. We are also inclined to take use of residuals approach to identify abnormal points, rather than basically do the empirical analysis for the quantified factors. For the purpose of improving the accuracy of empirical study, both of us have considered setting the factor which is related to reform the exchange rate system. Then the dummy variables are added into regression analysis in line with China’s reality. Thereafter the hypotheses would subsequently be proposed and tested through gathering and analyzing data. We have the probability to bring the difference or research gap to light by comparing now existing theories and the expected findings that we hold. In addition, since the study is in connection with quantitative research approach, which means qualitative data and mathematical methods are collected and involved in the research, this paper is of course fully concern in deductive approach (Bryman & Bell, 2007, p. 28).

But what is the clear-cut boundary between deductive approach and inductive approach? For inductive approach, there is an apparent logic to the idea of utilizing grounded theory to analyze the relative data and to build the theory (Bryman & Bell, 2007, p. 14). So the role of this approach is mainly to generate theory, which is totally different from the role of our research. Moreover, the prior scholars believe that inductive strategy frequently generates theories out of data, in other words, it can be implemented without rely any existing theory(Bryman & Bell, 2007, p. 14). All of these typical characteristics are not in line with natural feathers which exist in our research. So we accept it as true, that is the inductive approach is completely against the idea that we promote in our paper. The research complies closely with the steps of deductive approach, in order to reveal our idea in a straightforward way, the following Figure 4 is depicted:

![Diagram of research approach]

**Figure 4:** The process of deduction and induction approach  
(Source: Bryman & Bell, 2007, p. 11-13, 406, 94)
2.5 Research Strategy

The further emphasis of our task then switches to describe the research strategy that we pick up. As the scholar stated before, “The enquiry into social or human problems based on testing a theory composed of variables, measured with numbers, and analyzed with statistical procedures, in order to determine whether the predictive generalizations of the theory hold true, this study made by Creswell (1994, cited in Rocco & Hatcher, 2011, p. 119)”, which is the real description of quantitative strategy. Since our research is also engaged on the basis of theory testing and is weighted with large amount of numbers. We therefore hold strong faith this may be the best method of our expectance. Besides the basic nature of quantitative strategy that we mentioned above, the other vital characteristics should be pointed out as well, it is supposed to cheer readers to get deeper understanding by combining them closely with our subject. Basically, we have conducted our research and kept in step with the trace of thinking by Bryman and Bell: (Bryman & Bell, 2007, p. 155)

✓ Theory: The purpose of our paper is to explore different aspects of relationship between different variables. But what should we know initially about foreign exchange reserves or exchange rate and what are the theoretical considerations raised by previous researchers? We comb through stacks of books and related documents so as to refresh our mind and increase overall understanding. Both of us unanimously think the deductive approach should be taken to explore the relationship between theory and research.

✓ Devise concepts: After we know the basic theories about foreign exchange reserves and exchange rate, we start to narrow the concept down and to develop the particular concept that we are interested in. Several topics are taken into account at the early stage, for instance, shall we study the development of foreign exchange reserves, or shall we study the relationship between those two indexes? Ultimately, we make a choice on the second idea which is a sound controversial issue in China last few years.

✓ Select research respondents: In order to figure out the relationship between these two variables. The economic variables such as GDP, the total volume of import and export trade, foreign exchange reserves and exchange rate are considered as samples and brought over. Therefore, it is convenient to identify relationships among variables and support the researchers to reflect data in a more in depth way.

✓ Administer research instrument: It mainly works on data collection, in other words, it means the way that we usually use to gather data.

✓ Straightforward way to process data: We have coded the related information which is applied in this study through a straightforward way, which means we have transformed the useful information into numbers to give researchers incentive to analyze these quantitative data. For example, we transform the annual GDP into quarterly GDP on the basis of this policy.
Analysis data: The regression model and a bunch of statistical methods are taken in this paper. In order to deserve the most completed and scientific data, the ADF Test, Johansen co-integration Test and Granger Causality Test will be introduced after this chapter.

Findings: Throughout the entire process, investigators must explain the results of the analysis. For this work, we expect to detect the relationship between these two variables and to bring forward feasible comments to improve management of exchange market in the light of the reliable results.

There is clear boundary line between quantitative and qualitative strategies. That is the former strategy transforms the collected information into numbers, whereas the accent of qualitative method is placed on word expression by scientists (Saunders et al., 2000, p. 381). Due to it is meaningful to facilitate readers to get deeper understanding; we would like to picture the difference between them in Figure 5:

**Figure 5: Comparing the process of quantitative and qualitative strategies**
(Source: Bryman & Bell, 2007, p. 155, 406)
2.6 Choice of Theories

In order for us to hunt for the performable concept, the preceding literatures which have relation to our interested themes should be looked for and read. We are pretty keen on doing the projects that are associated with foreign exchange reserves initially. Both of us therefore seek numerous literatures concerning the foreign exchange reserves and something that has to do with it. The narrow and particular concepts were initially determined by reviewing broadly literature. However, the analogous researches are implemented widely in USA and many European counties rather than in China, developing this concept by combining the real condition of China cannot be avoided. Reviewing broadly literatures therefore feed us sufficient knowledge to figure out what is already existed in this academic domain and how to implement our study if there is a gap in knowledge.

We search literatures by taking use of database at university which requires us access via home page of library. It provides readers a good many of valuable resources in the type of full text. For the purpose of ensuring the quality of documents, we are inclined to download the peer-reviewed articles. This is mainly because these kinds of articles were strictly peer-reviewed when they were published, as opposed to the documents from external internet which are less credible and trustful. So as to gain the adequate relational hints of literatures, we have typed either single key word of our project or integrated different key words together in those databases (Bailin & Grafstein, 2010, p. 8). We believe it is an efficient way to search the literatures that we really want. In some cases both of us, as researchers look for the literatures from authentic journal, Google scholars as well as the related textbooks.

We are trying hard to explore the relationship between foreign exchange reserves and exchange rate of RMB, in order for us to search the related literatures as efficient as possible, the key words and their hits which are searched in the database. The following Table 1 is revealed:

<table>
<thead>
<tr>
<th>Key word</th>
<th>Amount of hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Foreign Exchange Reserves</td>
<td>18,400,000</td>
</tr>
<tr>
<td>Foreign Exchange Rate</td>
<td>115,000,00</td>
</tr>
<tr>
<td>Gross Domestic Product</td>
<td>113,000,00</td>
</tr>
<tr>
<td>Total volume of import and export trade</td>
<td>126,000,00</td>
</tr>
<tr>
<td>Industrial added value</td>
<td>16,700,000</td>
</tr>
</tbody>
</table>
2.7 Choice of Secondary Resources

After discussing the choice of theories, this section starts to elaborate the relevant beliefs which are matching with the secondary resources. The purpose of this research is, as we previously mentioned, attempting to find the certain relationship between foreign exchange reserves and exchange rate of RMB. Many economic variables such as GDP, total volume of import and export trade, foreign exchange reserves and exchange rate are required to count in this research. If it is necessary we have to transform part of data from annual amount into quarterly amount or vice versa. Besides this, we are also more likely to make stability collection either in combination of two different variables or alone. Therefore the secondary resource data positively is a simple yet reliable choice to facilitate our work.

The empirical research is developed by analyzing concerning data from 1994 to 2011. 17 years’ data are collected and calculated a bit when we trend to do the empirical analysis as far as we could. However, due to the time-zone is too far to work with, gathering data by adopting the methods such as interview and questionnaires contribute little to this paper. Therefore, the secondary resource should be introduced if we, as researchers could collect and analyze them in an unprejudiced way. Under normal circumstances, the researchers can benefit from this resource when the time is limited and geographical position has to take into account. More importantly, both of us are not required to be involved in the gather of relevant data, which is more time-efficient and cost-effective for investigators we think. Although we have not participated directly to collect the data, the quality of those second resources is still superior. Since the professional documents and articles are published in the scientific journals which have rigorous prerequisites to issue them (Bryman & Bell, 2007, p. 326). Basically, we collect the data of foreign exchange reserves and exchange rate of RMB from State Administration of Foreign Exchange, while the data of GDP are gathered from National Bureau of Statistics of China. In addition, Ministry of Commerce of the People’s Republic of China Comprehensive Department provides us data about the total volume of import and export trade. All of these departments are regarded as authoritative organization in China and we believe they usually offer to public reliable and creditable resources.

We have to take note of that the primary data are matchless with our research. As opposed to the secondary data, the investigators have to participate to collect date directly under primary resources collection (Bryman & Bell, 2007, p. 327). Due to we develop valuable sources by left through the printed books, E-books, related articles as well as available internet websites. The secondary resource obviously is the proper course to take.
2.8 Critical Review of the Sources

We are intending to end this chapter with a brief discussion about criticism of secondary resources. As we stated before, the secondary resources have many merits to promote research, particularly if the researchers would like to cut down the cost and save the time when the study is carried out. However, it does have some limitations that researchers have to bear in mind when we try hard to keep research as credible as we can.

Due to our analysis based on the monthly amount. We have to transform the quarterly GDP into monthly GDP by ourselves to facilitate the empirical analysis. It could be the biggest defect that the secondary resources are not target directed sources. We pick up the useful information by reviewing the resources which are regularly developed by other investigators. Therefore, absorbing the further useful information to support to develop every individual research is impossible (Zikmund, 2003, p. 136-137). However, for the primary resources, the investigators participate to collect date directly. The participators thus could gather any data they would like to, or any data support their researches, but it of course will spend a lot of time and coin (Zikmund, 2003, p. 136-137).

In the next place, the quality of secondary resource is out of current researchers’ control. We have not taken part in the whole process of data collection. Therefore, we have not known the way that secondary data was coded and the inherent factors that could impact the secondary data. For instance, the non-published documents are impossible to encompass the same credibility like the published materials. For the purpose of keeping our research away from trouble, we thus have to pay attention on such problem (Bryman & Bell, 2007, p. 334).

The last weakness remains to be pointed out is that the secondary resources has collected beforehand. Since it is gathered by prior researchers, the secondary data is outdated and it probably leads to biased results sometimes. Besides, one or two parts of whole article are frequently selected out from the general context. We also have to come across the entire article or text if we are unwilling to miss understanding (Bryman & Bell, 2007, p. 335).
CHAPTER 3

LITERATURE REVIEW

In this chapter we seek out suitable models related to our research objects through the theoretical reviewing. In addition, we also reviewed recent relevant literatures about relationship between foreign exchange reserves and foreign exchange rate.

3.1 Foreign exchange reserves

Foreign exchange reserves are the special assets that hold by national monetary authorities and could converted into other foreign currencies at any time. The International Monetary Fund (IMF) regards foreign exchange reserves as “those external assets that are readily available to and controlled by monetary authorities for direct financing of payments imbalances, for indirectly regulating the magnitude of such imbalances through intervention in exchange markets to affect the currency exchange rate, and/or for other purposes (BPM5, 1993, p. 97)”. In the strict sense, the foreign exchange reserves just include foreign currency deposits and the securities. However, the countries around the world put more and more kinds of assets into “foreign exchange reserves” at present, such as Special Drawing Rights (SDRs) and International Monetary Fund Reserve Positions. Moreover, the reserves usually contain several different currencies but US dollar almost occupied the largest part.

3.2 Exchange rate and exchange rate regime

Different countries have different currencies. In one country, each commodity has its own price. When one country exports commodity or service to another country, it has to change the price represented by local currency to the other price represented by foreign currency. The calculation of this price changing is decided by exchange rate. As we mentioned above, the exchange rate is “a currency that one needs in order to buy one unit of another currency (Sercu, 2009, p. 69)”. Therefore, the exchange rate is quoted in terms of how many units of one currency that could be exchanged to one unit of another currency. For example, 6.83 RMB can be changed to 1 US dollar (6.83RMB = 1USD). In this example, the RMB is referred to as quote currency and US dollar is base currency. In fact, there are two different expressions of exchange rate in the world, direct quotation and indirect quotation. When one country sets its local currency as the quote currency and one foreign currency as base currency, we
said this is “direct quotation”. Most of countries in the world use direct quotation to quote their exchange rates. On the contrary, if one country set its local currency as base currency, we said this is “indirect quotation”. Just a few countries use this quotation, such as United States and United Kingdom.

Exchange rate regime is the way that how a country manage its local currency relative with other currencies and the foreign exchange market. The two main regimes are fixed exchange rate and floating exchange rate. The fixed exchange rate means “peg the domestic currency to one or more foreign currencies (Caramazza & Aziz, 1998, p.1)”. Under this regime, the fixed exchange rate is regulated by country’s monetary authority. However, this fixed rate is not permanently, it could be changed when significant changes occurred in economic situation. Therefore, the fixed exchange rate is also called adjusted pegged exchange rate. Floating exchange rate means “determine the external value of a currency more or less by the market supply and demand for it (Caramazza & Aziz, 1998, p.1)”. There are many kinds of floating exchange rate, such as free floating, managed floating, and pegged floating. Under the floating exchange rate regime, the exchange does not float freely. The government will intervene when necessary.

**3.3 Relationship between foreign exchange reserves accumulation and RMB appreciation**

According to the statement of Goschen (2010), the fluctuation of exchange rate depends on supply and demand changes in foreign exchange market. Next, we will illustrate the relationship between them. In Figure 6, the horizontal axis Y represents quantity of foreign exchange and the vertical axis X represents exchange rate. Because the Chinese monetary authority accepts direct quotation of exchange rate, so the decrease of X means RMB appreciation while increase of X means RMB depreciation. In addition, the line D represents the demand curve of foreign exchange. As we known, if the price of foreign exchanges increase (RMB depreciates), the demand of foreign exchange will decrease. So the demand curve slopes downward. Line S means supply curve of foreign exchange. The supply of foreign exchange will increase when the price of foreign exchanges increase. So the supply curve slopes upward. Point E is equilibrium point; it means that foreign exchange supply equal to its demand and the exchange rate keeps stable.

If the foreign exchange reserves accumulated, the supply of foreign exchange will increase. The supply curve S will shift right to S’. Under the condition of constant foreign exchange demand, the demand curve stays the same. Thus, the supply curve and demand curve intersect at new equilibrium point E’. Compare E’ and E, the foreign exchange turnover increase while exchange rate decreases (currency appreciates). Therefore, the increase of foreign exchange reserves will lead to local currency appreciation.
On the other hand, if the monetary authority does not want currency appreciate, it will sell local currency and buy foreign exchange. In this situation, the supply and demand of foreign exchange both increase but exchange rate keeps stable. However, heavy selling of local currency would lead to the domestic inflation. When the harms from inflation outweigh the benefit from exchange rate keeping, monetary authority would give up the intervention in the market. Then the exchange rate would rise and local currency appreciation. Therefore, the huge accumulation of foreign exchange reserves will unavoidably cause local currency appreciation.

3.4 Suitable test models related to research

In this part, we will illustrate some important test methods related to our study. All of these test methods are used in previous studies. The introduction of them is concisely and ordered one after another.

3.4.1 Augmented Dickey–Fuller test

Typically, most of time series are non-stationary in regression model. If we implement regression analysis without stationary test, the result would be spurious regression. The spurious regression means “when non-stationary data are used, one may obtain seemingly significant relationships from unrelated variables (Gklezakou & Mylonakis, 2010, p.318)”. Therefore, many studies test the stationary of time series.
before regression analysis. For example, Kasman and Ayhan (2008) used it to analyze foreign exchange reserves and exchange rates in Turkey; Narayan and Smyth (2006) implemented unit root test to prevent structural breaks; and the research of Hoshikawa (2012) on exchange regime shift. At present, it is widely used Augmented Dickey–Fuller test (ADF) to check whether or not the time series is stationary.

The ADF test came from standard Dickey – Fuller test (DF) which first developed by Dickey and Fuller (1979). The main application of DF test is to check whether unit root exist in autoregressive model. If the unit root is present, we can say this autoregressive model is non-stationary. From Dickey and Fullers’ theory, the normal autoregressive model is (Greene, 2007, p. 689):

\[ Y_t = \lambda Y_{t-1} + \varepsilon_t \] (1)

In this model, \( \lambda \) is coefficient and \( \varepsilon_t \) is the error term \( (\varepsilon_t \sim N[0, \sigma^2]) \) and \( \text{Cov}[\varepsilon_t, \varepsilon_s] = 0 \forall t \neq s \). If \( \lambda = 1 \), then the autoregressive model has the unit root which also means the model is non-stationary. If \( |\lambda| < 1 \), the autoregressive model is stationary. In order to facilitate the calculation, this model was also written as:

\[ \Delta Y_t = (\lambda - 1)Y_{t-1} + \varepsilon_t = \delta Y_{t-1} + \varepsilon_t \] (2)

The \( \Delta \) is first difference operator and \( \delta = \lambda - 1 \). Therefore, \( \delta = 0 \) means autoregressive model has unit root and is non-stationary. In other words, we just need to test hypothesis: \( H_0: \delta = 0 \) and \( H_1: \delta < 0 \).

The DF test is based on the first order autoregressive model, however, the time series would be from higher order autoregressive model in reality. So an augmented version of DF test is developed which is ADF test. Compare with DF test, the ADF test has the same testing procedure but more larger and complicated. The normal ADF model given by Greene (Greene, 2007, p. 695) is:

\[ \Delta y_t = \alpha + \beta_t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \] (3)

Because ADF includes lags of the order \( p \), so it allows for higher-order autoregressive processes. The hypothesis of ADF is that \( H_0: \lambda = 0 \) and \( H_1: \lambda < 0 \). If the \( H_0 \) is rejected, it means the variables are stationary. Actually, there is an easy way to practice ADF test. We can use Eviews to calculate ADF statistic value of variable. Then compare this value with critical value, if ADF statistic value is less than critical value we can say the variable is stationary, and vice versa. When the variables are non-stationary, in a general way we will make first order difference of variables. Afterwards use ADF test again, if variables which after first order difference are stationary, then we can run regression analysis based on this first order difference variables.
3.4.2 Johansen Co-integration Test

Co-integration analysis is used to test whether the long-run equilibrium relationship exist among time series variables. The exact definition of co-integration was introduced by Granger and Engle (1987) which was “The components of the vector \( x_t \) are said to be co-integrated of order \( d, b \), denoted \( x_t \sim CI(d, b) \), if (i) all components of \( x_t \) are \( I(d) \); (ii) there exists a vector \( \alpha(\neq 0) \) so that \( z_t = a^x t \sim I(d - b), b > 0 \). The vector \( \alpha \) is called the co-integrating vector (Granger & Engle, 1987, p.253)”.

In simple terms, if time series are individually integrated but the linear combination of them has a lower order of integration, then these time series are said to be co-integrated. The basic idea of co-integration is that although two or more variables are non-stationary, some linear combination of them would still be stationary in the long-term then these variables are co-integration. When some variables have co-integration relationship, the external shocks would let value of variables away from equilibrium position in the short-term. However, all of them would be back to equilibrium position in the long-term. The co-integration test is most used in relationship analysis between different economic variables. For instance, Chiu (2008) applied it in analysis of exchange rate, price, and exchange reserves; Cifarelli and Paladino (2008) found optimal long-run reserves demand through co-integration test.

The popular method of co-integration test is Johansen Co-integration Test. There are two types of Johansen Co-integration test, trace and eigenvalue (Johansen, 1991). The null hypothesis of the trace test is the number of co-integration vectors \( r \leq \) sequence number, and the null hypothesis of the eigenvalue test is \( r = \) sequence number. Johansen have given the critical value at 5% level. We can compare the trace value with critical value; if trace value is greater than critical value then we reject the null hypothesis for trace test. In the same way, we can also compare eigenvalue value with probability value, if eigenvalue value is greater than probability value then we reject null hypothesis for eigenvalue test.

Granger and Engle (1987) also showed that if there is co-integration relationship exists among some variables, and then these variables must have an Error Correction Model (ECM) expression in the short-term. The main function of ECM is to reflect how the long-term equilibrium has influence on short-term fluctuation. The normal ECM is (Sun, 2005, p.294):

\[
\Delta y_t = \beta_0 + \sum_{i=0}^{p} \delta_i \Delta z_{t-1} + \sum_{i=0}^{p} \gamma_i \Delta y_{t-1} + \alpha ecm_{t-i} + \epsilon_t \\
\epsilon_t \sim N(0, \sigma^2) \quad (4)
\]
3.4.3 Granger causality Test

Granger causality test is developed by Granger (1969) and main purpose is to examine the causality relationship between two variables based on predictability of time series. For example, we have two time series $X$ and $Y$, if we want to predict the value of $Y$, there are two methods we can implement. The first is using past values of $Y$ alone and the second is combining past values of $X$ and $Y$. The $X$ could be said the “Granger cause” of variable $Y$ only if “$Y$ can be better predicted from the past of $X$ and $Y$ together than from the past of $Y$ alone, other relevant information also being used in the prediction (Pierce, D.A., 1977, p.11)”.

More formally, the $X$ could be Granger Cause of $Y$ if (Manage and Marlow, 1986, p.622):

$$
s^2(Y|\bar{Y},\bar{X}) < s^2(Y|\bar{Y})
$$

The $s^2(Y|\bar{Y},\bar{X})$ is the predictive error variance of $Y$ based on combination of past values of $X$ and past values of $Y$. On the other hand, the $s^2(Y|\bar{Y})$ represents the predictive error variance of $Y$ based on only past values of $Y$. In the same way, the variable $Y$ also could be Granger Cause of $X$ if (Manage and Marlow, 1986, p.622):

$$
s^2(X|\bar{X},\bar{Y}) < s^2(X|\bar{X})
$$

The variable $X$ could be Granger Cause of variable $Y$ and variable $Y$ also could be Granger Cause of variable $X$. Therefore, under certain conditions, the bidirectional Granger cause would exist between $X$ and $Y$ if below two equations occurs simultaneously:

$$
s^2(Y|\bar{Y},\bar{X}) < s^2(Y|\bar{Y})
$$

And

$$
s^2(X|\bar{X},\bar{Y}) < s^2(X|\bar{X})
$$

The next step is applying Granger causality test to examine two variables’ relationship. As we know, if $X$ is the Granger Cause of $Y$, the change of $X$ should happen before the change of $Y$. In addition, $X$ should contribute to improve the quality of $Y$’s prediction. More specific, in the regression model of $Y$, increasing the number of lagged $X$ variables should significantly improve explanation power of regression model. Now we use Ordinary Least Squares (OLS) method to build the model to illustrate the test process of Granger causality (Li & Ye, 2000, p.56):

$$
Y_t = \sum_{i=1}^{s} \alpha_i Y_{t-i} + e_{1t}
$$

(5)

$$
Y_t = \sum_{i=1}^{s} \alpha_i Y_{t-i} + \sum_{i=1}^{k} \beta_i X_{t-i} + e_{2t}
$$

(6)
Then we set the Residual Sum of Squares (RSS) of equation 5 and 6 are RSS_1 and RSS_2 respectively. Now hypothesis was set that:

\[ H_0: \beta_1 = \beta_2 = \beta_3 = \cdots = \beta_K = 0 \]

Which means increasing the number of lagged X variables in model does not significantly improve explanation power of regression model (X is NOT Granger cause of Y). Then we use F-test to test the hypothesis \( H_0 \). For a given level of significance \( \alpha \), if \( F > F_\alpha \) then reject \( H_0 \) which means X is Granger Cause of Y. If \( F \leq F_\alpha \), then X is NOT Granger Cause of Y. In the same way, we can also check whether Y is Granger Cause of X using similar method.

### 3.4.4 Dummy Variables

The regression analysis includes many types of variables. Some of the variables can be measured on a numerical scale such as price, age, and income. We regard these variables as quantitative variables. However, there are still some variables or attributes cannot be measured normally, for instance, the sex and region. In order to get more accurate results and facilitate processing, we can construct new variables to represent these unmeasured attributes. These constructed variables are Dummy Variables. In a general way, the dummy variable has two numerical values: 0 and 1. If we give the value 1 on dummy variable, it means that the variable or attribute which represented by dummy variable has effect on the outcome of regression analysis. On the contrary, if we give value 0 on dummy variable, it means the outcome does not be influenced. In regression model, dummy variables are most used to analyze the shocks from event. Bar-Ilan and Marion (2009) set dummy variables to reflect forced change in the exchange rate. In the same way, Agbola and Kunanopparat (2005) used dummy variables to indicate different exchange regime.

Dummy variables play the same role with quantitative variables in regression analysis. If all of the variables in regression model are dummy variables, we said this model is Analysis of Variance Model. If regression model includes both dummy variables and quantitative variables, we said this is Analysis of Covariance Model. In our study, we implement the Analysis of Covariance Model. The dummy variable usually symbolized by \( D_t \) and the general expression is (Kleinbaum et al., 2006, p.217):

\[ D_t \begin{cases} 1 & \text{if event happen} \\ 0 & \text{otherwise} \end{cases} \]
3.5 Previous studies

In order to obtain deeper understanding of our research, the previous studies we chose are all focus on foreign exchange reverses and foreign exchange rate. In addition, they are all recent studies and reflect latest research trends.

The studies of foreign exchange reserves were started from 1960s. Many people did lots of research in this field and construct basis of exchange reserves study, such as Heller (1966), Yudin (1965), Hamada and Ueda (1977). In term of the relationship between foreign exchange reserves and foreign exchange rate, Agarwal (1971) analyzed this problem through Agarwal model. He believed the requirement of foreign exchange reserves was based on fixed exchange regime. Moreover, the amount of exchange reserves could balance deficit of international payment and cost of holding exchange reserves equal to revenue of it. Frenkel (1983) found that after breakdown of the Bretton Woods system, the exchange regime changed to floating exchange which reduces the amount of foreign exchange reserves. Rajan (2002) researched the motivation and scale of holding foreign exchange reserves in developing countries. He regarded the fear of exchange rate volatility as the motivation of huge exchange reserves holding.

Narayan and Smyth (2006) examined the long-run and short-run relationship between exchange rate and foreign exchange reserves in China. They considered trade situation and GDP when selected the data, and then applied unit roots, dummy variables, co-integration and bounds tests to process the variables. They found that in the long term the real exchange rate influences foreign exchange reserves positively and significantly, however, in the short term there is no monotonic relationship between real exchange rate and foreign exchange reserves. In the same way, Cifarelli and Paladino (2008) demonstrated that exchange rate has positive influence on excess demand of foreign exchange reserves. They put import into model and using unit root test, co-integration test then found the new evidences of foreign reserves overstocking problem in Asia and Latin America. They attributed this problem to two reasons-fears of floating and mercantilist. For fear of floating, authors considered this accumulation problem came from the need of capability to resist external shocks and vulnerability of creditors. However, under the mercantilist, almost all the accumulation of reserves is driven by the demand of competitive exchange rates. More than that, they still used the PCA method to find impact of international factors such as US dollar exchange rate and US monetary policy. Finally, both of them have been proved that these factors were associated with foreign exchange reserves. The US interest rate has significant positive effect on reserves demand and the US exchange rate lead to in excess demand of foreign currency as central bankers.

In term of foreign reserves, Chee and Wan (2009) talked about the key macroeconomic variables which could affect reserves pool decision and develop a
framework of reserve currency pooling. They focus on the Asian countries and also use Johansen co-integration method to check every variable. Initially, they confirmed traditional determinants of foreign reserves such as interest rate, exchange rate regimes, and volatility of trade. Then they extend these determinants through added many additional variables and test them one by one. The results illustrate a "significant long-run relationship that exists between international reserve and major explanatory variables such as trade openness, reserve-import ratio, short-term indebtedness, exports volatility, net capital inflow, interest rate spread and GDP per capita (Chee & Wan, 2009, p. 1151)".

Unlike the few articles researching exchange rate’s influence on exchange reserves, there are many studies focused on how foreign exchange reserves affect foreign exchange rate. Friedman (1986) thought that the transaction of center bank in foreign market will lead the exchange rate keeping in a stable level. In addition, the stock of foreign exchange reserves will change accordingly. Girton and Roper (1977) thought that excess supply (or demand) of local currency in foreign market results the volatility of exchange rate and adjustment of exchange reserves. Kasman and Ayhan (2008) researched relationship between foreign exchange reserves and exchange rate in Turkey. In order to get more accurate result, they examined both nominal and real exchange rates. After the unit root test and co-integration test, authors concluded that in the long run there is no relationship between exchange rates and foreign exchange reserves. Moreover, they also used Granger causality test to check the causation, the results showed that the unidirectional Granger causality exist from foreign exchange reserves to the real exchange rate both in long run and short run. On the other hand, authors proved that foreign exchange reserves have significant ability to reduce volatility of exchange rates and the exchange rate could also be a determinant which influences accumulation of foreign exchange reserves in the long run. This result was also confirmed by Aizenman, Chinn and Ito (2010). They still focused on emerging countries but researched how trilemma policy affects economic performance. Particularly, they investigated monetary independence, reserve accumulation and output volatility. In addition, they also take account of foreign trade and GDP. The results showed that increase the fixity of exchange rate would lead to higher output volatility, but this effect can be “mitigated by holding international reserves if the level of international reserves is higher than 21–24% of GDP (Aizenman et al., 2010, p. 639)”. This means that the foreign exchange reserves could support the fixity of exchange rate and contribute to prevent exchange rate fluctuations.

Cady and Gonzalea-Garcia (2007) investigated international reserves, foreign currency liquidity and their effect on exchange rate volatility for 48 countries. Unlike other studies, they implemented panel data models and 15-year quarterly data from 1991 to 2005. The result shows that exchange rate volatility has significant relationship with a set of macroeconomic variables. Furthermore, authors combined model with the techniques from policy evaluation then conducted more detailed results- providing more information of foreign currency liquidity position could
reduce nominal exchange rate volatility. They also divided these countries into industrial countries and emerging countries to do the test and both results confirm that increasing reserve adequacy lead to low exchange rate volatility. Aizenman and Riera-Crichton (2008) research similarly chose both industrial countries and emerging countries. They evaluated the impact of terms-of-trade shocks, capital flows, and international reserves on the real exchange rate. They also research this topic from two aspects-developing countries and industrial countries. Firstly, authors justified that terms-of-trade shocks have significant impact on exchange rate, but the international reserves could cushion this influence which is more significant in Asian countries. Secondly, they found this cushion effect does not have same power in developing countries and industrial countries. Because financial depths in developing countries reduce this buffer effect, and authors think that real exchange rate is more sensitive in international reserves in developing countries. In terms of industrial countries, the hot money instead international reserves play an important role in exchange rate changes.

For the correlation between foreign exchange reserves and foreign exchange rate, many studies proved that the correlation relationship exists between these two economic variables. The research from Weymark (1995) claimed that, under the managed floating exchange rate regime, the excess supply and demand of local currency would be reflected by changes of exchange reserves and exchange rate. Prebheesh and Malathy (2007) investigated co-integrating relationship among foreign exchange reserves, exchange rate, and supply of local currency in India. They concluded that steady accumulation of foreign exchange reserves influence short-term capital flows and total money supply. C. Reinhart and V. Reinhart (2008) found that accumulation of foreign exchange reserves cause country’s policy power reduction, and further affect volatility of exchange rate. Liao (2008) had empirical analysis on this problem by using monthly data from 2005 to 2008. Results stated that there is a long-term co-integration relationship existing between exchange reserves and RMB appreciation and the elastic coefficients are big. In addition, he held a viewpoint that we should value the importance of macro-policy in exchange reserves decision making especially in not perfect market economy.

There are also some studies just emphasized the situation in industrial countries. Chiu (2008) researched what are the long run determinants of exchange rate in Taiwan and US. He extends the traditional PPP proposition and adds three new factors into the model which are foreign reserves, relative productivity, and monetary base. By using the co-integration method, he found that each of these factors has direct or indirect impact on the exchange rate. Furthermore, the Johansen test results also confirm factors maintain this relationship in the long run. For foreign reserves, it helps keeping stabilization of exchange rate from long-term perspective; on the other hand, the low exchange rate also helps foreign reserves accumulation. Stavarek (2011) discussed the problem of exchange market pressure in some new European Union countries. He used modified Griton-Roper model to build the optimal EMP model and
applied this model in each countries. The estimation results show that the money multiplier and the growth of domestic credit have significant and positive influence on EMP. Moreover, the EMP also determined by foreign disturbances which through changes of foreign capital inflow and Eurozone’s money supply. Finally, this study confirmed that "EMP in NMS with flexible exchange rate regimes, except for Poland, is not absorbed exclusively by exchange rate changes. Instead, changes in international reserves play a dominant role (Stavarek, D., 2011, p. 37)". Therefore, the author revealed internal relation between international reserves and exchange rate pressure which means the international reserves also has relationship with exchange rate.

In addition, Hoshikawa (2012) researched the regime shift of exchange rate in Japan. More specifically, he examines the long-term relationship between yen/dollar exchange rate and international reserves. He implemented ADF test, co-integration test, and dummy variables as analysis instrument. But differ from other studies, Hoshikawa used residual-based tests to take regression with regime shift then detect exchange rate policy change. The results declare that there is a long-term relationship existing between Japanese foreign reserves and yen/dollar exchange rate. Moreover, the slope coefficients and change in the intercept suggest that the intervention from central bank changed from "lean-against-the-wind type to a lean-in-the-wind type after the break (Hoshikawa, 2012, p.27)".

Aizenman, Chinn and Ito (2010) used trilemma indexes to measure the level of achievement in three policy goals in the trilemma which are financial openness, exchange rate stability, and monetary independence. They focused on some typical Asian countries and found all of the three policies were related to level of inflation in medium-term and output volatility. More concretely, the greater independence of monetary means lower output volatility and greater output volatility implies greater exchange rate stability. However, authors proved that this greater volatility could be mitigated by international reserves if one country has the international reserves higher than a threshold level. At last, they confirmed greater exchange rate stability and financial openness could reduce the inflation rate.

The foreign exchange reserves not only influence exchange rate, but also affect the choice of exchange rate regime. Agbola and Kunanopparat (2005) explored the determinants of exchange rate regimes in Thailand. Dummy variables, Johansen co-integration test and unit root test were applied to investigate time-series properties of variables. Result indicated that economic fundamentals, risk of currency crisis, and macroeconomic stability of the economy were three key determinants of exchange rate regime in Thailand. These findings were consistent with previous studies and authors also pointed that the government would like to choose pegged exchange rate regime especially in monetary shocks and financial crisis but the accumulation of foreign reserves would encourage the flexible exchange rate regime in Thailand.
Hagen and Zhou (2005) made a detailed study of the choice of exchange rate regime in 25 economies in Europe and CIS. The empirical results indicated that the Optimum Currency Area (OCA) considerations still offered the important guidance for the exchange rate regime choices. Furthermore, the regime choice not only affected by OCA, but also influenced by international reserves sufficiency, inflation rates, and cumulative inflation differentials. On the other hand, exchange rate pegs and macroeconomic stabilization also play the vital roles. Moreover, government deficits still have huge effects on regime choices which push the "moving from flexible to intermediate regimes as well as that of moving from fixed to intermediate ones (Hagen & Zhou, 2005, p.679)".

Rebelo and Vegh (2008) investigated the interrelationship between fixed exchange rate and international reserves. Under the Krugman – Flood – Garber model, the central bank should abandon fixed exchange rate only if international reserves reduce to a critical threshold value. But authors found that many central banks changed fixed exchange rate regime when they had plenty of international reserves. Therefore, they constructed a new model to reflect the real reality in the World. They showed that, if there is no exit cost fixed exchange rate should be abandoned immediately. When the exit cost existing, the optimal time to abandon is a decreasing function of fiscal shock size. Their model suggested that many countries gave up fixed exchange rate regimes when their central bank still had plenty of international reserves. This result was also consistent with other studies that the relationship between exchange rate and international reserves is not hard and fast.

Marion and Bar-Ilan (2009) took a macroeconomic perspective on the foreign reserves accumulation. They put a buffer stock model into standard open-economy model to catch motives for foreign exchange accumulation and this model was solved of two exchange rate policies-rule with escape clause and discretion. They used dummy variables to reflect different exchange rate regimes. Then they recognized that choice of exchange rate regimes could affect the accumulation of reserves and accumulation of reserves also could constrain the choice of exchange rate regimes. When the output is lower than potential level, “it is optimal under both discretion and the rule to adopt a weak currency and promote export-led growth to achieve output and inflation stabilization. This policy leads to reserve accumulation and is consistent with the behavior of China (Marion & Bar-Llan, 2009, p.802)".

After reform of exchange rate regime in 1994, many Chinese researchers paid more attention on issues of foreign exchange reserves and exchange rate. Although many of them focused on scale of exchange reserves, there were still some scholars referred to relationship between reserves and exchange rate. Jin (2000) considered real RMB exchange rate and interest margin between China and U.S. He built a regression model to test relationship between exchange reserves and exchange rate in China. The result showed that RMB appreciation accelerates accumulation of foreign exchange
reserves. Xu (2001) constructed the demand function of foreign exchange reserves for China. He found the exchange reserves have positive relationship with scale of economy but negative relationship with fluctuation ratio of exchange rate. Pan (2006) took positive analysis of exchange reserves based on monthly data from 2000 to 2005. Similarly, he also found a negative relationship exists between expected exchange rate and exchange reserves. Furthermore, he emphasized important role of expected exchange rate in process of exchange reserves accumulation. Yi (2007) analyzed demand function of foreign exchange reserves. He mentioned that dependence degree on import, interest spread, import volatility, and total retail sales of consumer goods are key factors on exchange reserves determination. Huang (2002) had a same viewpoint with Yi. She thought the demand of exchange reserves has positive relationship with GDP, export volatility, and variability of RMB exchange rate.

3.6 Summary of literature review and models

From recent studies we found that many scholars believed a certain relationship exist between foreign exchange reserves and foreign exchange rate. In addition, the same thing in different studies was that many scholars chose two or more additional variables into consideration, not just only tested foreign exchange reserves and exchange rate. The most used variables are foreign trade and GDP, such as Aizenman and Riera-Crichton (2008), Chinn and Ito (2010), Cifarelli and Paladino (2008), Narayan and Smyth (2006). So in our studies, we also decide to introduce foreign trade (total volume of export and import trade) and GDP into our regression model.

Another finding of literature review is that not so many studies focused on China’s situation. Some studies related to China were just analyzed based on period before reform of exchange rate regime in 2005. For example, Jin (2000) used the data from 1981 to 1999, and Yi (2007) collected data from 1996 to 2004. Therefore, we determine use the data from 1994 to 2011 to reflect comprehensive situation in China. In addition, we will test whether reform of exchange rate regime in 2005 has impact on foreign exchange reserves which was not mentioned in previous studies.

In order to answer the research statements in our study, the collected data will be tested by models one after another. Here we will illustrate detailed process of test methods implemented. Initially, like the study of Narayan and Smyth (2006), Cifarelli and Paladino (2008), and Hoshikawa (2012) etc., all of the time series data are tested by ADF to check whether stationary are them. If they are non-stationary, every variable will be transformed by first order difference and be tested again until all the variables are stationary. The second step is co-integration test which implemented by Chee and Wan (2009), Kasman and Ayhan (2008), Chiu (2008) etc., through it we will find whether the long-term equilibrium relationship exist among variables. Next, inspired by Cifarelli and Paladino (2008), Xu (2001), and Huang (2002), the Granger causality test is applied which could tell us causality relationship between two main
variables, foreign exchange reserves and foreign exchange rate. At last, be different from previous studies, we will test whether exchange regime reform in 2005 has impact on foreign exchange reverse by dummy variables.

To sum up, the structure of our study is similar with previous study, furthermore, we put more variables in regression model and implement more comprehensive test. The innovations of our study are that we use the latest data to perform analysis and research dynamic impact on foreign exchange reserves. At last, we will test the latest exchange rate reform’s impact on exchange reserves which have never done before.
CHAPTER 4
EMPIRICAL ANALYSIS

We are intended to show the process of analysis and of course present our empirical results in this chapter as well. The variables will be tested by different models then long-term equilibrium relationship is proved. More than that, causal relationship between foreign exchange reserves and foreign exchange rate is checked. At last, we examine the impact of foreign exchange rate reform.

4.1 Theoretical model

In this paper, we build our analysis model based on traditional regression model. Given China’s actual situation and taking into account the scale variable, foreign trade situation, exchange rate changes, and exchange rate regime to generate the following regression model:

\[ \ln Y_t = \beta_1 + \beta_2 \ln E_t + \beta_3 \ln IE_t + \beta_4 \ln SR_t + \mu \]  (7)

✓ \( Y_t \) means foreign exchange reserves;
✓ \( E_t \) is the exchange rate of RMB against the U.S dollar;
✓ \( IE_t \) expresses the foreign trade conditions which is the total volume of foreign trade in China;
✓ \( SR_t \) is the scale variable of GDP.

We made logarithm process for each data of variables in order for to reduce the impact of heteroscedasticity and ensure to get more accurate data.

4.2 Variables and the choice of sample data

Considering the reliability of data, the current situation of domestic and international economy as well as financial status and other issues, the selected sample interval is set from 1994 to 2011. For the purpose of assuring that the research is more reasonable and persuasive, we use monthly data to develop empirical test.

(1) Foreign exchange reserves: Data is collected from the State Administration of Foreign Exchange.
(2) The exchange rate: Exchange rate determines the exchange prices of home currency and foreign currency. China's exchange rate has experienced several major changes, which bring about corresponding changes in foreign exchange reserves. The exchange rate constitutes an important factor in China’s foreign exchange reserves. Data is same from the State Administration of Foreign Exchange.

(3) The total volume of import and export trade: We utilize the monthly data from Ministry of Commerce of the People’s Republic of China Comprehensive Department.

(4) Gross domestic product: A growing country usually increases the hold of foreign exchange reserves in order to meet increasing needs of external liquidity. We treat GDP as the scale variable of demand of foreign exchange reserves. There is no monthly GDP data, since the published data of GDP in China is quarterly and annual data. Therefore, we apply a certain calculating method to convert the quarterly GDP into monthly GDP. Quarterly GDP data from the website of National Bureau of Statistics of China.

Before empirical analysis, we will show the chart for each variable after logarithm conversion process. From these charts, we can find whether trend and intercept exist in each variable, the results are below:

![Figure 7: The logarithm sequence chart of foreign exchange reserves (lnY_t)](image-url)
Figure 8: The logarithm sequence chart of RMB exchange rate ($\ln E_t$)

Figure 9: The logarithm sequence chart of total volume of import and export trade ($\ln I_{Et}$)
Figure 10: The logarithm sequence chart of gross domestic product (lnSR_t)

From the figures above we can see that every variable has its own trend and intercept. This result meets the requirement of stationary test. Next, we will test variables step by step through different models.

4.3 Stationary test

In regression model, in order to prevent spurious regression happening, we have to test the stationary of each variable. In this study, we use ADF test to check the stationary of time series. The results of ADF test are in Table 2:

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF</th>
<th>Test Critical Values</th>
<th>Stationary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1% Level</td>
<td>5% Level</td>
</tr>
<tr>
<td>LnY_t</td>
<td>-0.883407</td>
<td>-3.462095</td>
<td>-2.875398</td>
</tr>
<tr>
<td>LnE_t</td>
<td>0.873231</td>
<td>-3.462095</td>
<td>-2.875398</td>
</tr>
<tr>
<td>LnIĒ_t</td>
<td>0.248214</td>
<td>-3.463749</td>
<td>-2.876123</td>
</tr>
<tr>
<td>LnSR_t</td>
<td>1.760530</td>
<td>-3.463924</td>
<td>-2.876200</td>
</tr>
</tbody>
</table>

The results show that each variable’s ADF value is bigger than test critical value in three levels. So, all of the four variables are non-stationary in regression model. For the purpose of getting stationary variables, we make first order difference of each variable. The equations are below:
\[ \Delta \ln Y_t = \ln Y_t - \ln Y_{t-1} \]
\[ \Delta \ln E_t = \ln E_t - \ln E_{t-1} \]
\[ \Delta \ln I_t = \ln I_t - \ln I_{t-1} \]
\[ \Delta \ln S_R_t = \ln S_R_t - \ln S_R_{t-1} \]

Then we implement ADF test again to check stationary of four new variables which transformed by first order difference. The results are:

**Table 3: Results of ADF test (first order difference variables)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF</th>
<th>Test Critical Values</th>
<th>Stationary</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta \ln Y_t )</td>
<td>-4.430485</td>
<td>-4.003226 -3.431789 -3.139601</td>
<td>Yes</td>
</tr>
<tr>
<td>( \Delta \ln E_t )</td>
<td>-4.1116967</td>
<td>-4.003226 -3.431789 -3.139601</td>
<td>Yes</td>
</tr>
<tr>
<td>( \Delta \ln I_t )</td>
<td>-2.938711</td>
<td>-3.463749 -2.876123 -2.574622</td>
<td>Yes</td>
</tr>
<tr>
<td>( \Delta \ln S_R_t )</td>
<td>-11.98743</td>
<td>-4.006059 -3.433156 -3.140406</td>
<td>Yes</td>
</tr>
</tbody>
</table>

We can see that ADF values of all new variables (after first order difference) are more negative than 5% critical level. This is an acceptable result and we think the variables after first order difference are stationary. Following the stationary test, another task of ADF test is to choose the optimal lag length. From Appendix 2 we can see that these four variables have different lag length based on Akaike information criterion (AIC) information. Therefore, we decide to use the traditional method to decide optimal lag length of regression model. The process is that, four variables are lagged in same length in regression model, and then we compare the AIC value of different lag length to choose the best one (See Table 4)

**Table 4: Statistics of regression model in different lag length**

<table>
<thead>
<tr>
<th>Lag length</th>
<th>( \mathbf{R}^2 )</th>
<th>F-statistic</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.32</td>
<td>11.57</td>
<td>-5.39</td>
</tr>
<tr>
<td>2</td>
<td>0.37</td>
<td>9.34</td>
<td>-5.42</td>
</tr>
<tr>
<td>3</td>
<td>0.38</td>
<td>7.34</td>
<td>-5.41</td>
</tr>
<tr>
<td>4</td>
<td>0.43</td>
<td>7.06</td>
<td>-5.46</td>
</tr>
<tr>
<td>5</td>
<td>0.43</td>
<td>5.68</td>
<td>-5.42</td>
</tr>
<tr>
<td>6</td>
<td>0.43</td>
<td>4.71</td>
<td>-5.45</td>
</tr>
</tbody>
</table>

From the Table 4 we can see, AIC has the maximum absolute value when the lag length is 4. In fact, we also check the lag length until 16, but the 4 is still best one. In summary, the first order difference variables are stationary in our regression model and the optimal lag length is 4.

**4.4 Co-integration Test**

As we mentioned above, we have tested the stationary of time series and proved that
all of the variables (Ln $Y_t$, Ln $E_t$, Ln$I_E_t$, and Ln$S_R_t$) are stationary after first order difference. In order to build the regression model, we should test whether the equilibrium relationship exists among these variables first. In short-term, we can always find the equilibrium relationship by Eviews. But in the long-term, this equilibrium relationship would be inexistence or existing more than one relationship. Therefore, checking the situation of long-term equilibrium relationship would be applied later. The method we use is Johansen co-integration test. From the co-integration test we can find whether a long-term equilibrium relationship existing among variables. Johansen test includes two steps when we use Eviews to take the analysis. The first one is building VAR model and the second one is checking co-integration relationship based on VAR model. Because we have proved that variables are stationary after first order difference and the optimal lag length are 4. According the statement of Gao (2005), if the variables are stationary after first order difference and have same lag length, we can build VAR model based on these variables but not the first order difference of them. So we construct VAR model with 4 lag length, the result is (more details see Appendix 3):

**Table 5: Output of VAR model**

<table>
<thead>
<tr>
<th></th>
<th>R-squared</th>
<th>Adj. R-squared</th>
<th>Sum sq. resid</th>
<th>S.E. equation</th>
<th>F-statistic</th>
<th>Log likelihood</th>
<th>Akaike AIC</th>
<th>Schwarz SC</th>
<th>Mean dependent</th>
<th>S.D. dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
<td>0.999867</td>
<td>0.999199</td>
<td>0.983114</td>
<td>0.977738</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.999856</td>
<td>0.999132</td>
<td>0.981685</td>
<td>0.975854</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum sq. resid</td>
<td>0.043794</td>
<td>0.001066</td>
<td>2.726341</td>
<td>2.310286</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.E. equation</td>
<td>0.015222</td>
<td>0.002375</td>
<td>0.120104</td>
<td>0.110561</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>88879.99</td>
<td>14743.21</td>
<td>687.7380</td>
<td>518.8067</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>578.6814</td>
<td>961.3599</td>
<td>153.1650</td>
<td>170.2207</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akaike AIC</td>
<td>-5.453217</td>
<td>-9.168543</td>
<td>-1.321990</td>
<td>-1.487579</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schwarz SC</td>
<td>-5.178587</td>
<td>-8.893912</td>
<td>-1.047360</td>
<td>-1.212949</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean dependent</td>
<td>8.208928</td>
<td>2.068128</td>
<td>6.513357</td>
<td>7.300967</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D. dependent</td>
<td>1.267910</td>
<td>0.080604</td>
<td>0.887466</td>
<td>0.711503</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Table 5, the AIC value is -17.74495 and SC value is -16.64643. These two values are all very negative that proved the good fitness of VAR model. Secondly, based on VAR model, we choose Johansen test to check the co-integration relationship. The hypotheses in Johansen test are checked one by one:

$H_0$: There is no co-integrating equation at the 0.05 level  
$H_1$: There is at least one co-integrating equation at the 0.05 level
\( H_0: \) There is at most one co-integrating equation at the 0.05 level  
\( H_1: \) There are two or more co-integrating equations at the 0.05 level

\( H_0: \) There are at most two co-integrating equations at the 0.05 level  
\( H_1: \) There are three or more co-integrating equations at the 0.05 level

\( H_0: \) There are at most three co-integrating equations at the 0.05 level  
\( H_1: \) There are four or more co-integrating equations at the 0.05 level

The Johansen test output by Eviews is:

**Table 6: Result of Johansen co-integration test**

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.369776</td>
<td>129.7244</td>
<td>63.87610</td>
<td>0.0000</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.093838</td>
<td>36.92689</td>
<td>42.91525</td>
<td>0.1745</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.046059</td>
<td>17.12082</td>
<td>25.87211</td>
<td>0.4060</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.037311</td>
<td>7.643018</td>
<td>12.51798</td>
<td>0.2822</td>
</tr>
</tbody>
</table>

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level  
* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values**

In the result of Johansen test, the trace statistic value is greater than 5% critical value in the first line which means the hypothesis “there is no co-integrating equation at the 0.05 level” is rejected. However, the Johansen test could not reject null hypothesis that there are one or more co-integrating equations existing. Therefore, it certifies that there must be one and only one co-integrating equation existing among variables. As a result, in the long-term, foreign exchange reserves have a co-integrating relationship with foreign exchange rate, volume of import and export trade, and GDP.

**4.5 Short-term model estimation**

From the history review of foreign exchange rate and foreign exchange reserves, we realized that we could not build just one model to reflect relationship among each variable both in long-term and short-term. Although there is a long-term equilibrium existing, the relationship still would be imbalance in short-term because the influence of many random factors, such as the exchange rate regime reform and financial crisis. In order to accurately estimate short-term model, we decide to build it based on Error Correlation Model (ECM). The ECM could reflect relationship between long-term equilibrium and short-term fluctuation. The model estimated by Eviews is:
ECM model shows that, foreign exchange rate has the negative relationship with foreign exchange reserves. On the contrary, total volume of import and export trade and GDP have the positive relationship with foreign exchange reserves. More specifically, the number of foreign exchange rate decrease 1% (RMB appreciate 1%) will lead foreign exchange reserves increase 0.7329%. Total volume of import and export trade and GDP increase 1% will cause foreign exchange reserves increase 0.0049% and 0.0142% respectively. In addition, the negative coefficient of error correction term (ECM\(_{t-1}\)) indicates the reverse adjustment power on short-term volatility, which means if foreign exchange reserves away from equilibrium position in short-term, the ECM could reverse adjust it and adjustment range is 3.29% of long-run equilibrium value.

### 4.6 Long-term model estimation

In short-term model, ECM\(_{t-1}\) reflects reverse adjustment power from long-term equilibrium. Therefore, we can also construct long-term regression model based on ECM\(_{t-1}\). The process shows below:

1. Building the initial ECM model which derive from short-term model:
   \[ \Delta LnY_t = \beta_1 + \beta_2 \Delta LnE_t + \beta_3 \Delta LnIE_t + \beta_4 \Delta LnSR_t + ECM_{t-1} \]  
   (9)
2. Rebuilding initial ECM model and set ECM\(_{t-1}\) as dependent variable:
   \[ ECM_{t-1} = \Delta LnY_t - \beta_1 - \beta_2 \Delta LnE_t - \beta_3 \Delta LnIE_t - \beta_4 \Delta LnSR_t \]  
   (10)
3. Replacing coefficients by new vectors:
   \[ ECM_{t-1} = \alpha_0 + \alpha_1 \Delta LnY_t + \alpha_2 \Delta LnE_t + \alpha_3 \Delta LnIE_t + \alpha_4 \Delta LnSR_t \]  
   (11)
4. Estimating new model by Eviews, the results is (more details see Appendix 4):
   \[ 0.0329 = 0.1107 - 0.0257 \Delta LnY_t - 0.0432 \Delta LnE_t + 0.0370 \Delta LnIE_t + 0.0056 \Delta LnSR_t \]  
   (12)

As the result, the final long-term regression model is:

\[ \Delta LnY_t = 3.0272 - 1.6809 \Delta LnE_t + 1.4397 \Delta LnIE_t + 0.2179 \Delta LnSR_t \]  
(13)

The results of long-term regression model show that foreign exchange rate still have the negative relationship with foreign exchange reserves. Similar with short-term model, total volume of import and export trade and GDP have the positive relationship with foreign exchange reserves. To be specific, the number of foreign exchange rate decrease 1% (RMB appreciate 1%) will lead foreign exchange reserves increase 1.6809%. Total volume of import and export trade and GDP increase 1% will
cause foreign exchange reserves increase 1.4397% and 0.2179% respectively in the long-term.

4.7 Granger Causality Test

In order to test the causal relationship between foreign exchange rate and foreign exchange reserves, we implement Granger Causality Test on them and the sample interval is from 1994 to 2010. Granger (1988) has mentioned that the Granger test is available only when the involved variables are stationary or non-stationary but co-integrated. In our study, we showed that all of variables (before first order difference) are non-stationary but have co-integration relationship in long-term. Therefore, we can take the Granger Test and the result is in table 7:

<table>
<thead>
<tr>
<th>Null hypothesis</th>
<th>F-statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnE&lt;sub&gt;t&lt;/sub&gt; does not Granger Cause LnY&lt;sub&gt;t&lt;/sub&gt;</td>
<td>1.02361</td>
<td>0.3962</td>
</tr>
<tr>
<td>LnY&lt;sub&gt;t&lt;/sub&gt; does not Granger Cause LnE&lt;sub&gt;t&lt;/sub&gt;</td>
<td>1.19092</td>
<td>0.0161</td>
</tr>
</tbody>
</table>

The conclusions from Granger Causality Test are that: firstly, for the null hypothesis “LnE<sub>t</sub> does not Granger Cause LnY<sub>t</sub>”, the probability value of F-statistic is 0.3962>0.05 (in the 5% significant level). Thus, we accept this hypothesis and believe that foreign exchange rate is NOT Granger cause of foreign exchange reserves; Secondly, for the null hypothesis “LnY<sub>t</sub> does not Granger Cause LnE<sub>t</sub>”, the probability value of F-statistic is 0.0161<0.05. Therefore, the hypothesis is rejected and the foreign exchange reserve is Granger cause of foreign exchange rate.

4.8 Variance Decomposition

In this part, we will analyze dynamic impact on foreign exchange reserves which came from stochastic disturbance of each variable. On the basis of VAR model, we perform variance decomposition of LnY<sub>t</sub> and LnE<sub>t</sub>. Variance decomposition determines how much of the forecast error variance of each of the variable can be explained by exogenous shocks to the other variables. Through this method, we can compare correlation and mutual influence degree among different variables, and then estimate relative importance of variable’s stochastic disturbance. The results are in Figure 11 and Figure 12:
In Figure 11, different curves reflect different variables’ contribution degree for forecast error variance. In terms of foreign exchange reserves, it is the most important variable in variance decomposition of itself. Although the contribution degree of foreign exchange reserves (LNYT) decrease with forecast period pass, it is still stable at 21.77%. Conversely, the contribution degree of foreign exchange rate (LNET) increases significantly especially after period 60 (year 1999). Its contribution degree exceeds LNYT’s at period 128 (year 2004) and then finally reach 60.92% in year
2011. However, the other two variables, total volume of import and export trade (LNIET) and GDP (LNSRT) did not have large impact on foreign exchange reserves. The contribution degrees of them are 11.71% and 5.61%. (Appendix 6)

In Figure 12, the foreign exchange rate is also the most important variable in variance decomposition of itself. Like the trend of foreign exchange reserves in Figure 13, the contribution degree of foreign exchange rate decrease with period pass, but it turns to increase at recent years and keep stable in 55.46%. On the contrary, contribution degree of foreign exchange reserves shows a “rises first, falls later” trend. The final degree of it is 20.86%. The total volume of import and export trade and GDP still maintain the low contribution degree of forecast error variance, they have 17.01% and 6.68% respectively.

On average, the contribution degree comes from foreign exchange reserves is (21.77%+20.86%)/2 = 21.315%. This degree is much less than that from foreign exchange rate which equal (60.92%+55.46%)/2 = 58.19%. Therefore, in terms of mutual influence degree between foreign exchange reserves and foreign exchange rate, the impact from foreign exchange rate is greater than impact from foreign exchange reserves.

4.9 Foreign exchange rate regime’s impact on foreign exchange reserves

The above analyses are all based on quantitative variables, next we will examine whether qualitative properties factor has influence on foreign exchange reserves. Specially, we choose foreign exchange regime as research object, because previews studies showed that is has the influence on both foreign exchange reserves and foreign exchange rate in other countries. Inspecting the sample interval, we found there was a substantial change of foreign exchange regime from 1994 to 2011(Figure 13). This change was the reform of exchange rate regime in 2005, China began to implement managed floating exchange rate based on market supply and demand, also with reference to a basket of foreign currencies. After that, RMB exchange rate’s flexibility increase obviously and RMB appreciate continuously. For this substantial change, we will analyze its influence by dummy variables.
Here, we set dummy variables as $D_t$, give value 1 on period before July 2005 and give value 0 on period after July 2005. Then we put dummy variables into our regression model, the modified model is:

$$
\ln Y_t = \beta_1 + \beta_2 \ln E_t + \beta_3 \ln IE_t + \beta_4 \ln SR_t + \beta_5 D_t + \mu \quad (14)
$$

$$
D_t = \begin{cases} 
1 & \text{period before July 2005} \\
0 & \text{period after July 2005} 
\end{cases}
$$

The main purpose of introducing dummy variables is to increase precision of the regression model. Through it we can observe how specific event influence the whole model. Based on least square method, the estimated model from Eviews is:

$$
\ln Y_t = 7.6161 - 1.5476 \ln E_t + 0.5876 \ln IE_t + 1.7542 \ln SR_t - 0.2688 D_t + \mu \quad (15)
$$

In this estimated model, $R^2 = 0.9636$ means the fitness of model is very well (Appendix 7), and coefficient of dummy variable is -0.2688. From these results we can say that the exchange rate regime reform has the influence on foreign exchange reserves. The negative value of dummy variable also indicates that growth rate of foreign exchange reserves was slowing after this regime reform. Therefore, the reform of exchange regime not only increase exchange rate’s flexibility, but also slows rapid growth of foreign exchange reserves.

4.10 Summary of empirical analysis

- Foreign exchange reserves and foreign exchange rate are non-stationary time
series. In the long-term, there is an equilibrium relationship existing between them. Foreign exchange rate has the negative relationship with foreign exchange reserves. This result is same with Xu (2001), Pan (2006), Cifarelli and Paladino (2008) but different with Narayan and Smyth (2006). On the contrary, total volume of import and export trade and GDP have the positive relationship with foreign exchange reserves which is the same result with study of Chinn and Ito (2010). Moreover, we introduce ECM model into analysis and find that in the short-term, foreign exchange reserves would be away from equilibrium position, but it will be adjusted back. The adjustment range is 3.29% of long-term equilibrium value.

- Through Granger Causality Test, with the same finding of Kasman and Ayhan (2008), we note that foreign exchange rate is NOT Granger cause of foreign exchange reserves, but foreign exchange reserve is Granger cause of foreign exchange rate. This result proved that the causality between foreign exchange reserves and foreign exchange rate is unidirectional.

- Differ from other researches in this field, we take new additional variance decomposition analysis in our study. In terms of foreign exchange reserves forecast, foreign exchange rate’s contribution degree for forecast error variance increases significantly and finally reaches 60.92%. The contribution degrees of the other two variables, total volume of import and export trade and GDP are 11.71% and 5.61%. For foreign exchange rate forecast, contribution degree of foreign exchange reserves shows a “rises first, falls later” trend. Total volume of import and export trade and GDP still maintain the low contribution degree. (17.01% and 6.68% respectively)

- Exchange rate regime reform has the influence on foreign exchange reserves. This result is also similar with other scholars’ studies, such as Hagen and Zhou (2005), Agbola and Kunanopparat (2005). The reform of exchange regime not only increase exchange rate’s flexibility, but also slows rapid growth of foreign exchange reserves.
CHAPTER 5

CONCLUSION

We will present the conclusion of our research in this chapter. In addition to this, the contributions and future study will be discussed as well. At the end of this section, the reasonable advices are going to be come up with.

5.1 Conclusions

In this study, we examine whether the correlation exists between foreign exchange reserves and exchange rate. More specific, we divided this research question into three objectives:

✓ Research statement one: Does a long-term equilibrium relationship exist between foreign exchange reserve and RMB exchange rate?
✓ Research statement two: If the long-term equilibrium relationship exists between foreign exchange reserve and RMB exchange rate, what is the causal relationship between them?
✓ Research statement three: Did the reform of RMB exchange rate regime have a significant impact on foreign exchange reserve?

We implement different test models to analyze four main variables which are foreign exchange reserves, foreign exchange rate, total volume of import and export trade, and GDP. The test processes are very logical and convictive. After empirical analysis, we found the good answers for our research question and the results of our analysis are also same with some previous studies. Next, we will conclude findings of our study:

✓ Research statement one: Does a long-term equilibrium relationship exist between foreign exchange reserve and RMB exchange rate?

There is an equilibrium relationship existing between foreign exchange reserve and RMB exchange rate in the long-term. Foreign exchange rate has the negative relationship with foreign exchange reserves. On the contrary, total volume of import and export trade and GDP have the positive relationship with foreign exchange reserves.
Research statement two: If the long-term equilibrium relationship exists between foreign exchange reserve and RMB exchange rate, what is the causal relationship between them?

Through Granger Causality Test, we found that foreign exchange rate is NOT Granger cause of foreign exchange reserves, but foreign exchange reserve is Granger cause of foreign exchange rate. This result proved that the causality between foreign exchange reserves and foreign exchange rate is unidirectional. Any changes of foreign exchange reserves would lead to the fluctuation of RMB exchange rate but not vice versa.

Research statement three: Did the reform of RMB exchange rate regime have a significant impact on foreign exchange reserve?

Exchange rate regime reform has the influence on foreign exchange reserves. The reform of exchange regime not only increase exchange rate’s flexibility, but also slows rapid growth of foreign exchange reserves.

5.2 Contributions and Future Study

As we mentioned before, lots of scholars start to pay close attention to foreign exchange rate reserves and related questions after 1994. But vast majority of them do the research around the scale of foreign exchange reserves. There are few researchers who turn attention to explore the relationship between the foreign exchange reserves and RMB exchange rate. Furthermore, the previous studies analyze only their relationship from a regular pattern of the outward of the data. They are lack of statistical study on the internal relationship of each variable. In a nutshell, they involve rarely empirical analysis on econometrics. Therefore, after collecting great amounts of data and taking rigorous analysis, we think this study could be a useful reference in this domain and thus support to the work for other researchers. Besides, it provides us a great opportunity to resolve interesting questions.

We figure out what is the real relationship existing between foreign exchange reserves and exchange rate. Beside two main variables, we introduce another two important economic variables in the regression model. However, excepting the variables we have mentioned, there are still several interesting indicators could be taken into account such as total Retail Sales of Social Consumer Goods (RSCG). Because of the limited time and external factors, we do not undertake a detailed research including all of relative variables. Therefore, we hope that our study can be further investigated by more details and variables.
5.3 Suggestions

In this section, based on the combination of international and domestic situation, we would like to give forward advices according to the empirical result that we stated before.

5.3.1 Increase the Elasticity of Exchange Rate and Attain Gradually Balance Status between Supply and Demand in Foreign Exchange Market

- In order to establish the benchmark of RMB exchange rate, the integrated assessments could be conducted by central bank according to economic fundamentals and the liberalization of financial market based on current RMB exchange rate. Besides, building the generative scheme, the long-term balance of international payments and fundamental equilibrium exchange rate should adapt with each other. The spot exchange rate could be ensured to fluctuate around this equilibrium exchange rate.

- Determining the upper and lower limits of RMB exchange rate in the target zone. At the same time, implementing an active management in this target zone. Moreover, the price of importing and exporting goods, amount of foreign exchange reserves and balance of international payments should be adequately taken into account when define the boundary of the target zone.

5.3.2 Optimizing the Structure of Foreign Exchange Reserves and Prompting the Diversification of Foreign Exchange Reserves

US dollars account more than 70% in China’s foreign exchange reserves. In the current situation, the huge national debt pushes U.S. government to enact the new inflationary policies with the purpose of diluting the corresponding debt. However, the Chinese government has to buy large numbers of T-bills in order to maintain the stability of RMB exchange rate, which largely increases the risk of foreign exchange reserves. Therefore, optimizing the structure of China’s exchange reserves becomes more and more important.

- First of all, Chinese government should reduce the proportion of US dollars in the foreign exchange assets. Furthermore, the SAFE ought to exploit other potential reserve assets, such as EURO and Yen.
Secondly, China should turn part attention to increase the investment in developing countries. Raising intensity of support and assistance for the newly-emerging countries. Furthermore, in order to avoid the various obstacles of foreign trade, China should also directly invest in U.S. and other U.S. allied countries.

Finally, the government should internationalize the RMB. The benefits from this are not only for the development of Chinese economy, but also for the structure of foreign exchange reserves.

5.3.3 Striving to Develop the Foreign Exchange Market and Enrich Foreign Exchange Derivatives

An integrated and efficient foreign exchange market will provide sufficient financial instruments which give entities assistances to resist the risk. The exchange rate is only formed in such effective foreign exchange market could be able to objectively reflect real relationship between demand and supply.

As the regime of RMB exchange rate is an increasingly market-oriented, the foreign exchange options, futures and other derivatives should be gradually introduced in China. It will provide a great variety of tools for the domestic and foreign enterprises. It could also support these companies to participate in the Chinese exchange market and hedge corresponding foreign exchange risk. Besides, increasing exchange derivatives will furnish much more channels for China’s central bank to intervene the fluctuations of foreign exchange market.
CHAPTER 6

QUALITY OF THE RESEARCH

This section is associated with whether or not this study satisfies the main criteria of quantitative research. Therefore, we inclined to evaluate the quality of our study by talking over four main terms such as causality and generalization etc. These four criteria usually work as yardstick to be employed to measure the quality of every quantitative research.

6.1 Reliability

Before we state our viewpoints to combine with those four terms, we are more would like to introduce relevant contents of this criterion a bit. As the scholars previously claimed, the criteria of reliability focus always on repetition, it is used to illustrate that the results of research can be repeated or not (Bryman & Bell, 2007, p. 163). Back to our study, we are going to reveal how reliable this research is from two facets. Thus, the stability and internal reliability are taken into account by us in order to conduct the detailed discussion.

✓ Is the measure is stable over time in this research? Our answer is yes when the empirical results of research do not fluctuate overmuch. “This means that, if we administer a measure to a group and then readminister it, there will be little variation over time in the results obtained (Bryman & Bell, 2007, p. 163)”.

First of all, a lot of literature and documents about this topic are read by us, we try so hard to choose the most appropriate and rational economic model which is adopted widely in the world. Each factor in this model is proposed through deep thought and in accordance with research experience of previous researchers. In addition, we selected data from 1994 to 2011, the data of over 17 years, to ensure that we get a more comprehensive and realistic results. Even some updated factors would be taken into account later, the more reasonable economic model and the improved data can also guarantee that our findings will have no huge fluctuate. Therefore, we think this research brings enough stability and it builds us confidence a bit.

✓ Is this research own enough internal reliability? The internal reliability is associated with the indicators that compose the scale are accordant. “In other
words, whether or not respondents’ scores on any one indicator tend to be related to their scores on the other indicators (Bryman & Bell, 2007, p. 163).”

For the second question, the answer is yes as well. Since this research satisfies the natural characteristics of internal reliability. We explore the long-term relationship between foreign exchange reserves and RMB foreign exchange rate as our first step, then the emphasis switch to detect the causal relationship between them. After realizing these two research objectives which were mentioned above. We form the reasonable proposal or suggestion that may support Chinese economy to develop healthily and may also keep the Chinese financial operation in order ultimately. It is so obviously that one indicator is closely related to other indicators, they are interactive with each other. Therefore, we believe that this research suffices the criteria of the internal reliability and then demonstrates the thesis is more reliable.

6.2 Validity

The second most prominent criterion of quantitative study is validity. It is usually associated with the question of whether or not the results of study are integrated. “In other words, it is very important to generate the integrity of the conclusions from a piece of research (Bryman & Bell, 2007, p. 41).” The same as the criterion of reliability which was detailed stated previously, we are intended to discuss the notion of validity in greater detail from two aspects as well.

✓ The measurement validity is one of the primary types of validity, which is significant to be aware by researchers. It is frequently adopted to quantitative study and to measure the concepts themselves. “Essentially, it is to do with the question of whether or not a measure that is devised of a concept really does reflect the concept that is supposed to be denoting (Bryman & Bell, 2007, p. 41).” Refer to this research we are going to figure out the exact relationship between two economic indexes. How to measure their relationship? Both of us looked up related theoretical sources, finally we built the mathematics model in accordance with previous researches. We therefore believe this measure undoubtedly represent the concept that we are going to talk over.

Besides, in the section of empirical analysis we have to do the correlative test when we are going to move to the further step. Thus the stationary test and granger test of causality should be considered as the different yet important measurements. For instance, before doing regression of time-series data, we think it is better to do the stationary test for variables. These tests are popular and frequently-used in the certain field. Therefore, they are stable and appreciated to
be used to measure the related concepts. At last, there is a kind of inter-relationship between validity and reliability. The former scholars claimed that “if a measure of a concept is unstable in that in fluctuates and hence is unreliable, it simply cannot be providing a valid measure of the concept in question (Bryman & Bell, 2007, p. 41)”. In a contrary, due to the measurements of concept are stable and fluctuate rarely in this research, we think we hold the validity a bit more hence the reliability.

Internal validity. This criterion emphasis on the causality of the issue. In other words, “it is concerned with the question of whether a conclusion that incorporates a causal relationship between two or more variables holds water (Bryman & Bell, 2007, p. 41)”. It is unified with the research nature of our paper. This thesis is to study whether there is causal relationship between different variables as well, according to regression model we constructed.

6.3 Causality

Refer to the quantitative research. The investigators are merely to explain how things are, but they are more would like to discuss why and the way things are (Bryman & Bell, 2007, p. 168). Therefore, the researchers get usually not only deep into the study itself, but also exam its causes and the way to resolve it. Rather than develop the research on the surface of phenomenon. Back to our job, we indeed interpret what the subject is and also argue the way it is. But we pay little attention to explain the causes that make this economic phenomenon happen. Besides, excepting the factors we have mentioned in the paper, there may be other subjective or objective factors could be considered. However, due to time constraints, we do not make a detailed study on them. We hope it can be our further investigation in the future.

6.4 Generalization

“In quantitative research the researcher is usually concerned to be able to say that his or her findings can be generalized beyond the confines of the particular context in which the research was conducted (Bryman & Bell, 2007, p. 169)”. It means as researchers we should make investigative findings not only fit our particular group, but also can be applied other contexts. As the prior scholars said, the people who undertake a study in the certain field should create the representative sample, in order for them to reach up to “generalization”.

Many previous researchers utilize the procedure of probability sampling to gather their representative sample and this procedure is usually carried out by selecting sample randomly. However, it maybe runs a risk through using the random selection,
so the use of this process still cannot ensure a representative sample. Taking into account this problem, the procedure of probability sampling has not been adopted in this research. We bring the previous related economic model combined with our topic, then according to the requirements of the model, to identify associated factors and select pretty useful factors from them. Thereafter, according to each factor to collect the corresponding data and the data of each factor is collected from 1994 to 2011, we believe the collection of completed data collection will make the research more convincing. Therefore, in order to guarantee our samples to be as representative as possible we do not employ random selection methods or other methods. What we study is long-term equilibrium relationship and causal relationship between foreign exchange reserves and RMB exchange rate. They are associated with financial and economic domain. Since we attempt to gather all the data as representative as we can, we hope the findings are not unique to the specific context whom the study is conducted.
Reference:

Books:


Articles:


Weymark, D.N. (1995). Estimating exchange market pressure and the degree of


Web pages:


Law:

Appendix 1: Results of ADF test
Appendix 2: Results of ADF test

(first order difference variables)
Appendix 3: Output of VAR mode

Vector Autoregression Estimates
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Sample (adjusted): 1994M05 2011M06
Included observations: 206 after adjustments
Standard errors in ( ) & t-statistics in [ ]

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**Summary Statistics:**

- **R-squared:** 0.999867
- **Adj. R-squared:** 0.999856
- **Sum sq. residuals:** 0.043794
- **S.E. equation:** 0.015222
- **F-statistic:** 88879.99
- **Log likelihood:** 578.6814
- **Akaike AIC:** -5.453217
- **Schwarz SC:** -5.178587
- **Mean dependent:** 8.208928
- **S.D. dependent:** 1.267910

**Determinant resid covariance (dof adj.)**: 1.68E-13

**Determinant resid covariance**: 1.19E-13

**Log likelihood**: 1895.730

**Akaike information criterion**: -17.74495

**Schwarz criterion**: -16.64643
Appendix 4: Estimation of short-term and long-term models

1. Short-term model

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R-squared: 0.143909  Mean dependent var: 0.023181
Adjusted R-squared: 0.127122  S.D. dependent var: 0.019681
S.E. of regression: 0.018387  Akaike info criterion: -5.130669
Sum squared resid: 0.068972  Schwarz criterion: -5.050709
Log likelihood: 541.1549  Hannan-Quinn criter.: -5.098341
F-statistic: 8.573074  Durbin-Watson stat: 1.158091
Prob(F-statistic): 0.000002

2. Long-term model

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R-squared: 0.451922  Mean dependent var: 0.022687  Adjusted R-squared: 0.382277  S.D. dependent var: 0.018974
S.E. of regression: 0.014913  Akaike info criterion: -5.463524  Sum squared resid: 0.040254  Schwarz criterion: -5.074488
Prob(F-statistic): 0.000000

60
## Appendix 5: Granger Causality Test

**Pairwise Granger Causality Tests**

- **Date:** 12/08/11   **Time:** 18:03  
- **Sample:** 1994M01 2011M06  
- **Lags:** 4

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Appendix 6: Variance decomposition

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### Variance Decomposition of $\text{LNET}$:

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Appendix 7: Estimation of dummy variables model

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<td>0.074376</td>
<td>-3.614317</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

R-squared | 0.963590 | Mean dependent var | 8.172410 |
Adjusted R-squared | 0.962876 | S.D. dependent var | 1.294773 |
S.E. of regression | 0.249471 | Akaike info criterion | 0.084683 |
Sum squared resid | 12.69608 | Schwarz criterion | 0.164644 |
Log likelihood | -3.849412 | Hannan-Quinn criter. | 0.117012 |
F-statistic | 1349.719 | Durbin-Watson stat | 0.730513 |
Prob(F-statistic) | 0.000000 |       |          |