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The Impact of China’s Monetary Policy on Global Commodity Prices

by

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Abstract

The global commodity prices have taken a roller coaster ride for the past ten years, and the fickle monetary policy initiated by the US Federal Reserve is thought to be one of the primary causes of such huge swings. At the same time, with adoption of the open-up policy and tremendous economic development, China has gradually emerged as a major player in the world commodity market, which suggests that the tendency of price change for commodity may also be affected by China’s monetary policy. It is necessary to investigate the relationship between China’s monetary policy and world commodity prices through empirical analysis in order to increase accuracy of market forecasting.

This paper examines the effects of China’s monetary policy on global commodity prices through cointegration analysis and VAR model. Our results show that an expansionary monetary policy in China has a positive effect on commodity prices, and the prices for energy commodities are affected most by China’s monetary policy. Additionally, we have selected several indicators that allow us to represent the direction of China’s monetary policy into our research. The results show that the mid-term loan interest rate in China can be used to increase forecasting accuracy for edibles and energy commodity price trends, and 3-month Shanghai Interbank Offered Rate (SHIBOR) is useful to predict the price trend in industrial inputs commodity sector.

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List of Abbreviations

ADF	Augmented Dickey-Fuller
EURIBOR	Euro Interbank Offered Rate
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
IMF	International Monetary Fund
IRF	Impulse Response Functions
LIBOR	London Interbank Offered Rate
LII	Mid-term Loan Interest Rate Indicator
NYMEX	New York Mercantile Exchange
OPEC	Organization of the Petroleum Exporting Countries
PBoC	People's Bank of China
RMB	Renminbi (Chinese Yuan)
RR	Reserve Requirement Ratio
SHIBOR	Shanghai Interbank Offered Rate
TR/CC CRB	Thomson Reuters/Core Commodity CRB Index
US	United States of America
USD	United States Doller
VAR	Vector Autoregression
VECM	Vector Error Correction Model

1. Introduction

1.1 Background

With the constant deepening of economic reforms and as a result of the opening up policy for the past few decades, China has rapidly entered into the world economy and became an inseparable part. Being a country with the largest population as well as the largest manufacturing scales, commodity prices have always been on the priority watch list for the economic decision-making bodies in China.

As a result of the world economic disruption, the global commodity prices have taken a roller coaster ride over the past ten years. Before the reform of the economic system and the opening up policy to the outside world in 1978, China only accounted for less than 4% of global economic output (Farooki & Kaplinsky, 2012). At that time, China was unable to influence the global commodity market and had to passively take any price set by the market (Wang & Ge, 2008). With rapid economic growth for the past forty years, China has become one of the biggest commodity consumers in the world, and has attempted to fight for the pricing control power in commodity market to match its status. As a result, China is likely to be transformed into an influential price maker in the global commodity market, and stop acting merely as a price taker. To enhance its power in the global commodity market, various supporting programs have been initiated by the Chinese government, including building the trading center of future markets, and encouraging investment in overseas acquisition of commodity trading companies (Mou D. , 2014). The recent inclusion of Renminbi (RMB) into Special Drawing Rights (SDR) currency basket has also sent an aggressive signal to the market that a greater eastern influence is to be expected (He, 2016).

Presumably, greater involvement in global commodity market for a country means that the commodity prices are more sensitive to its national monetary policy (Hammoudeh, Nguyen, & Sousa, 2014). With constant enhancement of China's presence in the global commodity market, there is a reason to believe that China's monetary policy could affect prices of commodities. Due to the conduction mechanism, the impact of monetary policy can be transmitted more efficiently to the capital market (Forrest, 2014). On the other hand, the current faltering economy has forced China to use monetary policy more frequently to solve problems. It is worth to note that China launched a 4 trillion RMB (586 billion USD) stimulus package in late 2008 immediately after financial crisis, which has successfully helped the economy to recover from recession (Biswas, 2016). Given this precedent, the recent unusual depreciation of the RMB has been interpreted by the market as a foreshadowing of next conventional or unconventional quantitative easing, which may affect the world commodity price trend to a great extent (Sheng, 2016).

Monetary policy plays an important role in increasing the growth rate of a country's economy by influencing the cost and availability of credit, controlling inflation and maintaining balance of payments equilibrium (Chand, 2015). Unlike other major economies such as the United States, where monetary policy is often being implemented in a direct and transparent way, China chooses to follow a more indirect and diversified approach to manage its monetary system. As a consequence of that, it is difficult to assess the impact of China's monetary policy on commodity prices directly through traditional economic theories. It is necessary to evaluate the impact taking into account the Chinese characteristics.

1.2 Research Motivation

Motivation for this research came from China's increasing commodities pricing power and the raising concern of a hard landing for its economy. China accounts for a major share of commodities' imports as well as exports, and it has gradually driven the commodity prices in accordance with its own economic cycle (Mou D. , 2014). On the other hand, the recent faltering of China's economy makes investors fear that the forthcoming monetary easing policy may disrupt the existing pricing system in global commodity market. Hence, it is necessary to find out the relationship between China's monetary policy and commodity prices in order for commodity traders to be properly prepared in advance.

1.3 Academic Relevance

A thoroughly study of relationship between commodity prices and the US monetary policy has been conducted over the years by numerous researchers. However, due to the particularity of the China's monetary policy, few academic research addressed this sector, which often results in over or under-estimation of its impact on global commodity prices with strong perceived bias. From global trading industry perspective, it is essential to establish an objective evaluation of the impact of China's monetary policy on prices of different types of commodities to enhance forecasting accuracy.

1.4 Research Questions

The main objective of this paper is to examine and evaluate the impact of China's monetary policy on global commodity prices. Firstly, we confirm the existence of such impact and investigate the influential direction of China's monetary policy towards commodity prices. Secondly, we classify various commodities into three categories (edibles, industrial inputs and energy) and compare the differences of the effect to different commodity sectors. Lastly, we examine various indicators for China's monetary policy and make recommendations for commodity trading companies in terms of market trend forecasting.

With reference to our research motivation and academic relevance, this paper is guided by the main research question:

What is the effect of China's monetary policy on commodity prices?

with the following three sub-questions:

1) *What is the correlation between China's monetary policy and global commodity prices?*

2) *How and to what extent does China's monetary policy affect the prices of different types of commodities?*

3) *What is the best indicator of China's monetary policy that has the predictive effect on the change of commodity prices?*

Cointegration analysis and Vector Autoregression (VAR) model analysis will be used to answer the above questions. The results of VAR model analysis include three parts: Granger causality test, impulse response function, and variance decomposition. The first and second questions can be answered through cointegration analysis, and the third question will be solved mainly based on the results from the VAR model analysis, including the results generated from Granger causality test, impulse response function, variance decomposition, and partial results from cointegration analysis.

1.5 Research Structure

In order to have a better illustration, Figure 1 shows the contextual structure of this study.

Chapter 1 gives a brief introduction of the topic, explaining the reason for choosing this topic and its academic relevance, formulating main and sub research questions at the end of the Chapter.

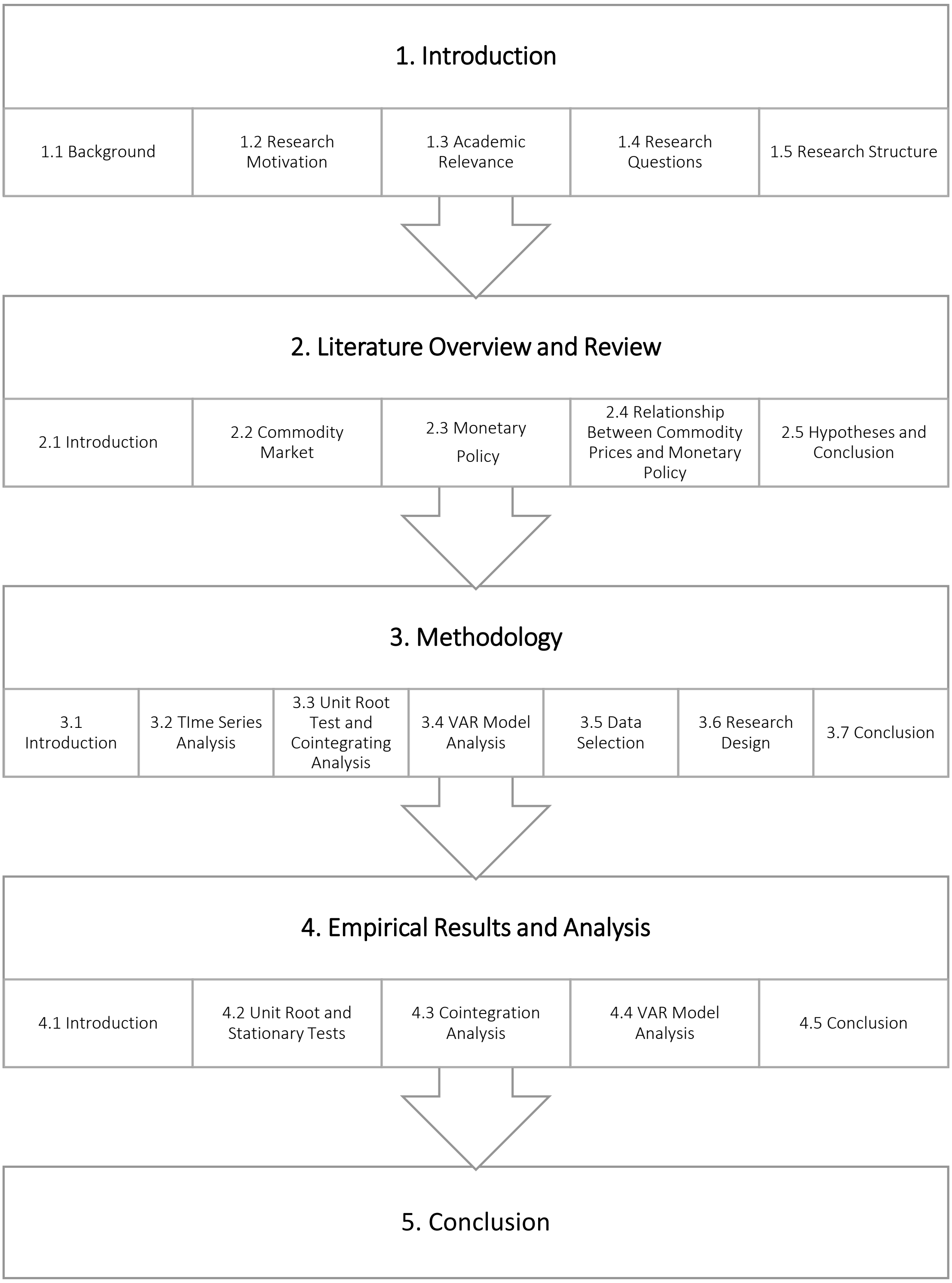
Chapter 2 describes essential knowledge necessary to research this topic. In the second and third sections of the Chapter, we provide an overview of the commodity market and monetary policy, both in general and in China's. The fourth section reviews previous studies on relationship between monetary policy and commodity prices, which establishes fundamental knowledge and research hypotheses for this study.

Chapter 3 explains the academic framework of the chosen methodological approaches, and discusses the data selection procedures and the logics behind it. Detailed description on cointegration analysis and VAR model analysis are presented in this Chapter, followed by an overview of research design established for this paper.

Chapter 4 presents the outputs of the cointegration analysis and VAR model analysis, with primary interpretation of the results. The three sub-questions will all be answered at the end of this Chapter.

Chapter 5 summarizes all the findings and draws final conclusions. The conclusion includes further interpretations of previous findings, combined with discussion of limitations of this research and our recommendations for future studies on similar topics.

Figure 1. Contextual structure of the conducted research



2. Literature Overview and Review

2.1 Introduction

To analyze the relationship between commodity market and China's monetary policy, this chapter provides essential knowledge on commodity market, monetary policy and the relationship between these two factors. Firstly, this chapter explains the notion of the commodity market, introducing major types of global commodities, features of commodity market, as well as China's commodity market status and trends. Secondly, this chapter shed light on the monetary policy. The characteristics of the central bank and frequently used monetary policy instruments are discussed. The salient features of China's monetary policy are also described in comparison with the other major economies. Thirdly, in order to analyze how commodity market is affected by the monetary policy, the relationship between commodity price is illustrated, including the historical events in the U.S. as well as the previous studies on the relationship between commodity price and monetary policy.

2.2 Global Commodity Market

This section starts with the introduction of the types of commodities, followed by main features of commodity market in terms of identification, time frame, associated risk, benefits, trade volume and volatility in commodity price. At the end, China's commodity market status and trends are assessed.

2.2.1 Major Types of Commodities

A commodity is a natural resource that can be traded in the market, which is taken as a fundamental component for industrial and agricultural production and consumption. The International Monetary Fund (IMF) has categorized commodities into two broad categories: energy and non-energy, when non-energy commodity can be further divided into edibles and industrial input groups (IMF, 2016).

Edibles

Edible commodities contain most types of agriculture products, which can be subdivided into two sub-sections: food and beverages. Each sub-section includes but is not limited to the commodities specified in Table 1.

Table 1. Types of edibles commodities

Food	Beverages
- Cereals (wheat, maize, rice, barley)	- Coffee
- Vegetable Oils / Protein Meals (soybean oil, palm oil, fishmeal)	- Cocoa Beans
- Meat (beef, lamb, swine meat, poultry)	- Tea
- Seafood (fish, shrimp)	
- Sugar	
- Fruit (banana, orange)	

(Source: IMF, 2016)

Industrial Inputs

This category includes commodities that are used for industrial production and development, which can also be further divided into two sub-sections: agricultural raw materials and metals. Each sub-section includes but is not limited to the following commodities listed in Table 2.

Table 2. Types of industrial inputs commodities

Agricultural Raw Materials	Metals
- Timber (hardwood, soft wood)	- Copper
- Cotton	- Aluminum
- Wool	- Iron Ore
- Rubber	- Tin
- Hides	- Nickel
	- Zinc
	- Lead
	- Uranium

(Source: IMF, 2016)

Energy

Energy commodities are essential components for both domestic and industrial consumption. Energy trade contributes to more than half of trading volumes in commodity market. Major energy commodities are presented in Table 3.

Table 3. Types of energy commodities

Oil	Coal	Natural Gas
- Crude Oil	- Thermal Coal	- Liquefied Natural Gas (LNG)
- Petroleum Products		

(Source: IMF, 2016)

2.2.2 Overview of Global Commodity Market

The commodity market is like the stock market which is a financial institution that enables investors to buy and sell goods. In case of commodity market, traders deal with the shares of raw materials that are used for industrial manufacturing, food and energy (FAO, 2006). Commodities can be exchanged, which means that buyers may buy the same products from various sources, and traders may sell the commodity to many buyers.

Commodities are produced on a global basis, however, not a single country could produce all types of identical commodities. Against this background, commodity traders become more important in making commodity traded in every country in the world. Commodities can be regarded as non-differentiated products, where each unit of a commodity is exactly like every other unit (Hofstrand, 2007). The fluctuation of commodity prices a global phenomenon. Therefore, price differences for the same commodities between individual countries is very small.

Traders trade contracts at commodity exchanges, in which, agreements to buy and to sell commodities for a certain amount of money at a specific time is made. Some big exchanges, such as the New York Mercantile Exchange (NYMEX), are established to ensure that buyers take delivery of what is written in the contract without carrying out the inspection of goods. Besides the spot contracts, commodity markets also have future contracts, where a buyer pays the seller a price specifying a date for delivery at a date in the future. Future contract has time maturity, which is due from the time the commodity is delivered to the buyer.

The comparative risks associated with trading of shares of commodities depend on the assets purchased. Certain commodities like wheat have been able to hold at a steady price but other commodities like oil may face unstable prices. Commodity market presents benefits to investors, which depends on the commodity value of physical possessions. Normally, investors are inclined to buy commodities under uncertain economic conditions.

Both production and consumption of major commodities tend to be in very large quantities, and in most cases they are traded at the wholesale level rather than at the retail level. The prices of commodities may vary greatly due to numerous natural or human factors such as climate change, social conditions, economy situations and consumer preferences. Due to these characteristics, commodities have frequently been used for speculative purposes in specialized commodity trading market, which is similar to the stock market.

Due to large trading volumes and to the fact that most commodities share a common physical character which makes it easier to handle in bulk, sea-going bulk fleets often carry out the transportation duty for delivering commodities worldwide (Stopford, 2009). Bulk fleets can be divided into dry bulk carriers and tankers. Dry bulk carriers are mainly used for transporting non-energy commodities (also some energy commodities such as thermal coal), while tankers transport energy commodities. Some minor commodities are also transported by container vessels and specialized carriers.

2.2.3 China’s Commodity Market Status and Trends

China is a major participant in the world commodity market, and the impact of China’s economy and politics related to strategic reserve holdings, trade, environmental issues are generally seen to have a huge impact on commodity prices (Roache, 2012). Due to a variety of production factors and consumption behavior, the Chinese influence has a different effect on different types of commodities and to a different extent. We have divided the commodity market into three sectors in accordance to the IMF’s categories and will analyze them separately.

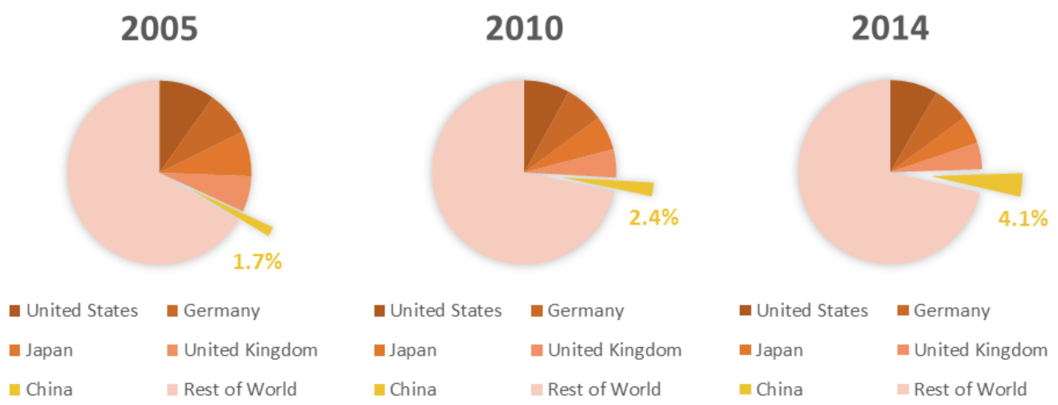
Edibles

China’s food and agricultural sector had evolved over more than ten thousands years and turned into one of the largest and most productive agricultural industries in the world (Karplus & Deng, 2008). With large population and rapid improvement in living conditions, domestic agricultural production can no longer meet the local demand. As such, in 2004 China started to reverse its long-term status as net exporter to net importer of agricultural products (Carter, 2011). Major agricultural imports in China focus on land-intensive products such as soybean, cotton, palm oil and wool, while major exports mostly include the labour-intensive products, such as fruit and vegetables (FAO, 2012). China has taken up a bigger share in both export and import of agricultural products over the past decade (Figure 2 & 3).

Figure 2. China and top exporters of food / agricultural products (% of world total)

(Source: UNCTAD, 2015)

Figure 3. China and top importers of food / agricultural products (% of world total)



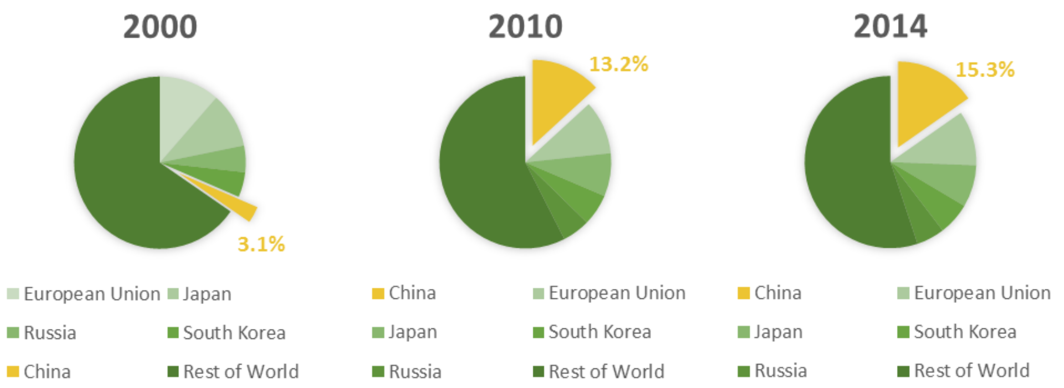
(Source: UNCTAD, 2015)

Industrial Inputs

The fundamental drivers of China's economy, resource-intensive investment and manufacturing exports, underpinned a great demand for imported raw materials, especially metals (Roberts, Saunders, Spence , & Cassidy, 2016). China has become a dominant global importer of metal products, ranging from a 30% share in bauxite and cooper ore, 40% in lead and more than 50% in iron ore (Farooki & Kaplinsky, 2012). If we take steel industry as example, we can see that steel production was a major pillar during the times of planned economy. With the economy reform and increasing demand from domestic construction sector, steel industry developed rapidly in China. It has become a key and strategic industry that accounts for nearly 16% of the country's gross domestic product (GDP) (Kwan, 2014). Although after the financial crisis in 2008 this industry is beset by excessive capacity problem, today

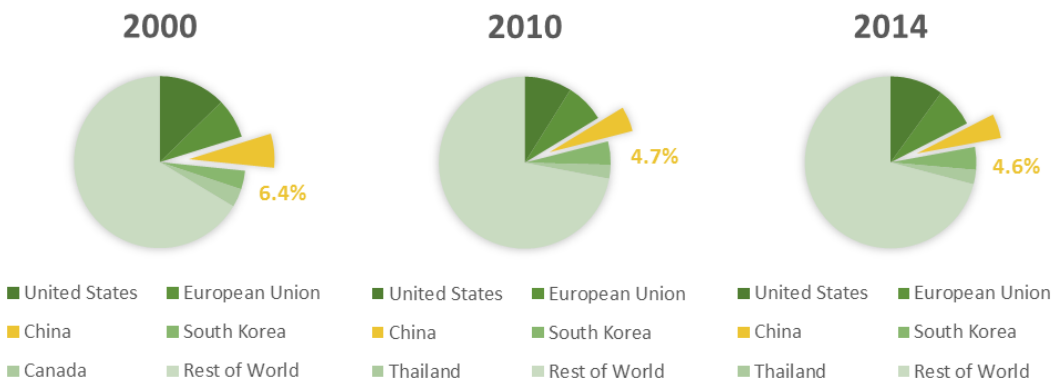
China is still the world’s largest iron ore importer and steel exporter (Figure 4 & 5) (Gandhi & Sarkar, 2016).

Figure 4. China and top exporters of iron ore / steell products (% of world total)



(Source: WTO, 2015)

Figure 5. China and top importers of iron ore / steell products (% of world total)



(Source: WTO, 2015)

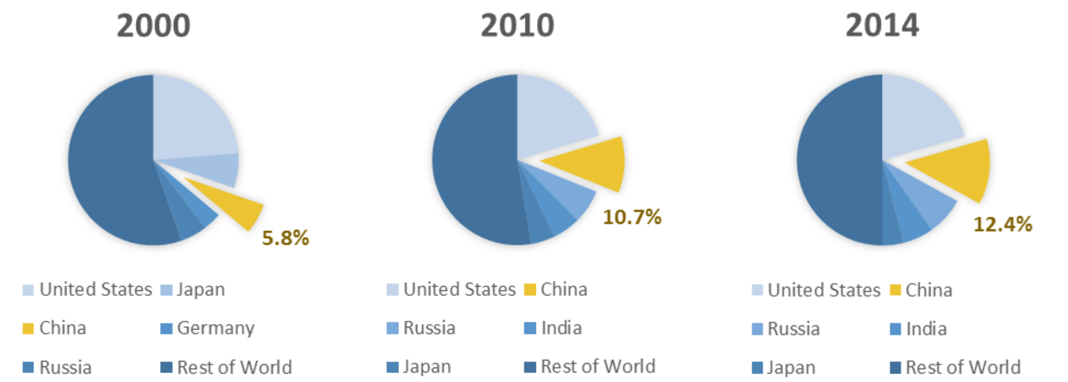
Energy

The expansion of economy and growth of household expenditure have led to a surge in demand for primary energy consumption in China, which had not been able to satisfy the needs of the domestic production since 1990s (Zhao, 2007). At present, the thermal power still plays a leading role in power generation in China. China consumed half of the coal produced worldwide to generate more than 70% of energy consumed domestically (Liu, 2011). Apart from that, it is important to note that China is also a top coal producer. The coal import dependence rate has been below 10% for several years and most of thermal power is generated from local coal (Fan, 2014). Oil and natural gas import dependence rates, however, are relatively high, above 50% and 30% respectively (Fan, 2014). Oil and natural gas considered to be strategic reserves by the Chinese State, the recent drop in prices for these energy commodities has encouraged more oil tankers to sail towards Chinese ports. With the discovery of shale-gas, China is gradually overtaking the US as the world leader in oil imports. In addition, China has launched several ambitious policies to tackle environment issues and to encourage the use of clean energy. As a consequence of this, consumption rate and share of import for natural gas in China is expected to pick up in the next ten years (Figures 6, 7 & 8) (Chen G. , 2009).

Figure 6. China and top consumers of coal (% of world total)

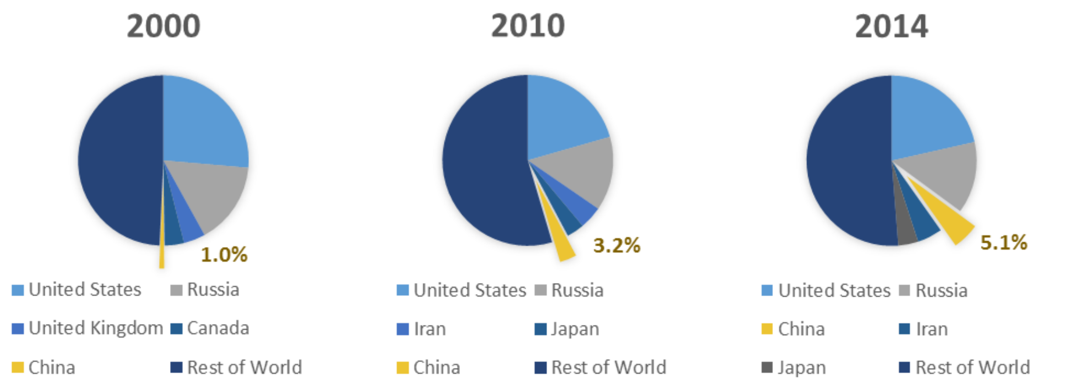
(Source: Enerdata, 2016)

Figure 7. China and top consumers of crude oil (% of world total)



(Source: Enerdata, 2016)

Figure 8. China and top consumers of natural gas (% of world total)



(Source: Enerdata, 2016)

2.2.4 Summary

Undoubtfully, China is generally considered as one of the biggest players in the commodity market. With rapid increase in consumption, China has changed its role from a commodity supplier to a commodity buyer, and its impact on commodity prices has shifted to the demand side rather than to the supply side. However, due to different measurements and scales, it is diffucult to determine in which commodity market China holds relatively more weight and has more impact on the price level of that commodity. Roache (2012) analyzed commodity consumption pattern in 2010, and found that China consumed 23% of agricultural crops, 40% of base metals and 20% of non-renewable energy resources produced worldwide. Assuming such pattern remains the same as at today, it is reasonable to believe that commodity prices are more sensitive to the Chinese influence in industrial inputs sector, than edibles and energy sector.

2.3 Monetary Policy

In this section we provide an overview of monetary policy on a general basis in order to illustrate the unique nature of China's monetary policy in comparison with other major economies. Firstly, the main features of monetary policy are assessed, followed by the overview of monetary policy instruments with open market operation, adjustment of discount rate, change of reserve requirements in respect to expansionary and contractionary monetary polies. In the end of the section, salient features of China's monetary policy are discussed.

2.3.1 Overview of Monetary Policy and Instruments

Monetary policy is an adjustment of money supplied on the market in order to avoid disequilibrium in monetary system, which can also be seen as a attempt to offset changes in money demand by controlling money supply (Salter, 2014). Monetary policy is mostly conducted by a nation's central bank, or similar regulatory committee. By implementing effictive monetary policy, central banks can maintain stable price level, thereby supporting conditions for the long-term economic growth and maximum employment (Federal Reserve, 2016). In most cases, although the goals of monetary policy are estabilished by political authorities, central banks are independent regulatory bodies that conduct monetary policy in pursuit of those goals without political control (Bernanke, 2010). This is because that monetary policy needs to take longer time for full effect, and political myopia may destroy its long-term task. Moreover, monetary policy has often been used as a counter measure for spillover effect resulting from fiscal policy that leads to political power.

The central banks have three major instruments to manage monetary system: open market operations, the discount rate and changes in reserve requirements, which we discuss in detail below.

Open market operations

Open market operations refer to sale and purchase of government securities by using the monetary base, which consists of supply of physical currency and reserves from commercial banks held at the central banks (Salter, 2014). When excess liquidity occurs, central banks reduce money supply through selling assets. If inadequate liqudity occurs, central banks inject money to the market by buying assets. It should be mentioned that the central banks do not have ability to control the whole money supply, but they indirectly control the money supply by directly manipulating monetary base. The more stable the relationship between the base and supply, the more effective is the implementation of the policy by the central banks (Salter, 2014). Mishkin and Serletis (2011) examined the effectiveness of different instruments used by the central banks, and found that open market operation is by far the most effective and flexiable tool, which can be conducted on a day-to-day basis.

Change in discount rate

Discount rate is an interest rate that commercial banks pay for the short-term loans taken from central banks (Mankiw & Taylor, 2014). When investment market is overheated, central banks raise the discount rate so it becomes costly for commercial banks to borrow from the central bank, thus less amount of loan will be lent out and investment is discouraged. Coversely, investment is encouraged if central banks lower their discount rate. Generally speaking, by changing discount rate, the central banks create an incentive mechanism for investment to control money supply.

Change in reserve requirements

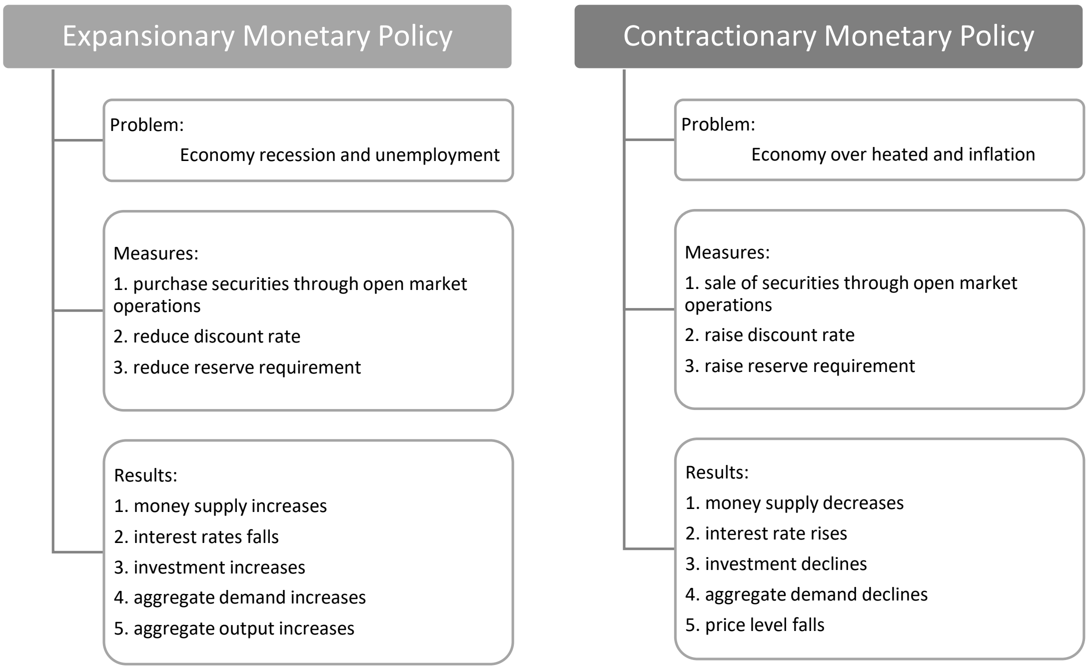
Reserve requirements refer to financial regulation on the minimum amount of reserves that banks must hold against their deposits (Mankiw & Taylor, 2014). By increasing reserve requirements, more reserves are held by the central banks and less money is in supply. Reducing reserve requirements provides commercial banks with more funds to lend thus money supply increases. As change in reserve requirements has a huge impact on money multiplier and disrupts regular business of commercial banks, central banks seldomly use this tool unless the country is under severe recession or inflation (Phillips, 2014).

2.3.2 Expansionary and Contractionary Monetary Policy

The above mentioned monetary policy instruments are the main tools used by central banks to solve economic problems. Keynesian economists believe that the unavoidable booms and busts in economic activitities (i.e. business cycles) can be controlled by government intervention through active monetary policy (Jahan, Mahmud, & Papageorgiou, 2014). An expansionary monetary policy is often used in a recessionary gap, where central bank purchases government bonds, reduces discount rates and reserve requirement ratio in order to increase money supply and boost up investment activities. On the contrary, a contractionary monetary policy is often used in an inflationary gap, where central bank issues government bonds, raises discount rates and reserve requirement ratio in order to reduce money supply and ensure inflation rate remains at a healthy level.

Figure 9 below shows how expansionary and contractionary monetary policy help central banks solve economic problems.

Figure 9. Expansionary and contractionary monetary policy



(Source: Mukherjee, 2015)

2.3.3 Salient Features of China's Monetary Policy

As the world's second largest economy, China has always been a special actor on the world stage. Yet China is not a complete open-market economy, despite the fact that tremendous structural changes in its economy and financial system had happened over the past three decades. Till today, every major policy decision needs approvals from the State, and so does its monetary policy. Pibler (2015) examined the independence of People's Bank of China (PBoC), the central bank of China, and concluded that PBoC is highly dependent on the State Council for the following reasons:

- The capital of PBoC is entirely contributed by the State Council
- The budget of PBoC is evaluated and supervised by the State Council
- PBoC has an obligation to transfer its net profit to the State Treasury

Due to high dependency of PBoC with the central government, monetary policy in China is often used as a political means to solve nation's economic problems. With strong executive ability, monetary policy is more used as a supportive measure rather than a counter measure for fiscal policy led by the State. Hence monetary policy in China has in turns been given more objectives for implementation). Solntsev (2008) summaried the main tasks of China's monetary policy in the following way:

- Stepwise strengthening of the national currency
- Steaming of domestic inflation
- Balancing behaviors of bank loans to enterprises

- Encouraging consumption through consumers, home loans and other financial instruments
- Stepping up of financial stability and competitivess of banking system.

The monetary system in China has its own characteristics that distinguish it from the monetary systems of other major economies. Former member of the Monetary Policy Committee of PBoC, David Li (2013) pointed out the unique nature of the Chinese economy from a monetary perspective, including high domestic saving, large portion of government investment, predominance of national banks, various semi-economic agents and home bias in capital flow. In view of the unique nature, China applies an unconventional approach to manage the monetary system, and its effectiveness usually deviates from our expectations.

Open Market Operations

The history of open market operations in China is relatively short. The PBoC started to initiate open market operations only in 1996, but it unfolded its flexibility and diversity very soon thereafter (Sun, 2015). Central bank bills had been the major characteristic before 2005, but repurchase transactions and currency swaps are now frequently used in the central bank's operations. Open market operations have already taken the most important position in the basket of policy instruments for the PBoC and had been frequently used on a rountine basis (Xu J. , 2006).

- Central Bank Bill:
  This bill is issued by the PBoC as a debtor for financial institutions to monitor and affect RMB foreign-exchange reserves (Yang & Kuhn, 2012). The frequency of central bank bill issuance is twice a week, and PBoC provides a great variety of maturity choices from 3-months to 3-years. The transparency of central bank bill issuance is relatively low and has often been criticised. Partial improvements have been made by PBoC to regularly announce the issuance schedule with maturity terms (Neftci & Menager-Xu, 2007). China has established a reference rate for Chinese interbank loans, similar to the London Interbank Offered Rate (LIBOR) and Euro Interbank Offered Rate (EURIBOR). This reference rate is called the Shanghai Interbank Offered Rate (SHIBOR). The daily reference rate of SHIBOR is measured principally with reference to the current rate of central bank bills. Hence, the PBoC is able to indirectly regulate investment activities of commercial banks by issueing or purchasing central bank bills.

- Repurchase Transactions:
  A repurchase agreement, often referred to as a repo, is a contract for sale of a security with a commitment of the seller to buy back from the buyer at a certain price and on a designated future date (Shevlin & Chang, 2015). The PBoC began to carry out short-term repo (7 to 182 days) in 2004 to enhance efficiency of opening market operations and to strengthen control over the monetary base (Liang, Ouyang, & Willett, 2009). As continuous growth of foreign-exchange reserves leads to constant growth of the monetary base, PBoC's repurchase transactions also have a long-term tendency in practice (Yang & Kuhn, 2012).

- Currency Swaps:
  The central bank local currency swaps consist of an agreement between two central banks for swapping their currencies at a fixed or floating rate, to provide temporary liquidity in a foreign currency (Destais, 2014). Currency swaps and repurchase transactions share similar economic properties, both aimed at withdrawing monetary base from the system (Yang & Kuhn, 2012). By the end of 2015, PBoC has signed bilateral swap agreements with 31 countries for the total amount of more than 3 trillion RMB (US$ 448 billion). The countries that signed bilateral currency swap agreements with China are shown in Appendix I and II. It should be mentioned that the main reason for China being keen to swap deals is to promote internationalization of RMB instead of managing monetary system.

Regulation of Interest Rates

Unlike most of major economies, China does not need to adjust investment behavior indirectly through discount rates, because interest rates of commercial banks in China are regulated by the PBoC. The rationale behinds is to prevent fierce competition between commercial banks and to protect their long-term profitability (Li D. D., 2013). Loan interest rates in China are strictly in line with the indicating leading rate regulated by the PBoC, with restricted floatability (usually at around 10% floating band). Regulating interest rates was often seen as a product of planned economy, and China already embarked on interest rate liberalization reforms. Hence, adjusting interest rates as monetary policy is increasingly rare nowadays.

Change in Reserve Requirements

Change in reserve requirements as a monetary policy has the longest history in China compared to other instruments, and it can be traced back to 1984 where the first reserve requirements regime was established (Sun, 2015). Gehringer (2015) analyzed China's monetary policy framework and pointed out that adjusting reserve requirement ratio is the center of China's monetary policy, and that it had been actively used over the past decades. Pan *et al.* (2012) believed that the close relationship with commercial banks makes it possible to frequently change reserve requirement without much public resistance. Pan *et al.* (2012) also pointed out that although change of reserve requirements has a relatively weak impact on overall money supply in China, it carries a strong symbolic function that suggests the future trend of monetary policy, which can be used as a market indicator.

Other Unconventional Monetary Policy Instruments

Besides explicit instruments, PBoC also frequently implements other atypical instruments such as "window guidance", by putting moral pressure on financial players to make themoperate consistent with national needs. Fernald et al. (2014) investigated the effectiveness of China's monetary policy and their results showed that although unconventional monetary poloicy continues to play important role in the China's economy, the transmission mechanism of China's monetary starts to look more standard and closer to the Western economies.

2.3.4 Summary

Based on the above analysis of monetary policy in general and the monetary policy in China, we summarized traditional and Chinese operation of policy instruments in Table 4:

Table 4. Monetary Policy and Instruments

Traditional Operation of Policy Instruments	China's Operation of Policy Instruments	Corresponding Monetary Policy
- Purchase of Government Securities	- Purchase of Central Bank Bills - Purchase of Repurchase Agreements - Purchase of Foreign Currency through Currency Swap	Expansionary Monetary Policy
- Reduce Discount rate	- Reduce Loan Interest Rate Indicator	
- Reduce Reserve Requirement Ratio	- Reduce Reserve Requirement Ratio	
- Sale of Government Securities	- Sale of Central Bank Bills - Sale of Repurchase Agreements - Sale of Foreign Currency through Currency Swap	Contractionary Monetary Policy
- Increase Discount rate	- Increase Loan Interest Rate Indicator	
- Increase Reserve Requirement Ratio	- Increase Reserve Requirement Ratio	

With regards to the study on monetary policy, common approach is to investigate the average interest rates offered by commercial banks of the selected country. However, given the unique nature of the Chinese monetary policy, interest rate is largely controlled and regulated by the PBoC. Hence, the fluctuation in interest rates cannot fully represent the extent of monetary policy in China compared to other open-market economies. Therefore, it is necessary to find other representative variables to analyze the impact of Chinese monetary policy on commodity pirces. From the analysis of uniqueness of China’s monetary policy, we find that frequent change of reserve requirement ratio is the key feature compared to other major economies, which has potential to be selected to represent direction of China’s monetary policy in general picture.

2.4 Relationship Between Commodity Prices and Monetary Policy

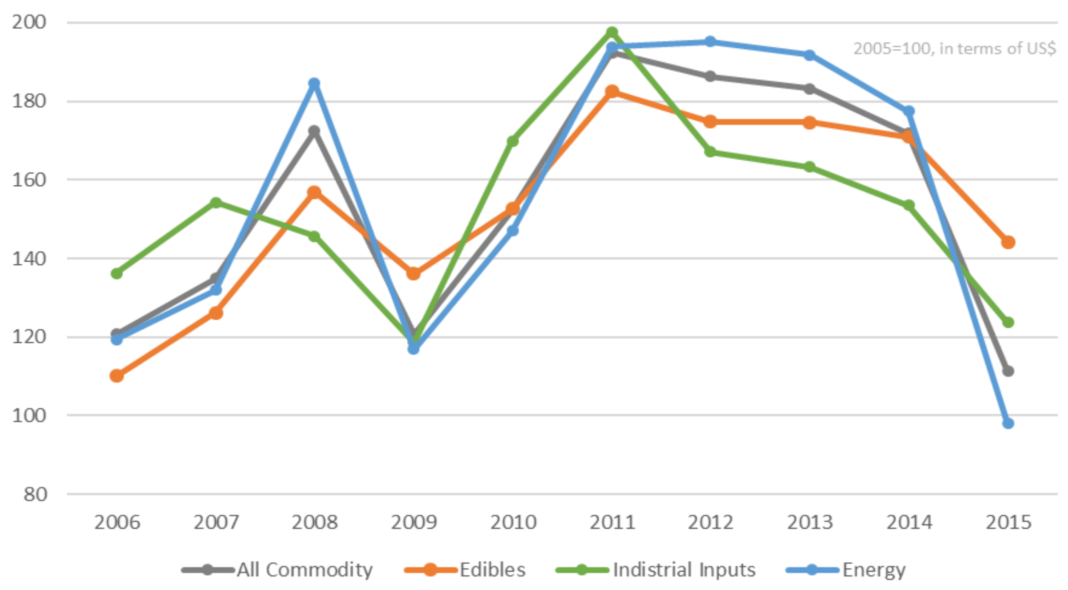
In this section we study the relationship between commodity price and monetary policy based on the historical events and previous research carried out on this topic. Firstly, we introduce the market for the major commodity types from 2006 to 2015. Secondly, we provide an overview of previous studies on the relationship of commodity price and monetary policy. Results from different studies indicate a mixed opinion on this relationship.

2.4.1 Background

Currently the world is experiencing the cheapest-oil era ever since the dramatic price fall in 2014. The decrease in oil price is good news for oil importers such as Japan and China, but bad news for oil exporters such as Russia and Venezuela. The oil price collapse is largely blamed on the price war between Organization of the Petroleum Exporting Countries (OPEC) and the US shale-gas exploiters, mostly due to the failure in achieving cooperative supply restrictions among the OPEC members.

However, it is not the end of the story. Not only oil and petroleum products, iron ore, coal, grain, almost all major commodities have entered into the downlink channel at the same time since 2014, as shown in Figure 10. The rationale behind it is that the plunging commodity prices created curiosity among the economists, and various hypotheses have been proposed to explain this phenomenon.

Figure 10. Commodity price indices (2006 – 2015)

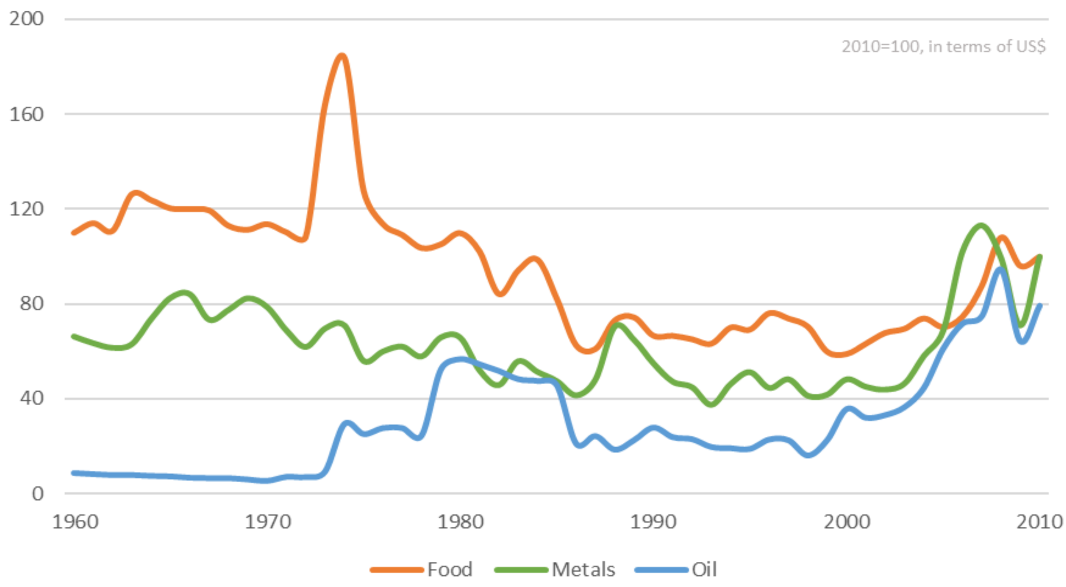


(Source: IMF, 2016)

The most logical explanation is the world economic slowdown. In fact, most of the countries still have not fully recovered from the financial crisis and have to trim their gross domestic product (GDP) growth forecasts. The low economy growth is straining the demand for commodity, which in its turn puts pressure on the commodity market and pushes the prices lower. However, this explanation does not apply to the United States. There are signs that show that a robust economic recovery in the US is on the way, with decreasing unemployment rate and significant trend in increasing capital inflow. But at the same time, major commodity price index in the US market declines, especially compared to the global level (Frankel, 2014).

Looking at previous experiences makes us pay attention to the impact from the monetary policy. To recall a familiar historical pattern: falling US real interest rates in the 1970s, from 2002-2004, and from 2007-2008 pushed up commodity prices, while lifting interest rates in the 1980s did the opposite: commodity prices came under pressure, as shown in Figure 11 (Frankel, 2014). This has given economists and academic researchers a hypothesis on the relationship between monetary policy and commodity market. At the end of 2014, The US Federal Reserve has officially ended the quantitative easing programme, and expectations for a more contractionary monetary policy is raising (Sharf, 2014). Correspondingly, commodity prices are now in a strong bear market. This cannot be simply regarded as a coincidence, and some attributes of plunging commodity prices should be given to the monetary policy.

Figure 11. Historical commodity price indices (1960 – 2010)



(Source: World Bank, 2016)

2.4.2 Literature Review

The research on relationship between monetary policy and commodity price has a long history. Frankel (1984) firstly observed that a rise in money supply would result in increase in real prices of commodities, and claimed that monetary policy would affect world commodity prices. Garner (1989) used monthly data to examine the relationship between oil price, US monetary base and treasury bill. The empirical evidence backed up Frankel's claim and suggested that index of industrial commodity prices can be a useful trend indicator for monetary policymakers. Barsky & Killian (2004) also supported Frankel's view and pointed out that the fluctuation of oil prices can be partially explained by the US monetary policy, which is a good predictor in respect to commodity trading. Leeper and Zha (2003), Amatov and Dorfman (2015) assessed the impact of the US Federal Reserve's movement on commodity prices. Their results showed that the US's monetary policy can generate significant direct effects on various types of commodities through liquidity effect. Frankel (2006) after having reviewed and reanalysed his previous research, pointed out that monetary policy and commodity prices can be mutually influenced, and the effect depends on the size of the countries and their involvement in global market.

The study of theory on transmission mechanism of monetary policy to commodity market has not reached an agreement. Frankel (2014) observed and summarized that high interest rates can affect commodity prices through four possible channels:

- By increasing inventive for extraction and selling products today rather than tomorrow
- By decreasing companies' desire to hold inventories
- By sending signal for portfolio managers to shift out of commodity contracts into treasury bills
- By domestic currency appreciation and reducing price of world traded commodities in domestic terms

On the other hand, Thomson and Summers (2012) re-examined the relationship between monetary policy and commodity prices, and concluded that there is no strong evidence to prove a significant relationship between them. Anzuini et al. (2012) developed an econometric framework based on Vector Autoregression Model (VAR) and concluded that monetary policy does affect commodity prices prices, but the direct effect is not overwhelmingly large and generally occurs in a limited period of time. Amatov and Dorfman (2015) chose a different approach by using Vector Error Correction Model (VECM) and generated a similar result. The results showed that the effect of monetary policy on commodity prices has a longer adjustment period than we expected.

There exis a few studies on the impact of China's monetary policy on commodity prices. Hammoudeh *et al.* (2014) and Chen (2015) used different model to test the effectiveness of China's monetary policy on commodity prices, and their results suggested that there is a long term equilibrium relationship between global commodity prices and China's monetary policy, and China's expansionary monetary policy is positively correlated to commodity prices, but its impact is limited. Wang & Chang (2015) compared the impact of China's and the US monetary policy on commodity prices, and concluded that the impact of the US monetary policy is descreasing while the impact of China's monetary policy is increasing. The main task for this paper is to find out whether China's monetary policy affects commodity prices, and how it does so.

2.4.3 Summary

We summarized the main conclusions from the literature review in Table 5 which presents the response and explanatory variables used in the studies as well as conclusions for each study we analysed.

Table 5. Summary of Literature Reviews

Study	Response Variables	Explanatory Variables	Conclusion
Frankel (1984)	Industrial materials price index,	US interest rates	Rise in money supply would result increase in real prices of commodities.
Garner (1989)	US monetary base and treasury bill rate	US Oil price index	Commodity prices can be good market trend indicators for monetary policy decision-makers.

Study	Response Variables	Explanatory Variables	Conclusion
Barsky & Killian (2004)	World Oil price index,	US CPI inflation	The fluctuation of oil prices can be partially explained by US monetary policy.
Leeper (2003)	IMF world commodity price index,	US CPI inflation, M2 money supply, Federal funds rate	Monetary policy has direct impact on commodity prices through liquidity effect.
Frankel (2006)	Various types of commodity prices and	Various interest rates from selected countries	Monetary policy and commodity prices can be mutually influenced, depends on size of countries and involvement in global market.
Thomson & Summers (2012)	World Oil price index	US interest rates	No strong evidance can prove that a significant relationship exists between monetary policy and commodity price.
Anzuini et al. (2012)	US commodity price index	US CPI inflation, M2 money supply, Federal funds rate	The effect of monetary policy on commodity prices is relatively weak and in a limited period of time
Hammoudeh et al. (2014)	IMF world commodity price index,	China CPI inflation, M2 money supply, interest rates	China's expansionary monetary policy is positively correlated to world commodity prices.
Chen (2015)	Copper future prices	China M1 / M2 money supply, loan interest rate, government credit	There is a long term equilibrium relationship between copper future prices and China's monetary policy
Wang & Chang (2015)	Thomson Reuters/Core Commodity CRB Index (TR/CC CRB)	China M2 money supply, US M2 money supply	There is a relatively large gap in respect of influcial power between US's and China's monetary policy on commodity prices, but the gap is shriking

Various studies show that positive correlation can be found between the US expansionary monetary policy and global commodity prices, and the results are generally based on the fact that the US occupies a pivotal position in the world commodity trading market. Based on previous studies and taking into account the fact of increasing presence of China in the commodity market, we could make our assumption that China's monetary policy could affect global commodity prices as well, whereby an expansionary monetary policy has a positive impact on the prices and vice versa. It is necessary to use statistical analysis to find out whether our assumptions can be proved by empirical evidence.

2.5 Hypotheses and Conclusion

Many studies have been conducted with focus on the U.S. monetary policy and commidity price, but very few studies were carried out on the relationship between the Chinese' monetary policy and commodity price. This may be due to the fact that China has started to become one of the fastest growing emerging economies only in the past twenty years. In addition, the investigated relationship between China's monetary policy and commodity price is not identical, that makes this research rather impotant. Based on the above analysis of the global commodity market and China's monetary policy, together with the review of previous studies, we propose the following hypothesis for our study:

- ***Hypothesis 1****: Expansionary monetary policy in China is positively correlated to global commodity prices.*

If we recall the historical patterns in the US monetary policy and commodity prices, an expansionary monetary policy have the positive side-effect of giving a boost to the commodity prices. We believe such phenomenon certain universality, and expect the same transmission mechanism that also applies to China. In other words, we expect an expanionary monetary policy in China will cause increasing incentive for commodity suppliers to sell earlier instead of holding in inventory, and the associated depreciation of RMB will diminish the purchasing power of Chinese consumers, which in its turn will reduce the price of internationally traded commoties in domestic terms. If such hypothesis can be confirmed, then our results are consistent with the conclusions from the studies of Hammoudeh et al. (2014) and Chen (2015). If not, then our results are contradicting to the conclusions from previous studies and further investigation is required.

- ***Hypothesis 2****: The impact of China's monetary policy on industrial inputs commodity price is larger than on prices of edibles and energy commodities.*

Although it is difficutlt to measure market position of China on different commodity market sectors due to various measuring scale, it is possible to presume based on unified measurement of domestic consumption. In terms of consumption, China consumes more commodity of industrial inputs than edibles and energy commodities, which implies that industrial inputs commodity market relies more on the Chinese market. We expect such dependence lead to industrial inputs commodity being more sensitive to China's monetary policy. If such hypothesis can be confirmed, then we have the evidence to show that the impact of monetary policy of a country on commodity prices is related to its market position, and imply that with increasing importance of China in the commodity market, we can expect a higher degree of influence from China's monetary policy towards global commodity prices in the future. On the other hands, if such hypothesis cannot be confirmed, then we do not have enough evidence to show that the impact of monetory policy of a country on commodity prices is related to its market position, and we cannot conclude that a higer degree of influence from China's monetary policy towards global commodity prices is expected in the future.

- ***Hypothesis 3****: Change of reserve requirement ratio is a suitable indicator to represent China's monetary policy towards variance in commodity prices.*

After studying China's monetary policy and instruments, we find that frequent change of the reserve requirement ratio is the key feature of China's monetary policy, and we expect the the direction of China's monetary policy can be represented by the movement of reserve requirement ratio. If such hypothesis can be confirmed, then we have the evidence to show change of reserve requirement ratios is a good indicator that can be used for forecasting price trend in commodity market. If not, then we do not have enough evidence to show that change of reserve requirement is a good indicator, and other indicators should be considered for testing their ability of forecasting towards price trend in commodity market.

All the hypotheses are in line with our research questions and sub-questions raised in the first chapter.The methodology approach and empirical results to verify the hypotheses stated above are discussed in Chapter 3 and 4.

3. Methodology

3.1 Introduction

This chapter begins with the discussion of time series analysis and statistical tests which will be used in later chapters of this paper. Further, detailed elaboration on data selection has also been included. The chapter continues with explanation on model design in order to answer the main and sub-questions that have been raised in the first chapter.

3.2 Time Series Analysis

A time series is a collection of observations of pre-defined data obtained through repeated measurements over a period of time (ABS, 2008). Time series analysis is mainly focused on the analysis of dependence among adjacent observations and investigate possible internal structures in the data (Mehendiratta, 2015). There are two main goals of time series analysis, one is to identify the nature of the phenomenon represented by the sequence of observations, the other one is to emphasize the improvement of forecasting accuracy (Singhal, 2007). In this paper, we focus on the goal to investigate the relationship between China's monetary policy and global commodity prices. In order to achieve this goal, the pattern of observed time series data needs to be identified and formally described (Singhal, 2007). Such time series data can be classified into two categories, stationary and non-stationary time series, where the former refers to time series that possesses the constant mean and variance over time, and the latter possesses the mean and variance that changes over time. The non-stationary series has no tendency to return to a long term deterministic trend as its variance is dependent on time, and analysis of two non-stationary variables are not consistent, because they may lose their joint relationship over time (Nilsson, 2009). In order to examine a long term relationship, it is necessary to choose stationary data to eliminate time influence.

3.3 Unit Root Test and Cointegration Analysis

To construct a stable and convincing model, unit root test needs to be conducted in order to ensure time series data selected are stationary. In this paper, unit roots are tested by Augmented Dickey-Fuller (ADF) test, a standard unit root test created by Dickey and Fuller (1979). The ADF test can be briefly expressed in the following way:

$$\Delta y_t = \alpha + \beta y_{t-1} + (\delta t) + \varphi_1 \Delta y_{t-1} + \varphi_2 \Delta y_{t-2} + \cdots + \varphi_k \Delta y_{t-k} + \varepsilon_t$$

where Δy_t is the first order difference of time series y_t and k is the number of lags for Δy. The stationarity of time series can be indicated by testing the null hypothesis when the coefficient of y_{t-1} (β) is equal to zero. If $\beta = 0$, the time series is non-stationary, if $\beta \neq 0$, the time series is trend-stationary and can be used in our model.

Unit root test is mainly a descriptive tool used to classify time series data as stationary or non-stationary. As non-stationary time series lead to non-standard distributions and perhaps spurious regression results. The recommendation for ADF test is to reject the hypothesis if there is a clear evidence for rejection, and classify such variable as stationary, or perhaps deterministic trend stationary, which can sort out the long term and the short term effects to be investigated in the VAR model (Sjo, 2008).

If two or more time series data are non-stationary, but a liner combination of them is stationary, then such series are said to be cointegrated (Meyers, 2011). Cointegrated variables follow an equilibrium relationship in the long-run, although they cannot find that equilibrium in the short-run (Zakrajsek, 2009). Time series data can be cointegrated in various ways and Johansen's maximum eigenvalue Test is often used to examine the existence of cointegration. The approach of Johansen test is based on the maximum likelihood estimation under assumption of normal distributed error variables (Kestel, 2003). The simplest form of VAR model is presented below, where k denotes the number of lags taken into account:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_k y_{t-k} + u_t$$

In order to use Johansen test, the VAR model needs to be transformed into a vector error correction model (VECM:

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 + \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t$$

where there are g variables and k-1 lags of dependent variables. Γ_i is the coefficient matrix for every lagged variable and Π is the long-run coefficient matrix (Hubana, 2013).

This VECM is estimated by use of a maximum likelihood estimation process, and the Johansen test can be seen as a multivariate case of an ADF unit root test. The Johannsen Test is used to find out the rank (r) of the matrix of Π. The focus of the test is to examine the rank (r) with no. of variables in the model (g). There are three possible cases, based on the rank ® of the matrix of Π (Hubana, 2013):

- r = g: all eigenvalues are largely different than 0, which indicates that the original variables are stationary and there is no cointegration relationship between the variables.
- r = 0: no eigenvalue is significantly different from 0, which indicates that there are no linear combinations of variables that are $\mathrm{I}(0)$, and there is no cointegration relationship between the variables.
- 0 < r < g: there are r linear combinations of variables that are $\mathrm{I}(0)$, which indicates that cointegration relationship exists between the variables, with r cointegrating vectors.

The Johansen Test examines whether the largest eigenvalue is 0 relative to the alternative that the next largest eigenvalue is 0 (Dwyer, 2015). We denote the rank of matrix Π as r and derives the following hypotheses:

$$H_0(r_0) : r = r_0$$

$$H_1(r_0) : r = r_0 + 1$$

where r_0 = 0, 1, 2…

Hypothesis tests will be continued until no significant evidence shows that H_0 should be rejected. The test of maximum eigenvalue is a likelihood ratio (LR) test, which can be written as follows (Dwyer, 2015):

$$\text{LR}(r_0, r_0+1) = -Tln(1-\lambda_{r_0+1})$$

where $\text{LR}(r_0, r_0+1)$ is the likelihood ratio test for examining whether r = r_0, T is the sample size and λ_i is the i^{th} largest eigenvalue. In this thesis the critical values with respect to the LR ratio, are proposed by Mackinnon, Haug, & Michelis (1999).

Cointegration analysis could reveal whether the global commodity prices and China's monetary policy move together over a longer period of time. If cointegration relationship exists, it implies that there is a long-run relationship between both time series, which further implies that there exists Granger causality between both variables in at least one direction (Jalil, Manan, & Saleemi, 2016). Through the results of cointegration coefficient we could see the direction (whether the variables are positively or negatively correlated) and the degree of influence between the variables. However, cointegration analysis does not indicate the direction of the causality. Hence, it is necessary to use Granger casualty test to ascertain the direction of the causality. In addition, impulse response functions and variance decompositions analysis can be used to investigate the short-term dynamics about this relationship.

3.4 VAR Model

The Vector Autoregrassion (VAR) model is one of the most flexible econometric models frequently used for analysis of multivariate time series. It is a natural extension of univariate autoregressive model to dynamic multivariate time series (Zivot, 2006). VAR model provides empirical evidence on the response of macroeconomic variables to various exogenous impulses in order to analyze the relationship between the variables (Iacoviello, 2011). Granger causality test, impulse response, variance decomposition are the tools proposed for disentangling the relations between the variables in the VAR model (Luetkepohl, 2011).

A VAR model is an n-equation, n-variable model in which each variable can be explained by its own values over a lag period, together with current and past values of the remaining variables (Iacoviello, 2011). A P^{th} order VAR model, VAR(P) can be written as follows:

$$y_t = \Phi_0 + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \cdots + \Phi_p y_{t-p} + \varepsilon_t$$

where Φ_i are (k x k) coefficient matrices and ε_t is an (k x 1) unobservable zero mean white noise vector process (uncorrelated or independent) (Zivot, 2006). Additional assumption for ε_t is that $\text{E}_{t-1}(\varepsilon_t) = 0$.

Traditionally VAR model requires all the input variables to be stationary, whereby each variable fluctuates around its mean value over time. It is necessary to pre-test for unit roots and cointegration prior the VAR analysis in order to make sure that suitable variables are chosen for the model. If the stationary requirement cannot be fulfilled, differencing to induce stationarity can be used in order to generate a stationary time series. It is worth to mention that differencing may throw away some possible information on the long-term relationships between the variables (Brooks & Tsolacos, 2010).

The VAR model used in our paper consists of two components, one represents global commodity prices and the other one represents China's monetary policy. Our main goal for this paper is to find out the impact of China's monetary policy on commodity prices, hence we have chosen to use time series data for global commodity prices as response variables and data for China's monetary policy as explanatory variables. We have selected various time series data used for VAR model, which are detailed elaborated and explained in Chapter 3.5.

The VAR model can provide framework for analyzing relationship between China's monetary policy and commodity prices, through Granger Causality test, impulse response functions and variance decompositions. Combined, these techniques allow us to have a clearer picture of how China's monetary policy affects the world commodity prices.

3.4.1 Granger Causality Test

Granger (1969) has developed a concept of 'granger causality' that is different from normal causality, which simply indicates one factor directly caused another. Granger causality is an econometric tool based on F-test framework to determine whether one time series variable can be used to predict the future of another variable (Xu & Sun, 2010). For example, if past values of X can be used to predict Y more accurately than by simply using the past values of Y. In other words, past values of X statistically improve the prediction of Y, then we could conclude that X 'Granger causes' Y (Comincioli, 1996). In practice, we take two variables into the following model:

$$Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{i=1}^{n} \beta_i X_{t-i} + \varepsilon_t$$

$$X_t = \alpha_0 + \sum_{j=1}^{n} \alpha_j Y_{t-j} + \sum_{j=1}^{n} \beta_j X_{t-j} + \varepsilon_t$$

We make hypothesis that X does not Granger cause Y and test whether β_i (i=1,2…n) = 0. If $\beta_i \neq 0$, then hypothesis should be rejected and we can conclude that X Granger causes Y. Similarly, we can test whether β_j (i=1,2…n) = 0 and determine whether Y Granger cause X. It is essential for selecting forecast indicators, as reverse Granger causality will result in a misleading solution.

3.4.2 Impulse Responses and Variance Decomposition

Granger causality test may not tell the full story about interactions between the variables, it is often of interest to investigate the impulse response relationship between the two variables in a higher dimensional system (Rossi, 2010). Impulse responses in VAR model mainly examine how and to what extent the dependent variables react to shocks from each independent variable (Xu & Sun, 2010). Impulse response functions (IRFs) trace the effects of one standard deviation shock to one of the time series data over a long period of time (Yonis, 2013). Pesaran and Shin (1998) designed a generalized impulse response function, which could adjust the effect of variables in different order and plotted in historical patterns for better demonstration.

Variance decomposition divides the variation in an endogenous variable into component shocks to the VAR model, which allows us to generate information with respect to relative importance of each random innovation in affecting the variables in the VAR model (Iacoviello, 2011). It traces out the proportion of the movements in the dependent variables that are due to their own shocks or other independent variables (Xu & Sun, 2010). The aim is to reduce uncertainty in one equation to the variance of error terms in all equations (Fuss, 2008).

Both impulse responses and variance decomposition emphasize the short term dynamic effect and our main task is to focus on the long term relationship. Hence, we only consider the results of impulse responses and variance decomposition as a confirmation of cointegration analysis and Granger causality test. It is worth mentioning that short term dynamics may differ from the effect in the long run due to market speculation activities (Li & Loewenstein, 2015). In terms of choosing forecasting indicator, the short term effect of selected variable should match its long term effect generated from the cointegration analysis.

3.5 Data Selection

Before moving towards model design, we first select the time series data that will be used for the model. We discuss seperately the response variables (dependent variables) and explanatory variables (independent variables) that have been chosen for this paper. The response variables consist of time series data representing commodity prices and explanatory variables consist of time series data representing China's monetary policy. We use monthly data for out research and the selected period for our data sample ranges from Janurary 2006 to December 2015 (ten years). In order to examine the impact of China's monetary policy on prices of commodities in different sectors, we have divided our research into three seperate groups according to IMF's catogeries, namely edibles, industrial inputs and energy sectors.

For response varibles, we use monthly commodity price indices published by IMF. As the raw index data are not seasonaly adjusted, firstly we de-seasonalize the index data (seasonal indices can be found in Appendix III). We divide the commodity prices into three sectors, and select representative indices for each sector of our model in the following way:

- *Food Commodity Index (FOD)*: food commodity index is used to represent edible sector, as 90% of edible commodities are contributed from food sector, and major edible commodities imported by China are food agricultural products (IMF, 2016).

- *Metal Commodity Index (MET):* metal commodity index is used to represent indistrial inputs sector, as 58% of indistrial inputs commodities contributed from metal sector, and major indudstrial inputs imported to China are metal commodities (IMF, 2016).

- *Petroleum Commodity Index (PTO):* petroleum commodity index is used to represent energy sector, as 85% of energy commodities refer to petroleum products (IMF, 2016). In addition, China consumers large scale of coal, but mostly through domestic production, and LNG market is growing but has not reached a significant level in the global market. Hence we use petroleum index to represent the energy sector.

In terms of explanatory varibles, we have selected M2 money supply as main studying data for China's monetary policy, as it is so far the most comprehensive indicator in

China that is representative for China's monetary policy (Wang & Chang, 2015). Despite its generality, it is often the case that the public needs to wait for the announcement of monthly M2 money supply figures for at least three months, which is incovenient for commodity trading company to get ahead of the market. Hence, M2 money supply is not a good indicator for commodity traders in terms of market forecasting, and we have selected other indicators to represent China's monetary policy. The selected explanatory variables are as follows:

- *M2 Money Supply (M2S)*: M2 aggregate money supply includes narrow money (such as coins and notes in circulation, other money equivalents that are easily convertible into cash), short-term time deposits in banks and 24-hour money market funds (Kariithi, 2007). Due to unconventional monetary policy implemented in China, M2 is the closest indicator that could capture the broad concerns of central banks towards the dynamics of money markets as well as credit condions (Hammoudeh, Nguyen, & Sousa, 2014). Increase in M2 money supply indicates that an expansionary monetary policy was implemented, while a decrease indicates that a contractionary monetary policy was implemented.

- *3-month Shanghai Interbank Offered Rate (SHIBOR)*: China attempts to liberalize interest rates in 2006, with the creation of a benchmark interest rate, the Shanghai Interbank Offered Rate (SHIBOR) (Mavredakis, 2014). SHIBOR was modeled after the London Interbank Offered Rate (LIBOR) to provide leading rate guidance for interbank system. Currently, three-month SHIBOR is mainly measured with reference to the rate of the central bank bill (Wang J. , 2015). Due to the lack of transparancy in the central bank bill rate, we have selected 3-month shibor to represent the dynamics in PBoC's open market operation. A decrease in SHIBOR indicates that the central bank is launching an expansionary monetary policy through open market operation, and increase in SHIBOR indicates that an contractionary monetory policy is being launched.

- *Mid-term Loan Interest Rate Indicator (LII)*: Although interest rate liberlization is in progress during this period, the state-owned banks still occupy the dominant position and strictly follow the lending rate governed by the PBoC with limited floatability (around 10% floating band) (Deng & Chen, 2016). Hence we have chosen to use interest rate indicator for the mid-term loan (one to three years) to represent the dynamics of change in interest rates. Lowering loan interest rate is a typical expansionary monetary policy, and increasing loan interest rate is a typical contractionary monetary policy. The list of changes of mid-term loan interest rate indicator from 2006 to 2015 can be found in Appendix IV.

- *PBoC Reserve Requirement Ratio (RR)*: Compared to other monetary policy instruments used by PBoC, change of reserve requirement is the most transparent and such change will often be announced in advance (one or two days before the implementation of the regulation). We have selected change in statutory reserve requirement ratio to represent the dynamics of reserve requirement system. Lowering reserve requirement ratio is a typical expansionary monetary policy, and increasing reserve requirement ratio is a typical contractionary monetary policy. The list of changes of PBoC reserve requirement ratio from 2006 to 2015 can be found in Appendix V.

Table 6 below illustrates the changes in explanatory variables and their corresponding monetary policy:

Table 6. Explanatory variables and corresponding monetary policy

M2S	SHIBOR	LII	RR	Corresponding Monetary Policy
Increase	Decrease	Decrease	Decrease	Expansionary Monetary Policy
Decrease	Increase	Increase	Increase	Contractionary Monetary Policy

To summarize, for our analysis we have selected the time series data presetned in Table 7, and all the data is transformed into the natural logarithm form in order to smoothen the time trend:

Table 7. Summary of response and explanatory variables

Variables		Short for	Transformation
Response Variables	Food Commodity Price Index	FOD	Logarithm
	Metal Commodity Price Index	MET	Logarithm
	Petroleum Commodity Price Index	PTO	Logarithm
Explanatory Variables	M2 Money Supply	M2S	Logarithm
	Shanghai Interbank Offered Rate	SHIBOR	Logarithm
	Mid-term Loan Interest Rate Indicator (1 – 3 years)	LII	Logarithm
	Reserve Requirement Ratio	RR	Logarithm

3.6 Methodology Design

The major focus for this paper is on the results from cointegration analysis and VAR model. The cointegration analysis is used to solve the first two sub-questions, and investigates the relationship between China's monetary policy and global commodity prices, and examines which types of commodities will be most affected by China's monetary policy.

Through the results of Granger causality test, impulse response and variance decomposition and partial results from cointegration analysis, the third sub-question, the suitable indicator for China's monetary policy towards global commodity price can be solved. Based on the characteristics of VAR model and associated tests, we have established the criteria for selecting the best possible indicator for China's monetary policy as follows:

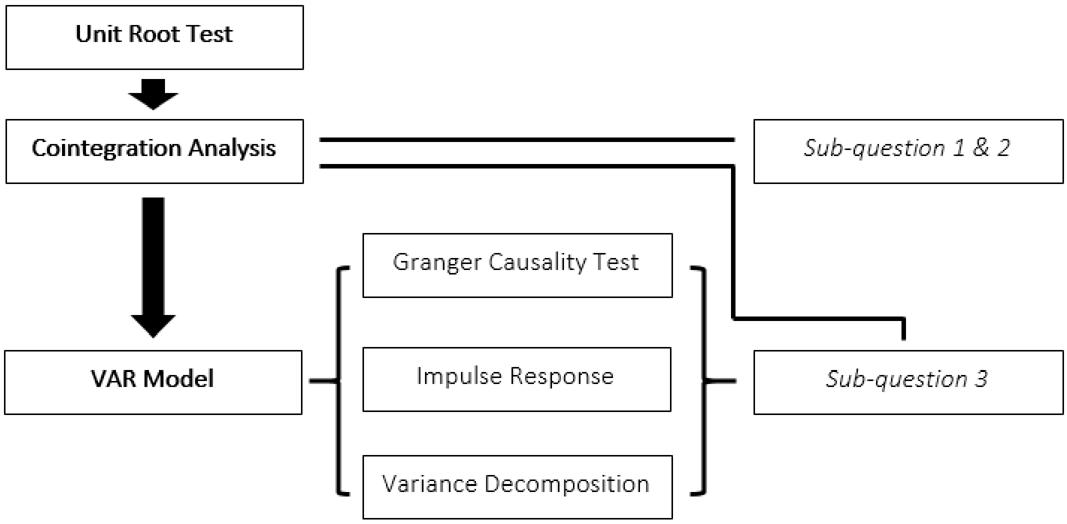
- The results of cointegration analysis for indicators should be in line with the results of M2S towards commodity prices (for example, if results show that M2S is positively correlated with commodity prices, then SHIBOR, LII and RR should be negatively correlated with commodity prices).

- The results of Granger causality test should indicate that past values of indicators should be able to statistically improve the prediction of commodity prices

- The results of impulse response should indicate that the short term dynamics between indicators and commodity prices should match their long term trend

In addition to fulfilling the above criteria, the suitable indicator should also bear greater relevance with change in commodity prices, both in long term (through the results of cointegration analysis) and short term (through the results of variance decomposition) compared to other indicators. The diagram of research design for this paper is shown below in Figure 12:

Figure 12. Methodology design



3.7 Conclusion

In this chapter we discussed the methodology approach used for this paper and explained the data used for the model. In the end of the chapter we presented the structure of the methodology approach. The empirical results are reported in the next chapter.

4. Empirical Results and Analysis

4.1 Introduction

This chapter begins with unit root tests to ensure the stationarity of the selected time series. Further, cointegration analysis will be carried out and VAR models will be built. Granger causality tests, impulse responses and variance decompositions will be conducted based on the VAR models. All the results generated in this paper are from time-series oriented econometric software – EViews.

4.2 Unit Root Stationary Test

Most economic variables used for the analysis are characterized by high persistence and possibly nonstationary behaviour, and it is necessary to pre-test them for unit roots prior to VAR analysis to determine appropriate transformation that could render data stationary (Gospodinov, Herrera, & Pesavento, 2013). We apply the Augmented Dickey-Fuller (ADF) test to examine stationarity of our time series variables, the results of the test are presented in Table 8:

Table 8. Results of unit root tests

Logarithm	ADF	P-value	Stationarity	First Order Difference	ADF	P-value	Stationarity
LNFOD	-2.3677	0.1531	nonstationary	DLNFOD	-6.7778	0.0000	stationary
LNMET	-1.7824	0.3876	nonstationary	DLNMET	-7.2867	0.0000	stationary
LNPTO	-1.7776	0.3900	nonstationary	DLNPTO	-7.1648	0.0000	stationary
LNM2S	-0.2138	0.9921	nonstationary	DLNM2S	-5.5451	0.0000	stationary
LNSHIBOR	-2.4869	0.1212	nonstationary	DLNSHIBOR	-5.869	0.0000	stationary
LNLII	-2.1643	0.2205	nonstationary	DLNLII	-5.5058	0.0000	stationary
LNRR	-3.3824	0.0135	stationary	DLNRR	-3.7011	0.0052	stationary

Based on these results, we can see (at 5% significance level), that the results are all non-stationary except for LNRR. Then we test for the first order difference of the selected variables and the results are all stationary. Therefore, we choose to use first order difference of selected time series variables for the model in order to fulfil the stationary requirement.

4.3 Cointegration Analysis

The above unit root test results show that LNFOD, LNMET, LNPTO, LNM2S, LNSHIBOR and LNLII is non-stationary, but it does mean that a stationary relationship cannot be found through inter-combination between them. In this section we use the Johansen's maximum eigenvalue test to investigate the cointegration relationship between our original selected data set. The results are separated by different commodity groups

Edibles

We take LNFOD, LNM2S, LNSHIBOR, LNLII, LNRR for the Johansen's max-eigenvalue test. Results are presented in Table 9:

Table 9. Results of Johansen's max-eigenvalue test (FOD)

Hypothesized No. of CE（s）	Eigenvalue	Max-Eigen Statistic	At 5% Critical Value	P-value
None *	0.483466	77.9525	34.8058	0.0000
At most 1 *	0.218049	29.0236	28.5880	0.0440
At most 2 *	0.203108	26.7902	22.2996	0.0110
At most 3	0.122494	15.4192	15.8921	0.0592
At most 4	0.049483	5.98846	9.1645	0.1916

The Johansen's max-eigenvalue test shows that at 5% significance level, there are three cointegration relationships among selected variables, which suggests an equilibrium relationship in the long-run. The unrestricted cointegrating coefficients are generated and presented in Table 10:

Table 10. Cointegrating coefficients (FOD)

Variables	LNFOD	LNM2S	LNSHIBOR	LNLII	LNRR	C
Cointegrating Coefficients	1.0000	-1.1843	0.4730	2.5592	-1.3765	-22.0817
Standard Error		(0.3739)	(0.3470)	(1.3830)	(0.3768)	(6.1987)

Based on the results reported above we can write the cointegration equation as follows:

$$\mathrm{LNFOD} = 1.1843 * \mathrm{LNM2S} - 0.4730 * \mathrm{LNSHIBOR} - 2.5592 * \mathrm{LNLII} + 1.3765 * \mathrm{LNRR} + 22.0817$$

The cointegration equation and Johansen's Max-eigenvalue Test results show that there is a long-term stable equilibrium between food commodity prices and China's monetary policy. In our selected sample, the coefficients for M2S and RR are 1.1843 and 1.3765 respectively, which means that 1% increase in M2S or RR will result in 1.1843% or 1.3765% increase on food commodity prices. The coefficients for SHIBOR and LII are 0.4730 and 2.5592 respectively, which means that 1% increase in SHIBOR or LII will result in 0.4730% or 2.5592% decrease on food commodity prices. M2S and RR have positive effect on food commodity prices, and SHIBOR and LII have negative effect on food commodity prices, among which LII influences the price level of food commodities the most in the long-run, based on the comparison of absolute values of cointegration coefficients. The results of SHIBOR and LII are in line with the results of M2S, while the results of RR contradicts the results of M2S.

Industrial Inputs

We take LNMET, LNM2S, LNSHIBOR, LNLII, LNRR for The Johansen's Max-eigenvalue Test. Results of this test are reported in Table 11:

Table 11. Results of Johansen's max-eigenvalue test (MET)

Hypothesized No. of CE（s）	Eigenvalue	Max-Eigen Statistic	At 5% Critical Value	P-value
None *	0.491020	169.9498	76.9727	0.0000
At most 1 *	0.243349	90.2588	54.0790	0.0000
At most 2 *	0.205356	57.3541	35.1927	0.0001
At most 3 *	0.129075	30.2305	20.2618	0.0015
At most 4 *	0.111297	13.9230	9.16454	0.0059

The Johansen's Max-eigenvalue Test shows that at 5% significance level, there are more than four cointegration relationships among the variables, which suggests an equilibrium relationship in the long-run. The unrestricted cointegrating coefficients are reported in Table 12:

Table 12. Cointegrating coefficients (MET)

Variables	LNMET	LNM2S	LNSHIBOR	LNLII	LNRR	C
Cointegrating Coefficients	1.0000	-1.8725	0.9471	4.7214	-1.5318	-34.4864
Standard Error		(0.4186)	(0.3888)	(1.5542)	(0.4220)	(6.9513)

Based on these results we can write the cointegration equation as follows:

$$\mathrm{LNMET} = 1.8725 * \mathrm{LNM2S} - 0.9471 * \mathrm{LNSHIBOR} - 4.7214 * \mathrm{LNLII} + 1.5318 * \mathrm{LNRR} + 34.4864$$

The cointegration equation and Johansen's Max-eigenvalue Test results show that there is a long-term stable equilibrium between metal commodity prices and China's monetary policy. In our selected sample, the coefficients for M2S and RR are 1.8725 and 1.5318 respectively, which means that 1% increase M2S or RR will result in 1.8725% or 1.5318% increase on metal commodity prices. The coefficients for SHIBOR and LII are 0.9471 and 4.7214 respectively, which means that 1% increase in SHIBOR or LII will result in 0.9471% or 4.7214% decrease on metal commodity prices. M2S and RR have positive effect on metal commodity prices, and SHIBOR and LII have negative effect on metal commodity prices, among which LII influence the price level of metal commodities the most in the long-run, based on the comparison of absolute values of cointegration coefficients. The results of SHIBOR and LII are in line with the result of M2S, while the result of RR contradicts the result of M2S.

Energy

We take LNPTO, LNM2S, LNSHIBOR, LNLII, LNRR for the Johansen's Max-eigenvalue Test and generate the following results reported in Table 13:

Table 13. Results of Johansen's max-eigenvalue test (PTO)

Hypothesized No. of CE（s）	Eigenvalue	Max-Eigen Statistic	At 5% Critical Value	P-value
None *	0.492751	80.0929	34.8058	0.0000
At most 1 *	0.217264	28.9053	28.5880	0.0455
At most 2	0.164403	21.1938	22.2996	0.0708
At most 3	0.092872	11.5016	15.8921	0.2168
At most 4	0.054668	6.63379	9.16454	0.1471

The Johansen's Max-eigenvalue Test shows that, at 5% significance level, there are two cointegration relationships among variables. The unrestricted cointegrating coefficients are as reported in Table 14:

Table 14. Cointegrating coefficients (PTO)

Variables	LNPTO	LNM2S	LNSHIBOR	LNLII	LNRR	C
Cointegrating Coefficients	1.0000	-2.8898	1.3853	6.2199	-2.3846	-48.8228
Standard Error		(0.7995)	(0.7422)	(2.9550)	(0.8079)	(13.2423)

Based on these results we can write the cointegration equation as follows:

$$\mathrm{LNPTO} = 2.8898 * \mathrm{LNM2S} - 1.3853 * \mathrm{LNSHIBOR} - 6.2199 * \mathrm{LNLII} + 2.3846 * \mathrm{LNRR} + 48.8228$$

The cointegration equation and Johansen's Max-eigenvalue Test results show that there is a long-term stable equilibrium between petroleum commodity prices and China's monetary policy. In our selected sample, the coefficients for M2S and RR are 2.8898 and 1.3853 respectively, which means that 1% increase in M2S or RR will result in 2.8898% or 2.3846% increase on petroleum commodity prices. The coefficients for SHIBOR and LII are 1.3853 and 6.2199 respectively, which means that 1% increase in SHIBOR or LII will result in 1.3853% or 6.2199% decrease on petroleum commodity prices. M2S and RR have positive effect on petroleum commodity prices, and SHIBOR and LII have negative effect on petroleum commodity prices. LII influence the price level of petroleum commodities the most in the long-run, based on the comparison of absolute values of cointegration coefficients. The results of SHIBOR and LII are in line with the result of M2S, while the result of RR contradicts the result of M2S.

In conclusion, we summarized the results of cointegration analysis in Table 15. "Direction" and "Degree" in the table refer to the direction and the degree of influence correlated between China's monetary policy and commodity prices. The degree of influence is represented by the absolute values of cointegration coefficients.

Table 15. Summary of results of cointegration analysis

Variables	M2S		SHIBOR		LII		RR	
	Direction	Degree	Direction	Degree	Direction	Degree	Direction	Degree
FOD	Positive	1.18	Negative	0.47	Negative	2.56	Positive	1.38
MET	Positive	1.87	Negative	0.95	Negative	4.72	Positive	1.53
PTO	Positive	2.89	Negative	1.39	Negative	6.22	Positive	2.38

4.4 VAR Model Analysis

Cointegration analysis can only explain the long-run equilibrium relationship, but this relationship cannot constitute a statistical cause-and-effect relationship, which means that statistical order of precedence between the two time series cannot be demonstrated (Gutierrez, 2007). In addition, we are also interested to investigate the short term dynamics between monetary policy and commodity prices. Therefore, we use VAR model to help us solve these problems. The statistical causality can be examined by Granger Causality Test and short term dynamics can be testified by impulse response and variance decomposition. The step of constructing VAR models is to decide on the number of lags used for each model.

4.4.1 Lag Length Selection

VAR model is very sensitive to the number of lags that were chosen. In order to achieve a better result, we have used several optimal lag selection standards to help us find the best suitable lag length for our model. The selection standards include sequential modified LR test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), Hannan-Quinn information criterion (HQ). Test results can be found in Appendix VI. The optimal lag lengths are chosen from the results of majority. Based on the results, the optimal lag lengths for FOD, MET and PTO are two, one and one respectively, as shown in Table 16:

Table 16. Optimal lag lengths for VAR models

Response Variables	Selection Criteria	Optimal Lag Length
FOD	LR / FPE / AIC	2
MET	FPE / AIC / SC / HQ	1
PTO	FPE / AIC / SC / HQ	1

Based on the suggested optimal lag length from the above results, we can build VAR models for each group. The established VAR models can be found in Appendix VII and the constructed VAR models for each sector can be written in matrices in the following way:

Edibles

$$\begin{pmatrix} DLNFOD_t \\ DLNM2S_t \\ DLNSHIBOR_t \\ DLNLII_t \\ DLNRR_t \end{pmatrix} = \begin{pmatrix} 0.4570 & 0.0167 & 0.0332 & 0.0951 & 0.0437 \\ 0.3573 & -0.1281 & 0.9640 & 0.2184 & 0.1267 \\ -0.0428 & -0.0259 & 0.3333 & -0.0106 & -0.0140 \\ -0.2481 & -0.1218 & 1.3617 & 0.3855 & 0.0656 \\ -0.0032 & 0.1312 & 0.2266 & 0.0788 & 0.4669 \end{pmatrix} \begin{pmatrix} DLNFOD_{t-1} \\ DLNM2S_{t-1} \\ DLNSHIBOR_{t-1} \\ DLNLII_{t-1} \\ DLNRR_{t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} -0.0148 & 0.0358 & 0.8321 & 0.1873 & 0.1461 \\ 0.4555 & 0.0065 & -0.8297 & 0.2775 & 0.0303 \\ 0.0279 & 0.0022 & -0.2270 & -0.0002 & -0.0069 \\ 0.4608 & -0.0227 & 0.8424 & 0.0778 & 0.0747 \\ 0.0526 & -0.0851 & -0.4386 & 0.0035 & 0.1307 \end{pmatrix} \begin{pmatrix} DLNFOD_{t-2} \\ DLNM2S_{t-2} \\ DLNSHIBOR_{t-2} \\ DLNLII_{t-2} \\ DLNRR_{t-2} \end{pmatrix} + \begin{pmatrix} -0.0093 \\ 0.0139 \\ 0.0017 \\ -0.0080 \\ 0.0005 \end{pmatrix}$$

Industrial Inputs

$$\begin{pmatrix} DLNMET_t \\ DLNM2S_t \\ DLNSHIBOR_t \\ DLNLII_t \\ DLNRR_t \end{pmatrix} = \begin{pmatrix} 0.3366 & 0.0087 & 0.1848 & 0.0650 & 0.0233 \\ 0.3734 & -0.1211 & 1.3529 & 0.2506 & 0.1741 \\ -0.0064 & -0.0288 & 0.2872 & -0.0087 & -0.0095 \\ 0.2946 & -0.1112 & 1.511 & 0.5094 & 0.1763 \\ 0.0593 & 0.0870 & 0.1198 & 0.1563 & 0.5927 \end{pmatrix} \begin{pmatrix} DLNMET_{t-1} \\ DLNM2S_{t-1} \\ DLNSHIBOR_{t-1} \\ DLNLII_{t-1} \\ DLNRR_{t-1} \end{pmatrix} + \begin{pmatrix} -0.0060 \\ 0.0138 \\ -0.0146 \\ -0.0046 \\ 0.0008 \end{pmatrix}$$

Energy

$$\begin{pmatrix} DLNPTO_t \\ DLNM2S_t \\ DLNSHIBOR_t \\ DLNLII_t \\ DLNRR_t \end{pmatrix} = \begin{pmatrix} 0.3600 & 0.0148 & 0.0580 & 0.0710 & 0.0517 \\ -0.0568 & -0.1347 & 1.3534 & 0.1935 & 0.1239 \\ 0.0308 & -0.0274 & 0.2986 & -0.0010 & -0.0048 \\ -0.0586 & -0.1329 & 1.9640 & 0.4203 & 0.0958 \\ 0.3425 & 0.0846 & 0.1092 & 0.1446 & 0.5844 \end{pmatrix} \begin{pmatrix} DLNPTO_{t-1} \\ DLNM2S_{t-1} \\ DLNSHIBOR_{t-1} \\ DLNLII_{t-1} \\ DLNRR_{t-1} \end{pmatrix} + \begin{pmatrix} -0.0043 \\ 0.0140 \\ -0.0145 \\ -0.0037 \\ 0.0015 \end{pmatrix}$$

After constructing the VAR models, the first thing to do is to check the stability of the model. If the constructed VAR models are stable, Granger causality test, impulse response and variance decomposition can then be conducted.

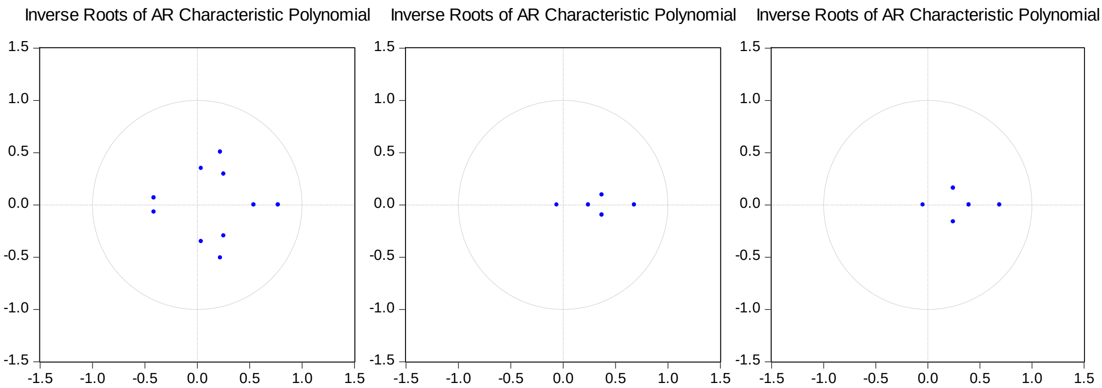
4.4.2 VAR Model Stability Test

Based on the above matrices for each VAR model, we verify the stability of the model, as it is required by the Granger causality test, impulse response and variance decomposition. Lutkepohl (2005) developed stability condition test method to check if their inverse characteristic polynomials of VAR model has roots outside the unit circle. The formula can be writtern as follows:

$$\det\left(I_K - A_1 z - \cdots - A_p z^p\right) \neq 0 \; for \; |z| \leq 1$$

If any z is greater than one, the VAR model is not stable. We have tested the stability of our constructed VAR models, the results are presented in Figure 13. The results show that all roots of the characteristic polynomial lie inside the unit circle, which means that our defined VAR models satisfy the stability condition. This means that the Granger causality test, impulse response and variance decomposition can be continued.

Figure 13. Results of VAR model stability tests (FOD – MET – PTO)



4.4.3 Granger Causality Test

From cointegration analysis results we can conclude that at least one Granger causality exists in each VAR model. We will use the Granger Causality Test to ascertain the direction of causality, which suggests which variables have a guiding function over the others. The results of Granger causality test for each sector are shown below:

Edibles

Table 17. Results of Granger causality test (FOD)

Hypothesis	F-value	P-value
DLNFOD does not Granger Cause DLNM2S	0.75774	0.4711
DLNM2S does not Granger Cause DLNFOD	0.04953	0.9517
DLNFOD does not Granger Cause DLNSHIBOR	0.79430	0.4544
DLNSHIBOR does not Granger Cause DLNFOD	15.9265	**0.0000**
DLNFOD does not Granger Cause DLNLII	2.77243	0.0668
DLNLII does not Granger Cause DLNFOD	14.6035	**0.0000**
DLNFOD does not Granger Cause DLNRR	0.68342	0.5070
DLNRR does not Granger Cause DLNFOD	9.49412	**0.0002**

The results in Table 17 show that at 5% significance level, SHIBOR, LII and RR are the granger causes of food commodity price. It is possible to statistically improve the prediction of food commodity prices by including past values of SHIBOR, LII and RR into the model. This implies that SHIBOR, LII and RR possess guidance functions towards the variance in food commodity price, and they can possibly be used as forecasting indicators.

Industrial Inputs

Table 18. Results of Granger causality test (MET)

Hypothesis	F-value	P-value
DLNMET does not Granger Cause DLNM2S	0.3788	0.5395
DLNM2S does not Granger Cause DLNMET	0.2151	0.6437
DLNMET does not Granger Cause DLNSHIBOR	0.2540	0.6152
DLNSHIBOR does not Granger Cause DLNMET	5.6688	**0.0189**
DLNMET does not Granger Cause DLNLII	1.3304	0.2511
DLNLII does not Granger Cause DLNMET	5.1660	**0.0249**
DLNMET does not Granger Cause DLNRR	0.6549	0.4200
DLNRR does not Granger Cause DLNMET	1.8339	0.1783

The results in Table 18 show that at 5% significance level, SHIBOR and LII are the granger causes of metal commodity price. It is possible to statistically improve the prediction of metal commodity prices by including past values of SHIBOR and LII into the model. This implies that SHIBOR and LII possess guidance functions towards variance in metal commodity price, and they can possibly be used as forecasting indicators.

Energy

Table 19. Results of Granger causality test (PTO)

Hypothesis	F-value	P-value
DLNPTO does not Granger Cause DLNM2S	0.0451	0.8321
DLNM2S does not Granger Cause DLNPTO	0.0026	0.9596
DLNPTO does not Granger Cause DLNSHIBOR	0.5328	0.4669
DLNSHIBOR does not Granger Cause DLNPTO	7.2302	**0.0082**
DLNPTO does not Granger Cause DLNLII	0.3064	0.5810
DLNLII does not Granger Cause DLNPTO	15.2545	**0.0002**
DLNPTO does not Granger Cause DLNRR	1.0772	0.3015
DLNRR does not Granger Cause DLNPTO	13.4166	**0.0004**

The results show that at 5% significance level, SHIBOR, LII and RR are the granger causes of petroleum commodity price. It is possible to statistically improve the prediction of petroleum commodity prices by including past values of SHIBOR, LII and RR into the model. This implies that SHIBOR, LII and RR possess guidance functions towards variance in the petroleum commodity price, and they can possibly be used as forecasting indicators.

In Table 20 we summarized the results of Granger causality tests:

Table 20. Summary of results of Granger causality test

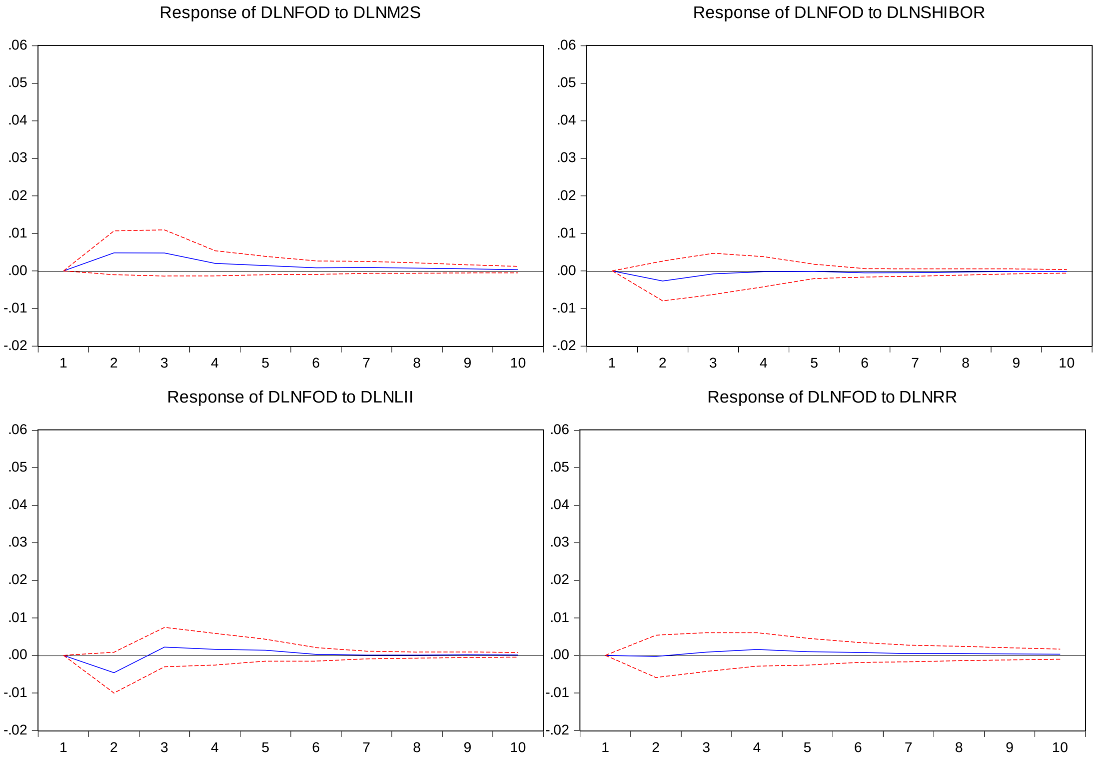
Variables	Indicator possess guidance function towards variance in commodity price			
	M2S	SHIBOR	LII	RR
FOD	No	Yes	Yes	Yes
MET	No	Yes	Yes	No
PTO	No	Yes	Yes	Yes

4.4.4 Impulse Response

The impulse response refers to the reaction of any dynamic system to the external change, which describes the reaction of the system as a function of time (Tsay, 2014). In order to examine how commodity price reacts to the shock from monetary policy in the short run, we use impulse response function to demonstrate the short term dynamics. The results for each sector are shown below:

Edibles

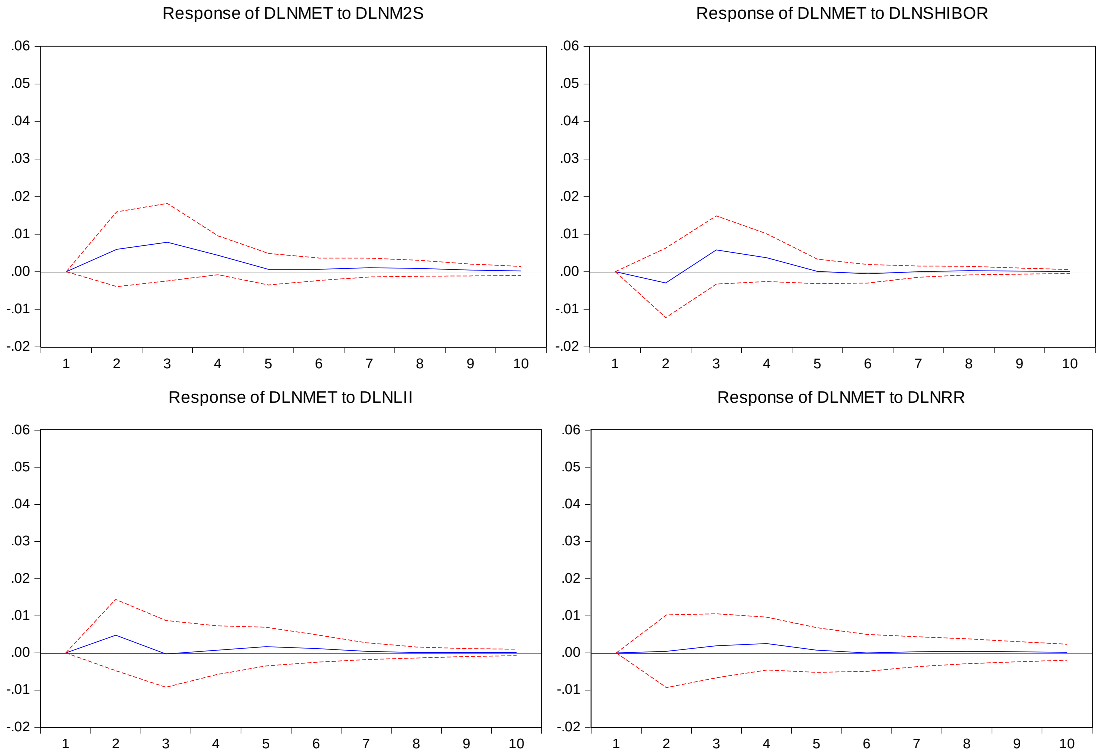
Figure 14. Results of impulse response (FOD)



Based on results shown in Figure 14, from the general view of monetary policy, in response of food commodity price to M2S, upon given one positive standard deviation shock, the price does not react immediately within the first lag period. A positive effect starts to come into play in the second lag period. The effect is sustained until the third lag period where it reaches its peak, and starts to diminish at the forth lag period until it stops at the sixth lag period. The immediate effects of the increase in SHIBOR, LII and RR towards food commodity prices are negative, negative and positive respectively. The results of impulse responses for SHIBOR, LII and RR in terms of short term effect are consistent with the results of the long term effect generated from previous cointegration analysis.

Industrial Inputs

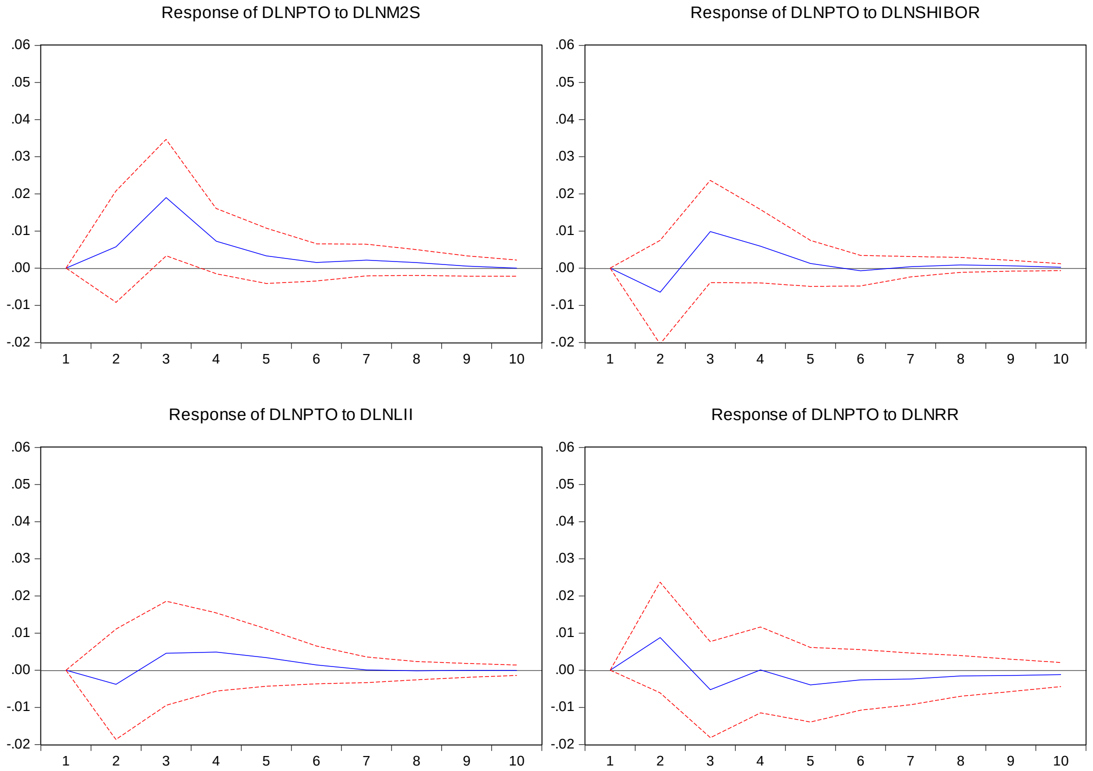
Figure 15. Results of impulse response (MET)



Based on results shown in Figure 15, from a general viewpoint towards monetary policy, in response to metal commodity price to M2S, upon giving one positive standard deviation shock, we find that the price does not react immediately within the first lag period. A positive effect starts to come into play in the second lag period. The effect sustains until the third lag period where the effect reaches its peak, and starts to diminish at the fourth lag period until it stops at the fifth lag period. The immediate effects of increases in SHIBOR, LII and RR towards metal commodity prices are negative, positive and positive respectively. The results of impulse responses for SHIBOR and RR in terms of short term effects are consistent with the results of long term effects generated from the previous co-integration analysis, while the result for LII is different from the previous co-integration analysis.

Energy

Figure 16. Results of impulse response (PTO)



Based on results shown in Figure 16, from general view of monetary policy, in response to petroleum commodity price to M2S, upon giving one positive standard deviation shock, the price does not react immediately within the first lag period. A positive effect starts to come into play in the second lag period. The effect sustains until the third lag period, where it reaches its peak, and starts to diminish at the forth lag period until it stops at the ninth lag period. The immediate effects of an increase in SHIBOR, LII and RR towards petroleum commodity prices are negative, negative and positive. The results of impulse responses for SHIBOR, LII and RR in terms of short term effects are consistent with the results of long term effects generated from the previous cointegration analysis.

In conclusion, most of impulse response results for commodity prices and M2 money supply are consistent with our results generated from the previous cointegration analysis, which confirms that an expansionary monetary policy in China has positive effect on commodity prices. The maximum effect of monetary policy on commodity prices takes place two to three months after the policy shock, which implies that a good indicator for the monetary policy should be made available three months in advance. The results of impulse response are summarised in Table 21:

Table 21. Summary of results of Granger causality test

Variables	Short term dynamic is in line with long term relationship		
	SHIBOR	LII	RR
FOD	Yes	Yes	Yes
MET	Yes	No	Yes
PTO	Yes	Yes	Yes

4.4.5 Variance Decomposition

The variance decomposition is used to aid in the interpretation of VAR model once it has been fitted, and it indicates the amount of information each variable contributes to the other variables, which means that it determines how much of the forecast variance of each the variables (FOD, MET, PTO) can be explained by exogenous shocks to the other variables (M2S, SHIBOR, LII, RR) (Koopman & Shephard, 2015). The results are shown below:

Edibles

Table 22. Results of variance decomposition (FOD)

Period	S.E.	DLNFOD	DLNM2S	DLNSHIBOR	DLNLII	DLNRR
1	0.029834	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.033267	95.33315	2.095220	1.384478	1.186965	0.000188
3	0.034158	93.06277	3.955849	1.313304	1.591324	0.076756
4	0.034312	92.34310	4.264427	1.314659	1.785465	0.292350
5	0.034467	91.99829	4.396148	1.313713	1.920773	0.371074
6	0.034587	91.91295	4.426005	1.315397	1.920359	0.425285
7	0.034674	91.84311	4.476292	1.319407	1.914488	0.446702
8	0.034712	91.78755	4.512929	1.319674	1.911926	0.467925
9	0.034729	91.75352	4.532918	1.318544	1.912836	0.482185
10	0.034738	91.73663	4.540091	1.317917	1.914001	0.491359

Industrial Inputs

Table 23. Results of variance decomposition (MET)

Period	S.E.	DLNMET	DLNM2S	DLNSHIBOR	DLNLII	DLNRR
1	0.051378	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.054847	98.75160	0.398635	0.069949	0.756147	0.023667
3	0.055537	98.16271	0.456054	0.072110	1.170128	0.139002
4	0.055726	97.87926	0.473452	0.072138	1.326194	0.248952
5	0.055790	97.74606	0.479380	0.072153	1.382915	0.319494
6	0.055816	97.68398	0.481644	0.072215	1.404735	0.357424
7	0.055826	97.65523	0.482575	0.072279	1.413751	0.376166
8	0.055831	97.64195	0.482979	0.072325	1.417687	0.385061
9	0.055833	97.63582	0.483159	0.072353	1.419464	0.389206
10	0.055834	97.63299	0.483241	0.072368	1.420281	0.391124

Energy

Table 24. Results of variance decomposition (PTO)

Period	S.E.	DLNPTO	DLNM2S	DLNSHIBOR	DLNLII	DLNRR
1	0.079863	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.085100	99.55715	0.005630	0.120730	3.48E-07	0.316491
3	0.086135	99.17205	0.007240	0.220486	0.032324	0.567904
4	0.086490	98.93730	0.009261	0.259145	0.070486	0.723804
5	0.086646	98.81280	0.010374	0.272246	0.092081	0.812495
6	0.086719	98.75019	0.010893	0.276920	0.101757	0.860235
7	0.086754	98.71937	0.011133	0.278771	0.105880	0.884843
8	0.086771	98.70437	0.011246	0.279572	0.107672	0.897137
9	0.086779	98.69713	0.011300	0.279936	0.108478	0.903156
10	0.086782	98.69365	0.011325	0.280105	0.108849	0.906068

From the above results we can see that changes in commodity prices are mainly explained by their own variance (over 90%), and the impact of China's monetary policy on commodity prices is one to stabilize around the fourth or fifth lag period. In response to food commodity price, SHIBOR, LII and RR shocks explain around 1.3%, 1.9% and 0.5% of the variations respectively. In response to metal commodity price, SHIBOR, LII and RR shocks explains around 0.1%, 1.4% and 0.4% of the variations respectively. In response to petroleum commodity price, SHIBOR, LII and RR shocks explains around 0.3%, 0.1% and 0.9% of the variations respectively.

In conclusion, we have summarized the results of variance decomposition in Table 25:

Table 25. Summary of results of variance decomposition

Variables	% variance attributable to change in commodity price		
	SHIBOR	LII	RR
FOD	1.3%	1.9%	0.5%
MET	0.1%	1.4%	0.4%
PTO	0.3%	0.1%	0.9%

4.5 Conclusion

An expansionary monetary policy in China (i.e. increase in money supply) has a positive impact on global commodity prices in all three commodity sectors (edibles, industrial inputs and energy). Energy commodity prices are found to be affected the most by China's monetary policy. From results of cointegration analysis we can conclude that compared to all three monetary policy instruments, loan interest rates influence commodity prices most in the long-run.

As the selecting criteria mentioned in the previous chapter for suitable indicators for the effect of China's monetary policy towards commodity prices, we have translated such criteria into methodological criteria in order to incorporate our results generated from the co-integration analysis and VAR model. This is done as follows:

- Direction of influence for the selected indicators towards commodity prices must be in line (to be opposite) with the direction of influence for M2S
- The selected indicators must possess guidance function towards variance in commodity prices
- The short term immediate effect of the selected indicator in response to commodity price should match their long term direction of influence
- In addition to fulfilling the above criteria, the absolute value of cointegration coefficient and variance attributable should be as large as possible

Based on the generated results reported in Table 26 and the criteria described above, we are able to select the suitable indicator for China's monetary policy towards commodity price.

Table 26. Summary of empirical results

Response Variables	FOD			MET			PTO		
Indicator	SHIBOR	LII	RR	SHIBOR	LII	RR	SHIBOR	LII	RR
Direction in line with M2S	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Guidance function	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Short term matches long term effect	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Cointegration coefficient (abs)	0.47	2.56	1.38	0.95	4.72	1.53	1.39	6.22	2.38
Variance attributable	1.3%	1.9%	0.5%	0.1%	1.4%	0.4%	0.3%	0.1%	0.9%

In the edible sector (FOD), SHIBOR and LII both are coherent with M2S, and thus possess a guidance function towards commodity prices. Moreover, their short term dynamics matches the long term trend. Since LII has a higher value of cointegration coefficient and variance attributable than SHIBOR, LII should be used as forecasting indicator for China's monetary policy towards the edible commodity price.

In the industrial input sector (MET), only SHIBOR has shown to be coherent with M2S, possessing a guidance function towards commodity prices, whereby its short term dynamics matches the long term trend. Hence, we find that SHIBOR should be used as forecasting indicator for China's monetary policy towards industrial input commodity prices.

In the energy sector (PTO), SHIBOR and LII both appear coherent with M2S, implying they possess guidance function towards commodity prices, whereby their short term dynamics matches the long term trend. The value of variance attributable for SHIBOR is slightly higher than LII, but in terms of cointegration coefficient, LII is significantly higher than SHIBOR. Hence, LII should be used as forecasting indicator for China's monetary policy towards the energy commodity price.

To recall our hypotheses proposed in Chapter 2, the results of co-integration analysis suggest that expansionary monetary policy in China is positively correlated with commodity prices, and prices of industrial input commodities are mostly affected by it. This confirms Hypothesis 1 and rejects Hypothesis 2. The results of the VAR model analysis suggest that SHIBOR and the loan interest rate are suitable for predicting the effect of China's monetary policy towards commodity prices. This rejects Hypothesis 3. Our hypotheses results are shown in Table 27 below:

Table 27. Summary of hypothesis results

Hypothesis	Formulation	Conclusion
1	Expansionary monetary policy in China is positively correlated to global commodity prices.	Accept
2	The impact of China's monetary policy on industrial inputs commodity price is larger than on prices of edibles and energy commodities.	Reject
3	Change of reserve requirement ratio is a suitable indicator to represent China's monetary policy towards variance in commodity prices.	Reject

5. Conclusion

Our paper addressed the issue of monetary policy effect on global commodity prices in the context of China, the world's second largest economy, and major consumers and importers of the commodities. Given the strong presence of China in the global commodity market, not only its fast growing appetite for commodities, but also its unique monetary policy could help explain and understand the movements in the global commodity prices.

There is empirical evidence from our empirical results, to support the conclusions reached by Hammoudeh et al. (2014) and Chen (2015), that a long term equilibrium relationship exists between global commodity prices and China's monetary policy, and that expansionary monetary policy in China is positively correlated with commodity prices. Our empirical results also suggest that the transmission mechanism of monetary policy towards commodity prices has a certain universality, while the intensity effect remains different. In terms of degree of influence, when comparing our results on the effect both in the long term (generated through cointegration analysis) and the short term (generated through impulse response and variance decomposition) with Wang & Chang's (2015) findings, we find that the effect of China's monetary policy on global commodity prices is much less pronounced than that of US monetary policy. This means that currently, the influential power of China's monetary policy on the global commodity market is not as substantial as the US monetary policy, and a change in direction of China's monetary policy alters the behavior of commodity prices trends in the world scale less than that of US monetary policy for now.

Considering the differences in various types of commodities, we have divided our research into three categories, covering edibles, industrial inputs and energy commodities. Although in terms of consumption, China consumes industrial inputs commodities nearly twice as much as edibles or energy commodities when expressed as a share of world production, our empirical results show that it is the energy commodity market that is most influenced by China's monetary policy. Hence, trading companies in the energy sector should be relatively more concerned with the direction of China's monetary policy than traders in the agricultural and industrial sectors. For shipping companies involved in commodity trading business, tanker owners carrying oil and petroleum products should be more aware of the relationship between China's monetary policy and commodity prices than do other dry bulk owners. This result also suggests that the degree of influence of policy over a particular market in a country is not proportional to the impact of its monetary policy on that market. We are thus unable to judge the degree of impact of a country's monetary policy on commodity prices, when only looking at its position and status in the market – the analysis is more complex than that. In other words, we cannot simply expect a growing influence from China and its monetary policy on the commodity market, just because of its increasing market share. It is necessary to evalute the impact of China's monetary policy on commodity prices through a well developed and deep empirical analysis, and continuous study of this topic is encouraged in order to get an even better and more refreshing understanding of the size, direction and mechanism of such impact.

The widely recognized indicator to analyze China's monetary policy is the monthly M2 money supply. However, the announcement of the monthly M2 money supply is often delayed by three months, and our results show that China's monetary policy usually starts to take effect on commodity prices in one month after implementation. Hence it is necessary to find out other indicators, which could properly represent the direction of China's monetary policy, and such information must be published in time. We have selected three possible indicators for China's monetary policy: 3-month Shanghai Interbank Offered Rate (SHIBOR), mid-term loan interest rate indicator and central bank reserve requirement ratio. Our empirical results suggest that mid-term loan interest rate is the suitable indicator for China's monetary policy towards price movement in edible and energy commodity markets, and 3-month SHIBOR is the suitable indicator for the industrial inputs sector. With continuous market-oriented reforms of interest rates in China, unified interest rates regulated by the PBoC will be gradually pushed from the stage. The 3-month SHIBOR also shows good characteristics to become the indicator for China's monetary policy in edibles and energy commodity sectors, and it can be used when liberalization of interest rate is fully implemented and enforced in China.

One interesting finding from our empirical results shows that the influence of the central bank reserve requirement ratio on commodity prices is different than we had expected beforehand. The same results generated for all three commodity sectors, show that an increase in the reserve requirement ratio has a positive (i.e. upward) effect on commodity prices. This is opposite to the effect predicted in theory that a contractionary monetary policy from China towards commodity prices through an increase in the reserve requirement ratio should have in theory. The logic behind this finding is that such phenomenon is unknown, and we are not sure whether such phenomenon can only be applied in China or whether it is universal, also for other major economies. Nevertheless, the transmission mechanism of change in reserve requirement ratio to commodity market is worth to be studied further.

There are several issues that have not been addressed in this paper. Firstly, our three commodity groups (edibles, industrial inputs and energy) can be further divided into several subgroups, where price level of the commodity from each subgroup may behave differently in response to the change in China's monetary policy. Secondly, there are other possible indicators that can also represent general picture of China's monetary policy, such as M1 money supply, consumer price index and foreign exchange rate, which may also have the potential to be used in commodity market forecasting. Finally, our study is mainly focused on analyzing the long term relationship between China's monetary policy and commodity prices, instead of the short term dynamic trends. For commodity traders, especially spot market traders who are more interested in the short term effect of China's monetary policy on commodity prices, an indicator with the property of capturing the short term dynamic should be considered, and more researches should be conducted in order to find such indicator. As for recommendation of further study, firstly it is necessary to investigate the transmission mechanism of change in reserve requirement ratio to commodity market. Secondly, detailed classification of commodity sectors is encouraged for future study. Finally, more representative indicators of China's monetary policy are recommended to be involved and testified during further research.

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Appendices

I. List of RMB Bilateral Swap Agreements

Table 28. List of RMB bilateral swap agreements

Earliest agreement	Economic partner	Maximum value in foreign currency	Maximum value in RMB
12-Dec-2008	South Korea	KRW 64 trillion	¥360 billion
20-Jan-2009	Hong Kong	HKD 490 billion	¥400 billion
8-Feb-2009	Malaysia	MYR 90 billion	¥180 billion
11-Mar-2009	Belarus	BYR 16 trillion	¥7 billion
23-Mar-2009	Indonesia	IDR 175 trillion	¥100 billion
29-Mar-2009	Argentina	ARS 38 billion	¥70 billion
9-Jun-2010	Iceland	ISK 66 billion	¥3.5 billion
23-Jul-2010	Singapore	SGD 60 billion	¥300 billion
18-Apr-2011	New Zealand	NZD 5 billion	¥25 billion
19-Apr-2011	Uzbekistan	UZS 167 billion	¥0.7 billion
6-May-2011	Mongolia	MNT 2 trillion	¥15 billion
13-Jun-2011	Kazakhstan	KZT 150 billion	¥7 billion
23-Jun-2011	Russian Federation	RUB 815 billion	¥150 billion
22-Dec-2011	Thailand	THB 320 billion	¥70 billion
23-Dec-2011	Pakistan	PKR 140 billion	¥10 billion
17-Jan-2012	United Arab Emirates	AED 20 billion	¥35 billion
21-Feb-2012	Turkey	TRY 3 billion	¥10 billion
22-Mar-2012	Australia	AUD 30 billion	¥200 billion
26-Jun-2012	Ukraine	UAH 19 billion	¥15 billion
26-Mar-2013	Brazil	BRL 60 billion	¥190 billion
22-Jun-2013	United Kingdom	GBP 21 billion	¥200 billion
9-Sep-2013	Hungary	HUF 375 billion	¥10 billion
12-Sep-2013	Albania	ALL 35.8 billion	¥2 billion
9-Oct-2013	European Union	EUR 45 billion	¥350 billion
21-Jul-2014	Switzerland	CHF 21 billion	¥150 billion
16-Sep-2014	Sri Lanka	LKR 225 billion	¥10 billion
3-Nov-2014	Qatar	QAR 20.8 billion	¥35 billion
8-Nov-2014	Canada	CAD 30 billion	¥200 billion
18-Mar-2015	Suriname	SRD 520 million	¥ 1 billion
10-Apr-2015	South Africa	ZAR 54 billion	¥ 30 billion
25-May-2015	Chile	CLP 2.2 trillion	¥ 22 billion
5-Sep-2015	Tajikistan	TJS 0.5 billion	¥ 0.5 billion
Total			¥3,158.7 billion

(Source: The People's Bank of China, 2016)

II. China’s Currency Swap Agreements with Other Central Banks

Figure 17. China’s currency swap agreements with other central banks

(Source: Federal Reserve Bank of San Francisco, 2015)

III. International Commodity Price Seasonal Index (2006 – 2015)

Table 29. Seasonal Index (FOD)

Month	Year										Seasonal Index
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Jan	0.797	0.862	1.115	0.893	0.941	1.211	1.043	1.113	1.018	0.889	0.988
Feb	0.817	0.888	1.203	0.868	0.935	1.248	1.075	1.116	1.042	0.854	1.005
Mar	0.821	0.883	1.249	0.876	0.941	1.212	1.100	1.106	1.087	0.833	1.011
Apr	0.838	0.880	1.242	0.917	0.964	1.251	1.099	1.100	1.095	0.825	1.021
May	0.890	0.890	1.249	0.985	0.949	1.222	1.068	1.125	1.079	0.819	1.028
Jun	0.894	0.920	1.289	0.994	0.918	1.184	1.058	1.127	1.038	0.820	1.024
Jul	0.881	0.930	1.279	0.950	0.964	1.170	1.152	1.113	1.015	0.836	1.029
Aug	0.863	0.943	1.180	0.937	1.011	1.177	1.157	1.058	0.980	0.803	1.011
Sep	0.827	0.985	1.097	0.905	1.040	1.130	1.130	1.015	0.927	0.766	0.982
Oct	0.836	0.993	0.921	0.909	1.087	1.064	1.106	1.021	0.913	0.760	0.961
Nov	0.860	1.012	0.865	0.936	1.097	1.053	1.096	1.009	0.921	0.738	0.959
Dec	0.862	1.067	0.840	0.949	1.170	1.033	1.105	1.034	0.919	0.748	0.973

(Source: IMF, 2016)

Table 30. Seasonal Index (MET)

Month	Year										Seasonal Index
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Jan	0.695	0.960	1.008	0.623	1.092	1.410	1.167	1.175	1.031	0.824	0.998
Feb	0.718	0.978	1.079	0.613	1.047	1.473	1.197	1.193	1.005	0.807	1.011
Mar	0.728	1.033	1.137	0.600	1.138	1.404	1.196	1.108	0.965	0.792	1.010
Apr	0.830	1.136	1.125	0.639	1.263	1.438	1.177	1.068	0.992	0.787	1.046
May	0.947	1.156	1.078	0.675	1.137	1.378	1.119	1.027	0.963	0.822	1.030
Jun	0.862	1.111	1.055	0.745	1.047	1.357	1.075	0.988	0.948	0.784	0.997
Jul	0.914	1.107	1.065	0.798	1.027	1.395	1.061	1.006	0.989	0.726	1.009
Aug	0.927	1.014	0.992	0.919	1.135	1.342	1.000	1.054	0.986	0.703	1.007
Sep	0.933	0.986	0.930	0.862	1.160	1.292	1.043	1.036	0.947	0.711	0.990
Oct	0.975	1.015	0.746	0.898	1.241	1.159	1.064	1.043	0.920	0.696	0.976
Nov	0.978	0.975	0.659	0.951	1.278	1.115	1.057	1.038	0.918	0.644	0.961
Dec	0.994	0.918	0.610	1.009	1.341	1.109	1.119	1.046	0.873	0.621	0.964

(Source: IMF, 2016)

Table 31. Seasonal Index (PTO)

Month	Year										Seasonal Index
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Jan	0.819	0.689	1.146	0.546	0.941	1.111	1.261	1.219	1.166	0.531	0.943
Feb	0.782	0.740	1.178	0.520	0.910	1.172	1.329	1.248	1.192	0.615	0.969
Mar	0.797	0.778	1.282	0.579	0.964	1.299	1.387	1.187	1.182	0.591	1.005
Apr	0.888	0.835	1.368	0.622	1.022	1.389	1.337	1.142	1.190	0.641	1.043
May	0.895	0.835	1.542	0.718	0.917	1.291	1.223	1.145	1.198	0.697	1.046
Jun	0.889	0.872	1.650	0.852	0.905	1.262	1.064	1.148	1.226	0.682	1.055
Jul	0.942	0.938	1.665	0.797	0.900	1.284	1.132	1.207	1.189	0.606	1.066
Aug	0.932	0.893	1.434	0.881	0.916	1.196	1.231	1.239	1.129	0.508	1.036
Sep	0.805	0.976	1.244	0.839	0.918	1.199	1.242	1.246	1.080	0.513	1.006
Oct	0.750	1.040	0.905	0.907	0.983	1.186	1.206	1.207	0.969	0.519	0.967
Nov	0.751	1.157	0.671	0.949	1.016	1.247	1.179	1.174	0.864	0.476	0.949
Dec	0.787	1.133	0.514	0.915	1.081	1.232	1.177	1.205	0.679	0.402	0.912

(Source: IMF, 2016)

IV. List of Changes of Mid-term Interest Rate Indicator (2006 – 2015)

Table 32. List of Changes of Mid-term Interest Rate Indicator (2006 – 2015)

Execution Date	Interest Rate (%)	Execution Date	Interest Rate (%)
28-Apr-2006	6.03	20-Oct-2010	5.60
19-Aug-2006	6.30	26-Dec-2010	5.85
18-Mar-2007	6.57	9-Feb-2011	6.10
19-May-2007	6.75	6-Apr-2011	6.40
21-Jul-2007	7.02	7-Jul-2011	6.65
22-Aug-2007	7.20	8-Jun-2012	6.40
15-Sep-2007	7.47	6-Jul-2012	6.15
21-Dec-2007	7.56	22-Nov-2014	6.00
16-Sep-2008	7.29	1-Mar-2015	5.75
9-Oct-2008	7.02	11-May-2015	5.50
30-Oct-2008	6.75	28-Jun-2015	5.25
27-Nov-2008	5.67	26-Aug-2015	5.00
23-Dec-2008	5.40	24-Oct-2015	4.75

(Source: Sina, 2016)

V. List of Changes of PBoC Reserve Requirement Ratio (2006 – 2015)

Table 33. List of Changes of PBoC Reserve Requirement Ratio (2006 – 2015)

Execution Date	Reserve Requirement Ratio Before Adjustment (%)	Reserve Requirement Ratio After Adjustment (%)	Adjustment Range (%)
5-Jul-2006	7.5	8.0	0.5
15-Aug-2006	8.0	8.5	0.5
15-Nov-2006	8.5	9.0	0.5
15-Jan-2007	9.0	9.5	0.5
25-Feb-2007	9.5	10.0	0.5
16-Apr-2007	10.0	10.5	0.5
15-May-2007	10.5	11.0	0.5
5-Jun-2007	11.0	11.5	0.5
15-Aug-2007	11.5	12.0	0.5
25-Sep-2007	12.0	12.5	0.5
25-Oct-2007	12.5	13.0	0.5
26-Nov-2007	13.0	13.5	0.5
25-Dec-2007	13.5	14.5	1.0
25-Jan-2008	14.5	15.0	0.5
25-Mar-2008	15.0	15.5	0.5
25-Apr-2008	15.5	16.0	0.5
20-May-2008	16.0	16.5	0.5
15-Jun-2008	16.5	17.0	0.5
25-Jun-2008	17.0	17.5	0.5
25-Sep-2008	17.5	17.5	0.0
15-Oct-2008	17.5	17.0	-0.5
5-Dec-2008	17.0	16.0	-1.0
25-Dec-2008	16.0	15.5	-0.5
18-Jan-2010	15.5	16.0	0.5
25-Feb-2010	16.0	16.5	0.5
10-May-2010	16.5	17.0	0.5
16-Nov-2010	17.0	17.5	0.5
29-Nov-2010	17.5	18.0	0.5
20-Dec-2010	18.0	18.5	0.5
20-Jan-2011	18.5	19.0	0.5
24-Feb-2011	19.0	19.5	0.5
25-Mar-2011	19.5	20.0	0.5

21-Apr-2011	20.0	20.5	0.5
18-May-2011	20.5	21.0	0.5
20-Jun-2011	21.0	21.5	0.5
5-Dec-2011	21.5	21.0	-0.5
24-Feb-2012	21.0	20.5	-0.5
18-May-2012	20.5	20.0	-0.5
5-Feb-2015	20.0	19.5	-0.5
20-Apr-2015	19.5	18.5	-1.0
28-Jun-2015	18.5	18.0	-0.5
6-Sep-2015	18.0	17.5	-0.5
24-Oct-2015	17.5	17.0	-0.5

(Source: Sina, 2016)

VI. Results of Lag Length Selection for VAR Model

Table 34. Results of lag length selection (FOD)

Lag	Log Likelihood	LR	FPE	AIC	SC	HQ
0	1308.862	NA	9.76e-17	-22.6759	-22.5565	-22.6274
1	1396.072	165.3200	3.31e-17	-23.7578	-23.0417*	-23.4671*
2	1426.227	54.5411*	3.03e-17*	-23.8474*	-22.5346	-23.3146
3	1447.674	36.9267	3.25e-17	-23.7856	-21.8761	-23.0106
4	1459.130	18.7267	4.16e-17	-23.5501	-21.0438	-22.5328

Table 35. Results of lag length selection (MET)

Lag	Log Likelihood	LR	FPE	AIC	SC	HQ
0	1255.128	NA	2.49e-16	-21.7414	-21.622	-21.6929
1	1333.882	149.2901	9.77e-17*	-22.6762*	-21.9601*	-22.3856*
2	1356.376	40.6854	1.02e-16	-22.6326	-21.3198	-22.0998
3	1379.647	40.0669*	1.06e-16	-22.6026	-20.693	-21.8275
4	1390.799	18.2305	1.36e-16	-22.3617	-19.8555	-21.3445

Table 36. Results of lag length selection (PTO)

Lag	Log Likelihood	LR	FPE	AIC	SC	HQ
0	1206.038	NA	5.84e-16	-20.8876	-20.7683	-20.8392
1	1290.485	160.0821	2.08e-16*	-21.9215*	-21.2054*	-21.6308*
2	1312.007	38.9263*	2.21e-16	-21.861	-20.5482	-21.3281
3	1330.460	31.7706	2.49e-16	-21.7471	-19.8376	-20.9721
4	1343.564	21.4225	3.10e-16	-21.5402	-19.034	-20.523

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VII. VAR Model Specification

Table 37. VAR Model Specification (FOD)

	DLNFOD	DLNM2S	DLNSHIBOR	DLNLII	DLNRR
DLNFOD(-1)	0.457013	0.016746	0.033198	0.095126	0.043682
DLNFOD(-2)	-0.014793	0.035791	0.832064	0.187298	0.146084
DLNM2S(-1)	0.35733	-0.128113	0.96403	0.21838	0.126697
DLNM2S(-2)	0.455543	0.006507	-0.829701	0.277539	0.030256
DLNSHIBOR(-1)	-0.042811	-0.02585	0.333281	-0.01059	-0.014048
DLNSHIBOR(-2)	0.027853	0.002156	-0.226967	-0.000207	-0.006926
DLNLII(-1)	-0.248103	-0.121809	1.361682	0.385492	0.0656
DLNLII(-2)	0.460834	-0.022719	0.842371	0.077805	0.074652
DLNRR(-1)	-0.003248	0.131175	0.226611	0.078835	0.466875
DLNRR(-2)	0.052622	-0.085119	-0.438646	0.003505	0.130718
C	-0.009327	0.013901	0.001698	-0.008047	0.000456
R-squared	0.262907	0.145023	0.565465	0.514857	0.553884
Adj. R-squared	0.19337	0.064364	0.524471	0.469088	0.511798
Sum sq. resids	0.094349	0.011853	0.471339	0.025772	0.022003
S.E. equation	0.029834	0.010574	0.066683	0.015593	0.014408
F-statistic	3.780816	1.797988	13.7939	11.24921	13.16064
Log likelihood	250.6756	372.0315	156.5737	326.5925	335.8406
Akaike AIC	-4.097019	-6.171479	-2.488439	-5.394743	-5.552831
Schwarz SC	-3.837328	-5.911787	-2.228748	-5.135052	-5.293139
Mean dependent	0.002283	0.012825	0.002626	-0.000786	0.006994
S.D. dependent	0.033218	0.010932	0.0967	0.0214	0.02062

Table 38. VAR Model Specification (MET)

	DLNMET	DLNM2S	DLNSHIBOR	DLNLII	DLNRR
DLNMET(-1)	0.336647	0.008684	0.18475	0.064975	0.023287
DLNM2S(-1)	0.373429	-0.121068	1.352857	0.25062	0.174106
DLNSHIBOR(-1)	-0.006382	-0.028794	0.287201	-0.008693	-0.009458
DLNLII(-1)	0.294587	-0.111208	1.951088	0.509366	0.176281
DLNRR(-1)	0.059279	0.086982	0.119835	0.15627	0.592726
C	-0.005981	0.013821	-0.014606	-0.0046	0.000777
R-squared	0.152739	0.115155	0.461259	0.406425	0.486942
Adj. R-squared	0.114915	0.075653	0.437208	0.379926	0.464038
Sum sq. resids	0.295644	0.012305	0.584376	0.031532	0.02533
S.E. equation	0.051378	0.010482	0.072233	0.016779	0.015039
F-statistic	4.03814	2.915161	19.17839	15.33742	21.25978
Log likelihood	185.933	373.5037	145.7311	317.9839	330.9064

Akaike AIC	-3.049711	-6.228877	-2.368324	-5.287862	-5.506888
Schwarz SC	-2.908829	-6.087994	-2.227441	-5.14698	-5.366005
Mean dependent	-0.001301	0.012881	0.002603	-0.00078	0.006935
S.D. dependent	0.054611	0.010902	0.096286	0.021308	0.020542

Table 39. VAR Model Specification (PTO)

	DLNPTO	DLNM2S	DLNSHIBOR	DLNLII	DLNRR
DLNPTO(-1)	0.360069	0.0148	0.058049	0.071038	0.05169
DLNM2S(-1)	-0.056779	-0.13471	1.35341	0.193498	0.123936
DLNSHIBOR(-1)	0.030825	-0.027374	0.29859	-0.000979	-0.004772
DLNLII(-1)	-0.058568	-0.132935	1.964044	0.420254	0.09581
DLNRR(-1)	0.342456	0.084594	0.109227	0.144616	0.584444
C	-0.004287	0.014031	-0.014519	-0.003703	0.001547
R-squared	0.151255	0.123954	0.453318	0.444602	0.519607
Adj. R-squared	0.113365	0.084844	0.428912	0.419808	0.498161
Sum sq. resids	0.714346	0.012182	0.592989	0.029504	0.023717
S.E. equation	0.079863	0.010429	0.072764	0.01623	0.014552
F-statistic	3.991918	3.16942	18.57445	17.93147	24.22848
Log likelihood	133.8825	374.0933	144.8678	321.9062	334.7876
Akaike AIC	-2.1675	-6.23887	-2.353692	-5.354342	-5.572672
Schwarz SC	-2.026618	-6.097988	-2.212809	-5.21346	-5.431789
Mean dependent	-0.003655	0.012881	0.002603	-0.00078	0.006935
S.D. dependent	0.084815	0.010902	0.096286	0.021308	0.020542