

The Quantitative Easing in China

Dapeng Nie

Dissertation submitted as partial requirement for the conferral of Master in Economics

Supervisor:

Prof. Doutor Vivaldo Manuel Pereira Mendes, Associate Professor, ISCTE Business School
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Abstract

In this thesis we analyze the recent events in China, as far as the aggressive attitude of the Central Bank of China (People's Bank of China, PBC in brief) is concerned towards avoiding the slowdown of the economy and the alleged possibility of its entry into deflation territory and the Zero Lower Bound. In the western way of looking into this problem, our major task is closely related to question whether Quantitative Easing (QE) in China seems to be (or no to be) of any usefulness at all. As we all know very well by now, many economists, top central banks officials, commentators and international institutions (like the IMF) are coming to realize the clear limits of monetary policy and QE in many developed western and Asian economies like Japan. After a long period having central banks creating money to unbelievable levels, many are now calling for the return of active fiscal policy.

In our case, and using a linear VAR model, we can conclude in the opposite direction for the Chinese case. Using the multipliers associated with inflation, we can conclude that real variables (like residential investment) show a rather small positive cumulative impact upon inflation, while wealth variables (like the Stock Market Index) show a rather small negative impact. Instead, it is the creation of money (Monetary Base) that displays a huge impact upon inflation. If the Monetary Base increases (first difference of its logarithmic value) by one standard deviation, the change in the CPI will be increased by 14.53 after just nine quarters. Therefore, deflation and the stringent limitations of monetary policy in the Zero Lower Bound do not seem to be applying to the Chinese economy by now, as well as the near future is concerned. Obviously, we are not suggesting that, due to this result, active fiscal policy should not also be used in order to achieve the general goals of economic policy in China.

Key Words

Quantitative Easing, Central Bank, China, VAR model

Gel Classification

E4, E5

Resumo

Nesta tese analisamos os eventos recentes na China, na medida em que a atitude agressiva do Banco Central da China está em causa no sentido de evitar a desaceleração da economia, à alegada possibilidade de entrada em território deflacionário e à existência do limite inferior zero das taxas de juro. Na perspectiva ocidental de encarar este problema, a principal tarefa está intimamente relacionada com a questão se o alívio quantitativo (QE) na China parece ter (ou não) qualquer utilidade. Como se sabe, actualmente, muitos economistas, altos responsáveis dos bancos centrais, comentadores e instituições internacionais (como o FMI) estão a começar a perceber os limites da política monetária e do QE em muitas das economias desenvolvidas ocidentais e asiáticas como o Japão. Após um longo período de criação de dinheiro até níveis inacreditáveis, pelos bancos centrais, muitos pedem agora o retorno da política fiscal ativa.

No nosso estudo, utilizando um modelo VAR linear, concluímos o contrário para o caso chinês. Utilizando multiplicadores associados à inflação, constata-se que as variáveis reais (como o investimento residencial) mostram um pequeno impacto cumulativo positivo sobre a inflação, enquanto por sua vez, as variáveis riqueza (como o Índice da Bolsa) mostram um pequeno impacto negativo. Em vez disso, é a criação de dinheiro (Base Monetária) que exibe um impacto enorme sobre a inflação. Se a base monetária aumenta (primeira diferença do seu valor logarítmico) um desvio-padrão, o consequente aumento do IPC é de 14,53 em apenas nove trimestres. Assim, a deflação e as rigorosas limitações de política monetária no limite inferior zero não parecem ser aplicáveis à economia chinesa até ao momento, bem como no curto-prazo. Obviamente, não sugerimos que devido a este resultado, a política fiscal ativa também não deve ser utilizado, de modo a atingir os objetivos gerais da política económica chinesa.

Palavras-chave

Flexibilização Quantitativa, o Banco Central, a China, o modelo VAR

Classificação JEL

E4, E5

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Contents

Abstract.....	i
Resumo.....	ii
Acknowledgement.....	iii
Contents.....	iv
1 Introduction.....	1
2 Literature Review.....	3
2.1 Krugman’s research related with QE policy.....	3
2.2 Cochrane’s attitude to QE policy.....	5
2.3 Cochrane’s solution to liquidity trap.....	8
2.4 Krugman’s suggestion when solving problems generated by liquidity trap.....	9
2.5 A glance at some other voices from local scholars of Japan.....	10
2.6 The reality of China.....	11
2.6.1 The investment in real estate market.....	12
2.6.2 The stock market.....	13
2.6.3 MB and M2.....	14
3 Empirical Analysis.....	16
3.1 About the selection of model and collection of data.....	16
3.2 The VAR Model.....	19
3.2.1 Graphs and descriptive statistics of the data.....	20
3.2.2 Unit root test and VAR model.....	24
3.2.3 Impulse Response Function.....	31
3.2.4 The multipliers.....	37
4 Concluding Remarks.....	41
5 Appendix.....	43

1. Introduction

The main purpose of this thesis is to detect has China already used Quantitative Easing (QE) policy or will it be necessary for China to apply such an aggressive policy in the near future considering the economic pressure it is facing now.

To begin with this topic, we have to know first what QE is. As explained by Blinder (2010), “Roughly speaking, quantitative easing refers to changes in the composition and/or size of the central bank’s balance sheet that are designed to ease liquidity and/or credit conditions.” But usually this policy has a strict restriction when it is going to be applied -the economy is in a liquidity trap, which means the conventional powerful tool - the nominal interest rate – loses its power: The nominal interest rate is almost or already zero in a depression.

As to our specific object of study – China – the situation is a little different: The nominal interest rate of China has never fallen below 0, but the People’s Bank of China (PBC) has pursued several actions which are suspicious enough to be treated as QE. So here we have to pick up three questions: 1. Are these actions QE? 2. Did they achieve the goal of alleviating the crisis? 3. In which situation the PBC will react with QE or similar action?

First we read and showed opinions of some main economists in this area including Krugman, Cochrane and Koo, among others. Because if there exist any actions related with QE in China, it must be guided by some of the schools mentioned above.

Then we introduced some researches related with the reality of China, for we have to offer theoretical support to our model, and explain more clearly the special complex situation PBC now is facing. This can help us interpret better what is now going on in China.

The next step is to use the best fitted VAR (Vector Auto-Regressive) model for the data that we have collected from some main official websites of China in order to see how CPI and monetary base react to shocks in some important markets of China.

Until now we have known main theories about QE policy, the situation of China

and statistical analysis result of the relation between main economic variables of China.

Combined with everything we mentioned above, at last we can answer the questions we have put forward at the beginning of this thesis: Has China used Quantitative Easing(QE) policy until now? How well the policies pursued can ease the economic plight? In which situation it would tend to print money to fight the stagnation or potential crisis?

2. Literature Review

In general, there are two main factions when discuss the rationality of QE: Supporters led by Krugman, and discommender with Cochrane as their head. So our basic method when analyzing the special case of China is to compare the arguments of the both sides to pick one theory which matches the reality of China best and then combine it with some existing findings of local researchers to answer the three questions we put forward in the very beginning of this thesis.

2.1 Krugman's research related with QE policy

“The central new conclusion of this analysis is that a liquidity trap fundamentally involves a credibility problem-but it is the inverse of the usual one, in which central bankers have difficulty convincing private agents of their commitment to price stability.”^① - central banks often face problem when trying to convince private agents of their commitment about price stability, in a liquidity trap, the market believes that the central bank will target in price stability if only it had chance, and hence the current expansion is merely temporary.

Krugman interpreted the liquidity trap as: the equilibrium real interest rate in which investment equals saving is negative, which means that the desired saving is more than desired investment even the interest rate is 0. And this real equilibrium interest rate is influenced by expectation of the public about the future price level. So what we should do is to select from these two options: let the interest rate fall below 0 to let desired saving equal desired investment, or try to influence the expectation of the public to rise the real interest rate to positive values. Based on this, Krugman proposed a way to get out of the liquidity trap: To produce inflation! Not only the termination of deflation, but higher inflation than the so-called “normal level”-of course not hyperinflation, for example, he suggested Japan to maintain at least 4% inflation in next 15 years. Because the deflationary pressure actually being manifested represent the economy trying to get a necessary inflation by cutting current price level to make it consistent with the expected future price level, so the only way to solve this is to get inflationary

^① Paul Krugman-*It's baaack: Japan's slump and the return of liquidity trap*-Pg.139

expectation of the price level.

But high inflation resulted by inflationary expectation is usually treated as a harmful factor by many economists, so someone may argue that if we have too much saving, we can choose to invest abroad. Krugman scoffed propositions like this as “naive”, he built a model of an economy with tradable and non-tradable sectors, for goods market remain far from perfectly integrated, a great part of employment and GDP (Gross Domestic Product) is generated by non-tradable goods and services, this weakens the effectiveness of capital exportation -if the non-tradable part is large enough (actually it is, even in some most advanced economy like USA and Japan), even investing abroad with 0 interest rate is not enough to bootstrap the economy out of liquidity trap.

However some other people have the preoccupation that an inflationary policy may lead to a “Beggar Thy Neighbor” vicious circle, as it did in the great depression which led to World War I. But Krugman proved such concerns are unnecessary by calculating a so-called “Beggar Thy Neighbor coefficient”, the formula is:

$$B = \frac{1-\rho}{1-\rho-\frac{1}{\tau}} \quad (1)$$

Where ρ is the relative risk aversion and τ is the share of traded consumption. According to the experience, Krugman sets $\rho=2$ and according to statistics, $\tau=0.2$ (In the paper he used Japan as the object of analysis) and gets the result that, central bank can raise five percent of Japanese output by increasing current account surplus no more than one percent.

So the relative small share of tradable part of real economy is a double-edged sword-which weakens the effectiveness of escaping from liquidity trap by exporting capital while making the inflationary policy less harmful to the rest of the world.

One thing we shouldn't forget is that Krugman just concentrates on Japan, as to USA, the situation is a little different (anyway both the GDP and the tradable part of which are much bigger than Japan), by analyzing the international effect of large scale purchase, Neely (2011) proved that the ongoing balance sheet expansion of FED (The Federal Reserve System) has great international effects by influencing yields of other

sovereign bonds. So even the inflationary policy is not as harmful as we usually think, we cannot abuse it.

According to Krugman, because exporting capital is useless, the inflationary policy becomes the unique choice for all central banks in liquidity trap. If and if only the central bank can credibly convince the public that it is going to seek a higher price level, it can bootstrap the economy out of the liquidity trap. The effectiveness of QE policy depends on how successfully the central bank can control the expectation of the public. A noteworthy point is, though Krugman and Cochrane debate fiercely on the correctness of QE policy, to a considerable extent both of them confirm the importance of expectation in execution of QE policy.

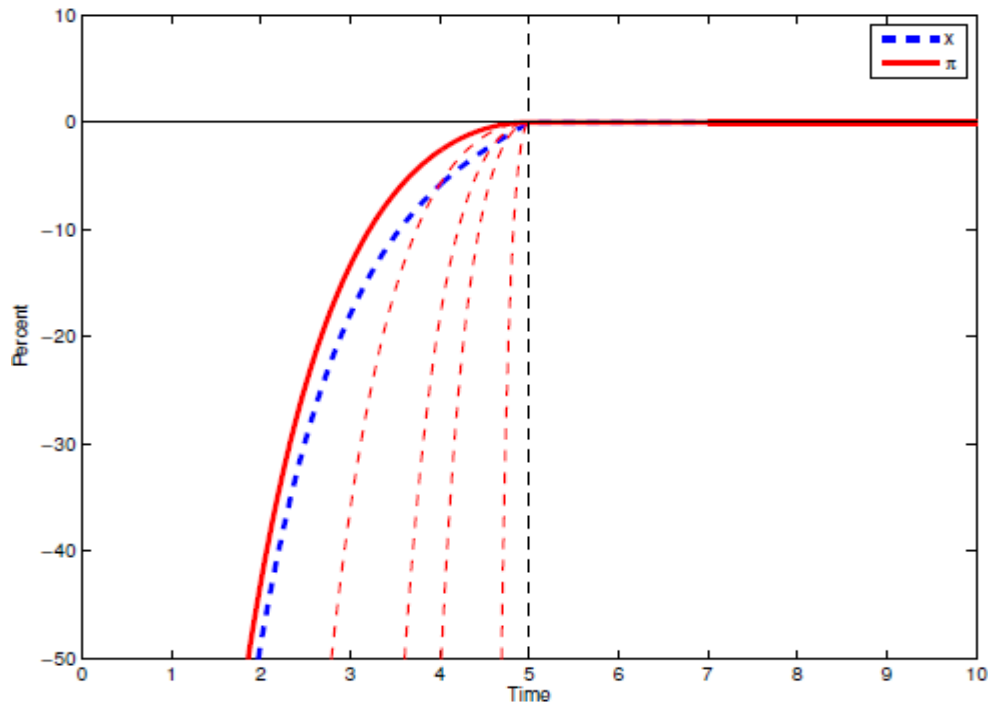
2.2 Cochrane's attitude to QE policy

Cochrane is a staunch opponent of QE policy.

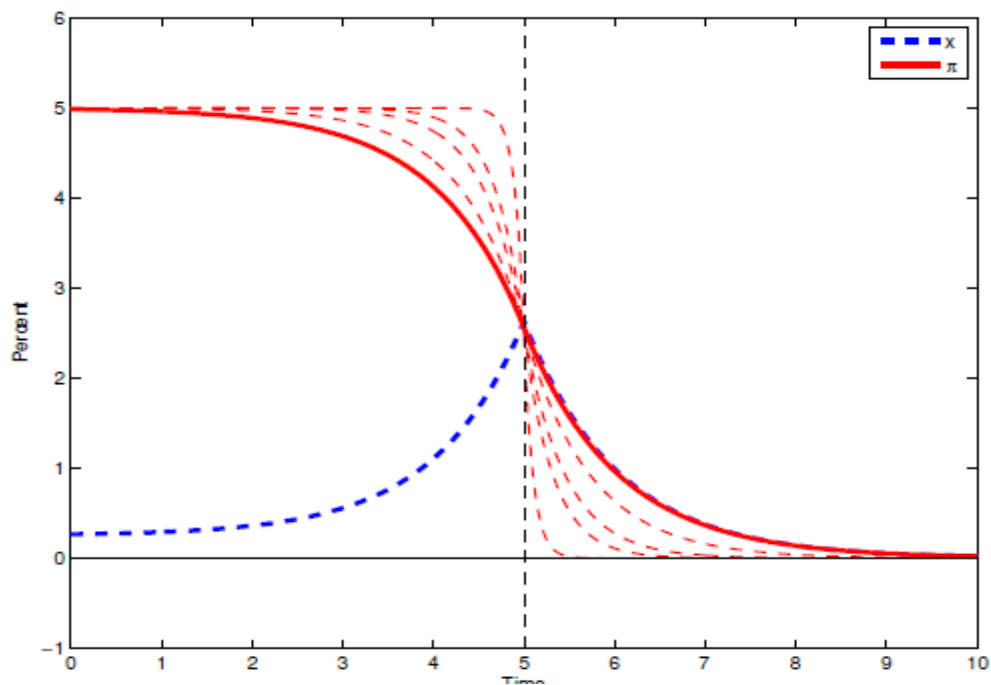
He even signed his name on an open letter (2010) to Mr. Ben Bernanke, who was the chairman of Federal Reserve, claiming that the ongoing QE policy can't help USA achieving the employment target, distorting financial market when greatly complicating Fed's effort to normalize its monetary policy in the future, and leads to hyperinflation. The theoretical base for prophecies about the hyperinflation is the quantity theory of money (QTM). According to the research of Dwyer and Hafer (1999), Grauwe and Polan (2001), Frain and Cochrane (2004), McCandless and Weber (1995), either testing the relation between money growth rate and inflation or the relation between inflation and money growth rate relative to real income, if some lags are permitted (money growth leading inflation), in long run, a strong proportional positive relation between the money growth and inflation can be detected. According to this, economists like Cochrane believe that hyperinflation may emerge in a few years after the QE.

But five years passed, the inflation level was still low, so Cochrane (2015) turned to emphasize that the QE policy pursued by central bankers is not as effective as we thought, the only factor which can decide the output of QE policy is the expectation. Because the widely accepted new-Keynesian model allows the existence of multiple equilibriums of inflation and output under the same model, the same parameters and

the same interest rate path. To show how expectation influences the result of policy, he simulated three possible equilibriums of one particular policy with different expectations as following.



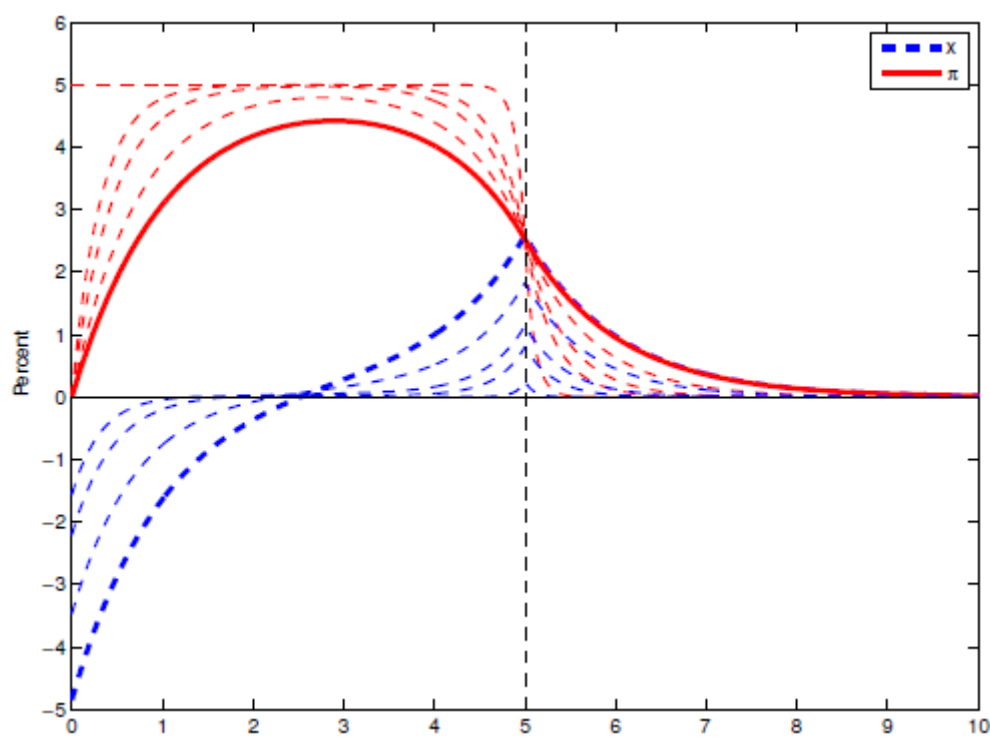
Graph 1 A Standard new-Keynesian equilibrium^②



Graph 2 A backward stable equilibrium^③

^② J.H.Cochrane- *The New-Keynesian Liquidity Trap*-Pg.8

^③ J.H.Cochrane- *The New-Keynesian Liquidity Trap*-Pg.9



Graph 3 A “no jump” equilibrium^④

In all the three graphs above, x denotes the output gap, π denotes inflation. Graph 1 shows the simulation of a standard new-Keynesian equilibrium, in which the public believes that the central bank will let the interest rate equals the natural rate immediately at end of the liquidity trap; graph 2 shows a backward stable equilibrium, under the assumption that the public thinks the central bank will keep the interest rate low for a period after the liquidity trap; and graph 3 is a “no jump” equilibrium, with the same expectation of graph 2, but requires higher price stickiness. The standard equilibrium seems disastrous in period of liquidity trap ($t < 5$), while the backward stable one seems much more mild though with a suddenly jump of inflation and output gap, as to the “no jump” one, looks like the best output we can get from a liquidity trap. And if central banks want a better output of liquidity trap (maybe “better process” is more accurate, because the inflation and output gap will return to the natural level after the crisis anyway, sooner or later), central bank should choose the best equilibrium —— unfortunately it cannot choose equilibrium by changing the interest rate (because all these graphs have the same interest rate path).

^④ J.H.Cochrane- *The New-Keynesian Liquidity Trap*-Pg.11

Cochrane indicates that the only way to influence the public's expectation is to make them believe that the central bank is seeking for a better equilibrium, and the central bank can only approach this target by credibly convincing the public that it will “explode” the economy if the public doesn't act as it wishes: if the public doesn't take necessary actions or hold necessary expectation (here the necessary expectation indicates inflationary expectation after the liquidity trap), the central bank will take actions to reach the standard equilibrium in graph 1 which leads to serious economic turmoil. According to Cochrane's prediction, if people believe that the central bank may perish together with them, they tend to believe that the low interest rate and high inflation will continue for a longer period even the liquidity trap has come to an end. However people will never believe this kind of threat, if any governor of central bank dares to destruct the economy by himself, he will be kicked out of the decision makers soon, so the problem turned out to be: Is it possible to choose the better equilibrium with the existing tools? The answer of Cochrane is “no”: If the central bank can only choose the interest rate path or inject money into economy, there is no guarantee that the economy will choose the optimal equilibrium. So according to Cochrane, QE policy is useless as well as adjusting interest rate when the economy is in a liquidity trap.

2.3 Cochrane's solution to liquidity trap

Usually when you oppose other people's plan, you can't only point out their mistakes, but have to offer another viable solution also. So after proving quantitative easing policy is “useless” (“useless” is only Cochrane's point of view and it does not represent the author's opinion), recently, Cochrane (2016) begins to announce that we can solve the current plight by using the fisher equation:

$$i_t = r_t + E_t \pi_{t+1} \quad (2)$$

He explained that after many years of recovery, the recent history of zero interest rates with low and stable inflation in the US and Europe, and longer experience in Japan implicate that inflation can be stable under an interest rate peg. He also admits that our recent pegs appear to be stable doesn't mean pegs are always and everywhere stable, but if only now the pegs are stable, according to equation 2, we can easily know that

even nobody can influence the real interest rate r_t , we can still rise the nominal interest rate to get a higher inflationary expectation, which is necessary to produce a higher inflation in the future. But this is a little bit different from the traditional Fisherian theory: the traditional Fisherian theory predicts that a rise in an interest rate peg will eventually raise inflation, allowing a short-run movement in the other direction while Cochrane's theory leads to conclusion that even in short run the inflation will not fall with a rising interest rate. So to test if his "neo-Fisherian" is right, he tried to establish the conventional belief that a rise in nominal interest rates lowers inflation, at least temporarily, in a simple modern economic model of monetary policy following an interest rate target that is consistent with the experience of stable inflation at the zero bound. But all attempts to escape from the prediction that raising interest rate will raise inflation, both in the long and short run all failed, these attempts include adding money into utility function, backward looking Philips curves, multiple equilibria (the concept of "multiple equilibria" was created in Cochrane's paper "*The New-Keynesian Liquidity Trap*" which was published in January of 2015, here he tried to prove that an interest rate rise does not directly lower inflation via supply and demand. Instead it induces the economy to jump from one to another of multiple equilibria and then generates some uncertainty) and Taylor rule. And a review of empirical evidence finds very weak support that raising interest rate will lower inflation. So he suggests the central bankers take the possibility of a positive reaction to interest rate changes seriously.

2.4 Krugman's suggestion when solving problems generated by liquidity trap

As Krugman said, "When uncertain about the right model, throw a bit of everything at the problem". So he suggested a mixed strategy when dealing with liquidity trap. His strategy is composed by 3 parts.

1. Fiscal expansion. It has two forms, one is to have more public works and the other is to cut taxes. Now the core debate of fiscal expansion is if it's possible to have an adequate fiscal expansion without having a default government in the future, take Japan for example, considering the poor demographic situation of Japan, if the government expanded the spending too much, the government debt can be lethal if

the interest rate strongly return to positive interval in foreseeable future.

2. Banking reform. Even Krugman emphasized that banking system is not the source of liquidity trap as common opinion had ascribed before, because the real problem is inferior demand in investment market. In a country where deposits are guaranteed by government, banks always tend to take risky and aggressive actions, so at least the wiliness to loan is enough. Too risky and too much loan is also a problem, so it is still helpful to reform the bank system, but if the central bank decides to do it, better to complete the reform by a single but complete operation, a slowly tightening reform will generate panic between banks which may lead to a credit crunch, and deprave the depression.
3. Managed inflation. It's directly connected with the QE policy, the only problem is, how much and how long inflation is required, but this is not the key point of this paper, the important reality is, if the central bank wants to get out from the liquidity trap, it should permit inflation in a longer period.

Until now, according to recent research, as Claeys, Leandro and Mandra (2015) have said "it seems the QE policy already having a beneficial impact on European public finances through the very significant fall in yields that has taken place throughout the euro area since mid-2014 in anticipation of the program." The success of QE in EU offers strong support to Krugman.

2.5 A glance at some other voices from local scholars of Japan

Japan's experience is very special, as the only large economy which has stayed in liquidity trap for more than 15 years, Japan is a valuable sample when analyzing liquidity trap, but the heavy losses caused by bubble burst of real-estate market resulted in a permanent conservative propensity between all economists of Japan, as Shirakawa (2014) explained, even in the liquidity trap, the long-term price stability is also the most important target of central bank, so we can understand the reason why when western economists like Krugman are continuously Japan's timidity, Japan still insist in a mild QE policy- they are scared by the tragedy in 1991 caused by excessive credit expansion. The special situation of Japan influenced opinions of local scholars, they confirm that

the QE policy has some positive effect, but too much QE or only relying on QE is wrong. Richard Koo is a leader of them.

Koo's opinion (2013) is different from both Krugman and Cochrane: He said that because in an economic crisis, private agents tend to increase saving to pay back debts other than borrowing more because their balance sheets are already damaged badly, even with zero interest rate. This means they are forced to shift their priorities away from the usual profit maximization to debt minimization, so the QE, the zero interest rate failed to stimulate the economy. The only way out is fiscal expansion. Krugman and Eggertsson (2012) confirmed Koo's opinion by modeling an economy which suffers from a suddenly shift of deleveraging.

Koo claimed that the QE policy can't completely solve problems generated by financial crisis, because balance sheet recession is a borrower's phenomenon, while financial crisis is of lender's side. Available tools to address financial crisis include liquidity infusions, capital injections, explicit and implicit guarantees, lower interest rates and asset purchases. As we can see, these policies pursued by FED, ECB and Bank of Japan have eased the financial crisis in different degrees, but all balance sheet problems that have emerged before Lehman Brothers' failure are still in place. In alleviating financial crisis, the central bank acted as the lender as last resort but failed to bootstrap the economy out of economic predicament because those countries are also suffering from borrower's problem. And the borrower's problem can only be addressed by the government performing as the borrower of last resort. Here we can clearly understand that Koo is also a supporter of quantitative easing policy, but according to his opinion, fiscal stimulation shouldn't only be an aid or optional part of QE policy, but another important phase when curing the economy from the financial crisis after QE.

2.6 The reality of China

If we use CPI as the dependent variable (because if China pursues a QE policy, CPI must change sooner or later), the problem then becomes: CPI will react to shocks in which variables?

According to PBC's behavior of recent years and some relevant researches, we choose four from all possible variables: the investment in real estate market, the stock market index, monetary base and M2.

2.6.1 The investment in real estate market

Here I have to express my gratitude to Fang, Gu, Xiong, and Zhou (2015), their paper is the first one and only one that gives a precise data support to one assumption, which is: as the most important market in China, the real estate market must have some important influence on PBC when developing new monetary policies, so it's possible for the changes in real estate market to influence the CPI of China.

Fang's research focuses on the housing boom of China. In brief, they got the following conclusions:

1. Comparing with the income level, even the middle and small cities' real state price has a relative mild increase, the big ones' price increased dramatically (As I calculated, for example, Beijing's real estate price has maintained an average annual growth rate of 30% since 1990).
2. Even the poorest families in China are trying to buy real-estates, this is not only because of the demand of living, one most important element that drives Chinese to buy houses is, China applies strict capital control, so the choices for normal people when investing are limited. Usually, they can only select from precious metals, stock market, bonds and house. Stock market in China is too volatile, and as Fang, Gu, Xiong, and Zhou have proved, the rate of return of stock market is lower than real estate market, the volume of bond market is too small, precious metal has kept decreasing for years, so the only way to invest in China is buying house: high rate of return, low risk (at least now, low risk). By the way, China has the almost highest gross saving rate in world (more than 50%), and these years, the saving interest rate is always decreasing, which also stimulates the desire of buying houses.
3. The income-to-price ratio (ITP) in Chinese big cities is higher than 8, usually the healthy real-estate market suggests a ITP ratio no more than 3, the last large economy with such high ITP ratio was Japan in 1991, when the bubble in real estate

market was to burst. But they also admit that, the very high down-payment (usually 30% to 40%) can prevent debt default of buyers, but such protection has its limit-it is sustained by the expected continues growth of future income- both from salary and from the growth of real estate price.

So we can see, if there is any problem in other sectors, capital flows inside China always tend to flock to real estate market. Obviously this phenomena increased the possibility of emergence of bubble in this market, so PBC will take it into account when adjusting its policy.

But on the other hand, PBC dares not cool down the housing market rapidly, as Jianwen (2015) proved, the depression in housing market can lead to deflation in China, so the dilemma of PBC is: Every time when some problems happen in other market, hot money in real estate market will continue to accumulate, but the cooling down policy in housing market may produce deflationary expectation which is destructive if the economy itself is in a depression.

As PBC will always take the reaction of real estate market into account, it's reasonable for us to put it into our model.

2.6.2 The stock market

It may seem a little strange to treat stock market as one factor that can influence the CPI, but what if the central bank has the willingness to ease a crash in stock market by printing money?

In the stock market crash which began on 12/06/2015, PBC announced it would offer “ample” liquidity support to Chinese Securities Finance Corporation Limited- which is the a state-owned company in China with the responsibility to stabilize the stock market via open market operations. This unlimited liquidity support was interpreted as a kind of indirect Quantitative Easing and actually expanded the volume of balance sheet of PBC.

Latter, PBC released another powerful policy permitting commercial lenders use loans as collateral to borrow cheap funds from the central bank, but it said nothing of the criterion when judging which lenders are qualified to make such loans, and loans of

risk to which degree can be treated as collateral (this is one of the biggest problem we met until now, PBC never explains too much of what it wants to do, and how to do, just leaving a signal and big space to imagine), but there is no doubt that PBC has showed its wiliness to start its banknotes printing presses if the situation of stock market continues to deteriorate.

And we found more theoretical support for our hypothesis that in China the stock market can influence the CPI: According to the research of Du and Li (2008), they found that the Shanghai Composite Index is granger causality of CPI in China, and these two variables will move to same direction when there is a shock.

So we select Stock Market Index as a variable: local scholars have proved that it can influence the CPI, and actually PBC has reacted to volatility in Stock market.

Here we use the method of Du, take the monthly average index of Shanghai Composite as a variable.

2.6.3 MB and M2

If we go back to check all the descriptions we've given out about QE until now, "changes in the composition and/or size of the central bank's balance sheet that are designed to ease liquidity and/or credit conditions", "liquidity infusions, capital injections, explicit and implicit guarantees, lower interest rates and asset purchases", all these actions taken by central bank need large amount of money, obviously if a central bank needs money, it can print it by itself. So put monetary base (MB) into the model is to observe in which situations the central bank tend to print money: according to series information we listed above, we suppose that central bank will use QE policy when there is crisis in stock market and real estate market and we can only test our hypothesis by analyzing the co-movement of monetary base with these two variables.

Money supply is a substitution of MB, because we know another important factor that can influence the effectiveness of quantitative easing policy is the money multiplier, because $M_1 = mb \times k$, k is the money multiplier, in some extreme circumstance, even the central bank injects huge amount of money into the economy, the CPI will keep low or even fall with the money multiplier sharply decreasing; in the opposite case, if the

money multiplier jumps high, central bank can produce very high inflation by printing only a little cash. But we use M2 instead of M1 here, because M2's scope is wider than M1, it includes many kinds of "near money" besides M1, because these "near money" can influence CPI also, we take M2 into consideration in case of MB's statistical performance is not good in our model.

3. Empirical Analysis

In this section we are going to analyze the considered data. We employ unit root tests in order to characterize the stationarity of the time series, we search for the best model fitting the data and we interpret Impulse Response Function (IRF) output.

3.1 About the selection of model and collection of data

When analyze co-movement of several time series, Vector Auto-Regressive (VAR) and Vector Error Correction (VECM) models can be a good choice as long as the data meet some basic requirements. For our particular situation, the model that best fit the data it is a VAR (4, 4) (with 4 variables and 4 lags), since no co-integration exists between the considered variables.

First we would like to introduce briefly the general definition of the VAR model.

VAR is an econometric device used to model multivariate time series which it is given by a particular system of multiple (auto) regression equations. It describes the evolution of a set of k variables (called endogenous variables) over the same sample period ($t = 1, 2, 3 \dots T$) as a linear function of their past values. The variables are collected in a $k \times 1$ vector y_t , which has as the i^{th} element, $y_{i,t}$, the observation at time " t " of the i^{th} variable. For example, if the i^{th} variable is GDP, then $y_{i,t}$ is the value of GDP at time t . A p^{th} order VAR, denoted by VAR (p), is:

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t \quad (3)$$

where the l -periods back observation y_{t-l} is called the l -th lag of y , c is a $k \times 1$ vector of constants (intercepts), A_i is a time-invariant $k \times k$ matrix of coefficients and e_t is a $k \times 1$ vector of error terms satisfying:

1. $E(e_t) = 0$, every error term has mean zero.
2. $E(e_t e_t') = \Omega$, the contemporaneous covariance matrix of error terms is Ω (a $k \times k$ positive-semidefinite matrix)
3. $E(e_t e_{t-k}') = 0$, for any non-zero k , there is no correlation across time; in particular, no serial correlation in individual error terms.

A p^{th} -order VAR is also called a VAR with p lags. The process of choosing the maximum lag p in the VAR model requires special attention because inference is dependent on correctness of the selected lag order.

There are some reasons for what we try VAR model first:

1. As we can see later, we finally chose four variables in nine potential options, and this gives rise to a problem if we use other models: which variables are exogenous and which variables are endogenous? The VAR model doesn't have this problem: all variables are endogenous.
2. VARs allow the value of a variable to depend on its own lags and the lags of other variables. Models thus offer a rich structure which may be able to capture more characteristics of the data. Specific to our case, as we have mentioned in literature review, it has been proved by many economists that if permit some lags, the relation between monetary base and CPI becomes more significant. The logic behind this assumption is: the market needs time to react to actions of central bank or shocks in other areas and once the central bank take some actions the impact of them will last for some periods and fade away slowly.
3. Assuming there are no contemporaneous terms on the right-hand side of the VAR, OLS (ordinary least square) can be used separately on each equation to estimate the coefficients of the system. This is because all the variables on the RHS (right hand side) are pre-determined i.e., at time t they are known. It can be shown that OLS will be consistent, asymptotically efficient and asymptotically normal.
4. Our purpose is to analyze in which situations the central bank of China tends to print bank notes. By constructing a VAR model, we can intuitively observe how the monetary base or M2 will react to shocks in different important economic area of China and then we can make some conclusion according to the impulse response function output. Though we didn't make any forecast here, but another advantage of VAR model is that forecast results are better than the ones resulting

from other conventional models.

Anyway, the VAR model also has some limitations, some of them enumerated below:

1. It is a kind of linear regression model, so if the structure of database is not suitable, we have to try non-linear models.
2. It requires that all variables are stationary or integrated of the same order (so when we can just get stationary variables by integrating the original time series to different orders, we will meet problem).

The solid and truthful data base is the first step towards success, so we tried hard when collecting these data of China from official website. In this work we consider and collect data for the following economic variables:

- Average price of residential real estate (yearly)
- Investment in residential real estate (monthly)
- Total sales of real estate both in value and area (monthly)
- Shanghai interbank offer rate (daily)
- GDP (monthly)
- CPI (both monthly basis and yearly basis) (monthly)
- Monetary Base and M2 (monthly)
- Reporate
- Liabilities of People's Bank of China (monthly)

Finally, I selected only five variables to build the VAR model: Investment in residential real estate (monthly), CPI (yearly basis), Monetary Base, M2 and Stock market index (monthly).

Besides the theoretical consideration we have mentioned in literature review, one of the most important reason for which we select these five variables is that all of these five variables' frequency is monthly. Originally, I tried to use real GDP as an optional

alternative of investment in residential real estate, because usually the real GDP is a more comprehensive and accurate indicator when describing the situation of an economy. But we can only get quarterly data of real GDP (of course no country will calculate the monthly real GDP), all other variables can be added up to quarterly form, but as we all know, China's statistic division just began after 1990, so if we use quarter data, the quantity of observations we can use will be too small. Moreover, since even monthly data has some noises, we choose to abandon the real GDP and use the remaining monthly data for accuracy consideration.

Another problem we met when collecting the data is that some time series show unusual features, as we can see below. For example, the shape of "Invest in real estate" curve in Figure 1 shows too strong similarity between different years (it seems like someone amplified the initial curve year by year), and very strong seasonality. We wrote to National Bureau of Statistics of People's Republic of China consulting these questions, they admitted that the data on their website was "micro adjusted" but they assured that the data is real and can be used in any serious academic research.

The main three resources of my data are: The website of PBC^⑤, the website of National Bureau of Statistics of People's Republic of China (NBSPRC)^⑥ and Professor Tao Zha's website^⑦.

3.2 The VAR Model

In this section, we use monthly time series representing the following economic variables: CPI (Yearly base), Investment in real estate market, M2, monetary base and Stock market index for the time period between March 2000 and December 2015. After some rearrangement, we have 190 observations for each one of the variables. The first step in our empirical study is to present the basic descriptive statistics of the data which allow us to take some important conclusion about the considered time series.

⑤ <http://www.pbc.gov.cn/>

⑥ <http://www.stats.gov.cn/>

⑦ <http://www.tzha.net/>

3.2.1 Graphs and descriptive statistics of the data

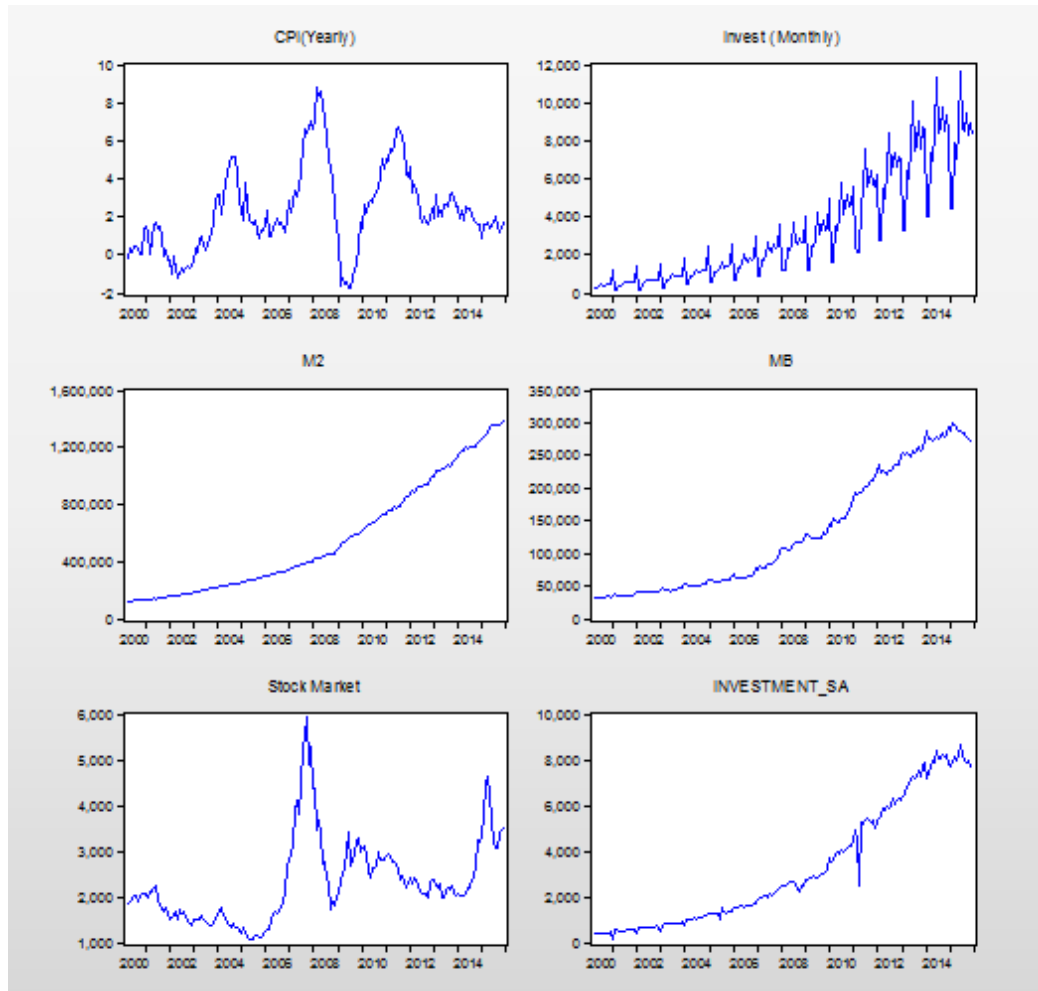


Figure 1. Plot of all selected time series (CPI, Invest amount in real estate market, Stock market index, Monetary base, M2 and Invest amount in real estate market seasonally adjusted)

Figure 1 shows the plot of the original time series where we can observe the presence of outliers, linear and non-linear trends and nonstationary behavior. We can observe strong seasonality in the graph of investment variable (monthly). This is because the investment in real estate market is influenced by many seasonal factors such as the weather (nobody want to begin the construction in rainy season), bank loan habits (usually banks tend to make loans at the first half of a year) and tradition (Chinese

tend to marry in some particular auspicious day and newlyweds' purchasing will stimulate the investment in real estate market). So we processed the data in order to remove the seasonality, the variable Invest-sa is the processed data.

Since we cannot accurately determine all the properties of the variables only by observing the graphs, we will further proceed with the descriptive statistics of each variables except investment (because of the strong seasonality, we decide to substitute it with Invest-sa).

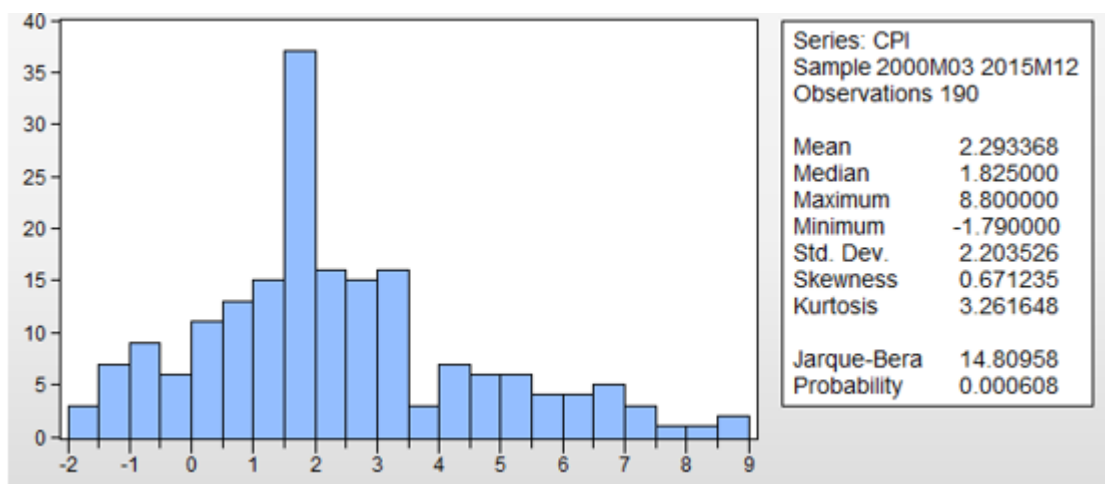


Figure 2. Descriptive statistics of CPI

Figure 2 illustrates the basic descriptive statistics of CPI time series, where we observe moderate positive skewness and a slightly leptokurtic distribution since the kurtosis is a little higher than 3. The Jarque-Bera test with the null

H0: the observations are normally distributed Vs

H1: the observations aren't normally distributed

shows that the original CPI time series is not normally distributed since the probability value is less than 0.05 (that is, the 5% significance level). From the graph, we cannot find any trend, but the mean is larger than 0, so we can conclude that there is an intercept.

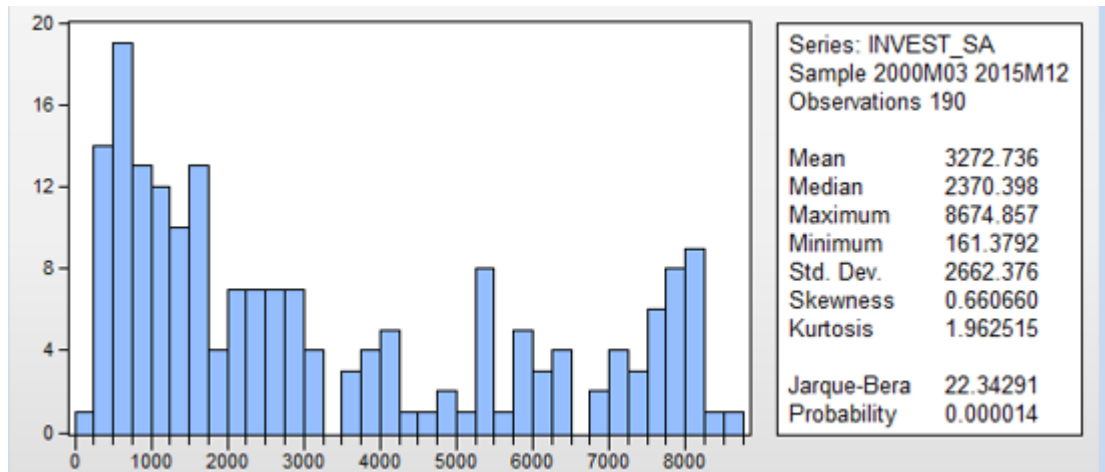


Figure 3. Descriptive statistics of Invest-sa

Figure 3 illustrates the basic descriptive statistics of Invest-sa time series. We observe moderate positive skewness and a platykurtic distribution since the kurtosis is lower than 3. The Jarque-Bera test shows that the Invest-sa time series is not normally distributed since the probability value is less than 0.05 (that is, the 5% significance level). By observing the graph (from Figure 1), we can find a linear trend, the mean is larger than 0, so we can conclude that there is also an intercept.

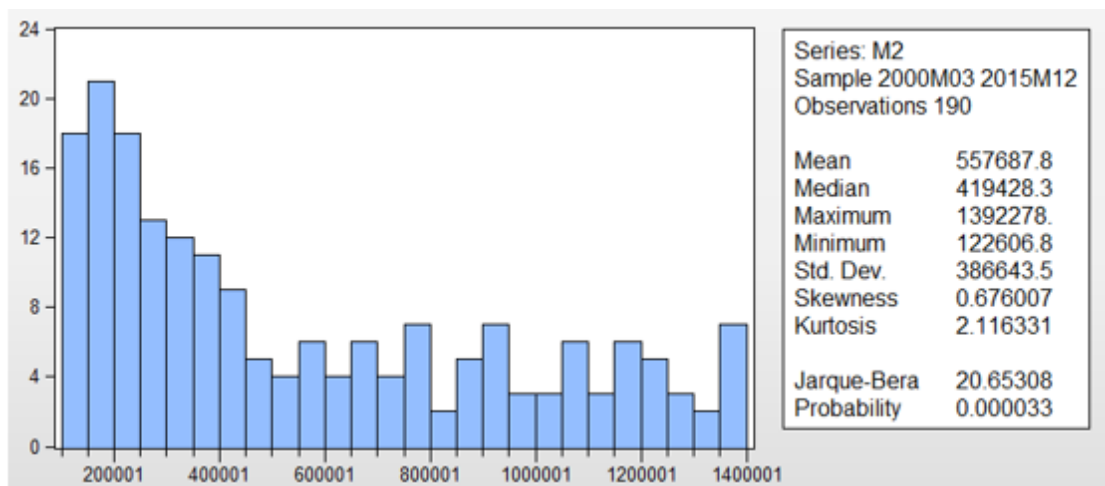


Figure 4. Descriptive statistics of the M2 variable

Figure 4 illustrates the basic descriptive statistics of the M2 time series. We observe some moderate positive skewness and a platykurtic distribution since the kurtosis is lower than 3. The Jarque-Bera test shows that the time series is not normally distributed since the probability value is less than 0.05 (that is, the 5% significance level). We also can observe a linear trend and a non-zero intercept.

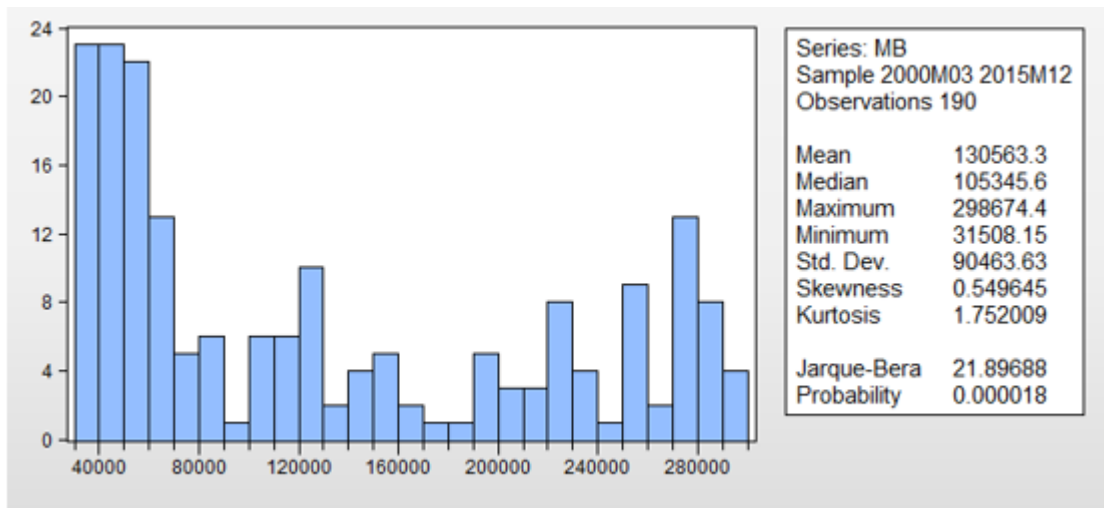


Figure 5. Descriptive statistics of the MB

Figure 5 illustrates the basic descriptive statistics of the MB time series, where we observe once again moderate positive skewness and a platykurtic distribution since the kurtosis is lower than 3. The Jarque-Bera test shows that the time series is not normally distributed since the probability value is less than 0.05 (that is, the 5% significance level). From the graph, we can find a linear trend and a non-zero intercept.

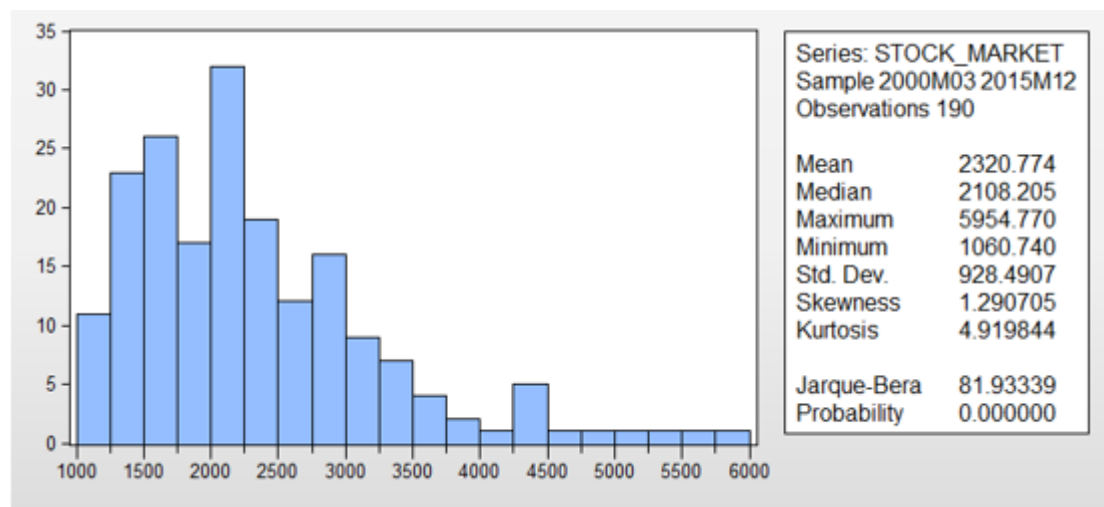


Figure 6. Descriptive statistics of Stock Market

Figure 6 illustrates the basic descriptive statistics of Stock Market time series, where we observe positive skewness and a leptokurtic distribution since the kurtosis is higher than 3. The Jarque-Bera test shows that the time series is not normally distributed since the probability value is less than 0.05 (that is, the 5% significance level). From the graph, we cannot find any monotone trend, but since the mean is larger than 0, so

we can conclude that there is a non-zero intercept.

Table 1 summarize the conclusion we can get from the descriptive statistic of each one of the variables:

	Intercept	Trend	Seasonality	Outlier	Normally distributed
CPI	Yes	No	No	Yes	No
Investment	Yes	Yes	Yes	No	No
Investment-sa	Yes	Yes	No	Yes	No
MB	Yes	Yes	No	No	No
M2	Yes	Yes	No	No	No
Stock Market	Yes	No	No	Yes	No

Table 1. Conclusion of descriptive statistics for all selected variables

3.2.2 Unit root test and VAR model

We say that a time series, $\{y_t\}$, $t = 1, \dots, T$, is weak stationary if the mean and the variance are constant on time and the covariance only depends on the lag and does not depends on time, that is:

$$(1) E(y_t) = \mu, \forall t,$$

$$(2) \text{var}(y_t) = \sigma^2 < \infty, \forall t$$

$$(3) \text{cov}(y_t, y_{t-k}) = \gamma_k, \forall t$$

Where μ is the mean, σ^2 is the variance and γ_k is the covariance of the random variable y_t .

In order to test if the time series are stationary, we used three specific tests, namely Augmented Dickey-Fuller (ADF test), Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and the Phillips-Perron (PP) test. These tests differ in how they treat serial correlation in the test regressions. ADF test use a parametric autoregressive structure to capture

serial correlation and PP tests use non-parametric corrections based on estimates of the long-run variance of Δy_t , where Δy_t denotes the first order difference of the time series y_t .

For the ADF and PP test the null hypothesis is:

H_0 : there is an unit root (the time series is non-stationary) VS

H_1 : there is no unit root for the time series (the time series is stationary).

For the KPSS test, the null hypothesis is:

H_0 : the time series is stationary VS

H_1 : the time series is non-stationary.

Table 2 presents the output conclusions of the ADF, KPSS and PP test employed to each one of the time series in levels.

	ADF		PP		KPSS	
	t-value	Prob	t-value	Prob	5% critical value	KPSS statistic
CPI	-2.60	0.939	-2.79	0.0611	0.463	0.313
Invest SA	-1.97	0.613	-2.38	0.389	0.146	0.402
M2	-0.65	0.97	-0.62	0.98	0.146	0.428
MB	-2.34	0.407	-2.03	0.583	0.146	0.388
Stock Market	-2.37	0.150	-2.24	0.194	0.463	0.543

Table 2[®]. Unit root tests conclusions for time series in levels

From this table we can infer that none of these time series are stationary in level, since the p-value is higher than 5% significance level and we do not reject the null (ADF, PP), so we proceed to stationarize the data by using the first-order difference operator.

® Figure 1-Figure 15 in Appendix

In what follows we apply the considered unit root tests on the first difference of these variables and we conclude about stationarity in Table 3:

	ADF		PP		KPSS	
	t-value	Prob	t-value	Prob	5% critical value	KPSS statistic
Δ CPI	-6.06	0	-13.31	0	0.463	0.05
Δ Invest SA	-15.5	0	-26.28	0	0.146	0.120
Δ M2	-2.98	0.141	-14.89	0	0.146	0.069
Δ MB	0.119	0.997	-15.38	0	0.146	0.20
Δ Stock Market	-7.23	0	-12.75	0	0.146	0.040

Table 3^⑨. Unit root tests for the first order differenced time series

According to the result of PP test, we found that, all these 5 variables are stationary in first difference since we reject the null. Further, we can see that, when we take unit root test of M2 and MB in first differences, they don't pass the ADF and KPSS test except M2, that pass KPSS, being stationary (the KPSS statistics it is higher than the 5% critical value). This is no problem, because usually, economic time series are stationary in same rank. Further, we employ unit root test on M2 and MB in second difference just to see what would happen, and the result is that they passed all 3 tests, but we cannot understand why "the change of change amount of M2/MB is related with the change of the remaining variables", it seems meaningless. On the other hand, all the time series passed the PP test in the first difference, and since this is the most credible and powerful one between the 3 unit tests, we can conclude that the five considered time series are integrated of order 1, that is, I(1).

In what follows we are going to use the first difference of these 5 variables in order to build a VAR model adequate to analyze the relation between these variables. We study several variable combinations in the VAR models and reject some of them based

⑨ Figure 16-Figure 30 in Appendix

on the residuals properties. Since M2 and MB's impacts in the VAR model are coincidental, we only put one of them into the model each time. The following table makes the summary of some VAR models based on the lag structure (Information Criteria based) and the residual correlation (Portmanteau Test):

VAR with M2		VAR with MB	
Suggested lags	If residuals correlated	Suggested lags	If residuals correlated
3	yes	1	yes
6	yes	2	no
10	yes	3	yes
12	yes		
20	yes		
24	yes		

Table 4^⑩. Lag number and residual correlation in considered VAR models

We can conclude from Table 4 that the VAR model that includes the variables CPI, MB, Invest SA and Stock Market in first differences with 2 lags is the only model with uncorrelated residuals. For this reason this will be the model we consider further in our analysis. We also take a look at the AR roots graph, all the points fall in the unit circle, which means the model is stable.

⑩ Figure 31-41 in appendix

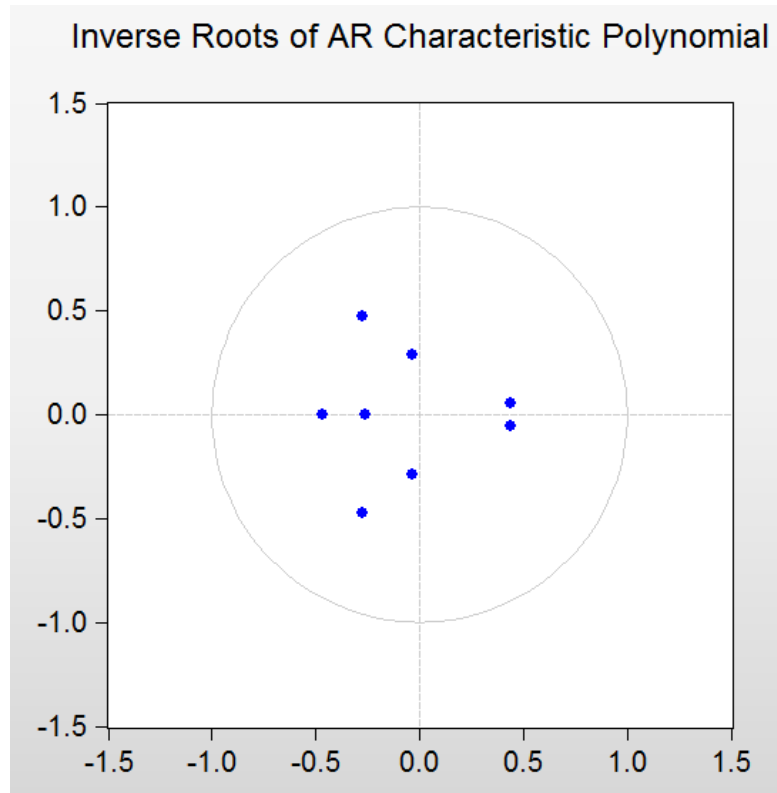


Figure 7. The AR roots graph

But usually, we need to take the logarithms (logs) of the variables Invest-sa, MB and Stock Market, this is because CPI is a kind of rate of change, and the other three variables are all real numbers. The huge differences in absolute values between variables in the model may produce too large coefficient of CPI when use the other three variable as dependent variable and too small coefficients of the other three variables when use CPI as the dependent variable. So we take logs of all the variables except CPI (it is already rate of change) to transform them into growth rate.

Theoretically, if the original variables passed the unit root tests, the log of them should also pass the same tests, but for prudence we take all necessary tests to the new generated 3 variables. Because CPI is stationary in first difference, we just test stationarity for the first difference of the newly generated log-variables:

	ADF		PP		KPSS	
	t-value	Prob	t-value	Prob	5% critical value	KPSS statistic
$\Delta \text{LogInvestSA}$	-9.02	0.00	-64.37	0.00	0.146	0.160
ΔLogMB	-1.41	0.86	-14.50	0.00	0.146	0.214
$\Delta \text{LogStock Market}$	-7.53	0.00	-12.47	0.00	0.463	0.572

Table 5^⑪. Unit root tests for the growth rate of the considered variables

From Table 5 we can conclude that all three variables are stationary in the first difference of the log of variables as we expected, since based on the PP unit root test we always reject the null of non-stationarity and based on KPSS test we never reject the null of stationarity.

Considering now these variables we test new VAR models and we conclude that for our purpose, the new VAR model best fitting the variables needs 4 lags according to Portmanteau tests^⑫ for residual correlation whose null hypothesis is:

H_0 : no residual autocorrelations up to lag h VS

H_1 : exists residual autocorrelations up to lag h

Then we have a look at the AR roots graph, all the points fall in the unit circle, which means the model is stable.

⑪ Figure 42-50 in appendix

⑫ Figure 51 in appendix

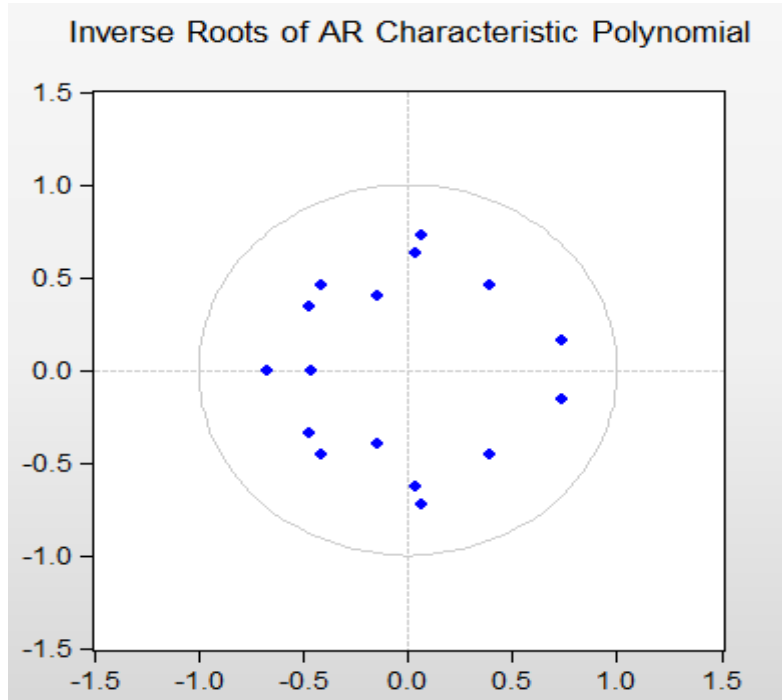


Figure 8. The AR roots graph

As we have explained above, the VAR model is a system of equations designed to analyze how the past (lagged) values of all variables can influence the current value of each variable. So, in our case, we finally got four equations: with ΔCPI , $\Delta LOGMB$, $\Delta LOGINVESTASA$ and $\Delta LOGSTOCK$ as dependent variable in turn and all four period lagged variables in the right-hand side. But according to the main purpose of this thesis, we only want to see how shocks in other variables can make the PBC decide to print money, that is, how shocks in other variables can influence CPI, so we only show up the estimated equation with ΔCPI as dependent variable here, that is:

$$\begin{aligned}
 \Delta CPI_t = & 0.03\Delta CPI_{t-1} + 0.11\Delta CPI_{t-2} + 0.11\Delta CPI_{t-3} + 0.07\Delta CPI_{t-4} - \\
 & 1.27\Delta LOGMB_{t-1} + 0.30\Delta LOGMB_{t-2} + 0.08\Delta LOGMB_{t-3} - 0.59\Delta LOGMB_{t-4} + \\
 & 0.06\Delta LOGINVESTASA_{t-1} + 0.80\Delta LOGINVESTASA_{t-2} + \\
 & 0.49\Delta LOGINVESTASA_{t-3} - 0.03\Delta LOGINVESTASA_{t-4} + 1.25\Delta LOGSTOCK_{t-1} - \\
 & 0.57\Delta LOGSTOCK_{t-2} + 1.08\Delta LOGSTOCK_{t-3} + 0.47\Delta LOGSTOCK_{t-4}
 \end{aligned} \tag{4}$$

3.2.3 Impulse Response Function

Since VAR model is a kind of non-theoretical model, we need to analyze the impulse response functions (IRF) to see how a shock in residuals (innovations) of each equation in the VAR system would influence on all endogenous variables. Normally we introduce one period standard deviation shock to one of the endogenous variable and we assume that the model is in a stable equilibrium and errors are not correlated.

So the last step is to see the impulse response of *CPI* and *MB* to shocks on different explanatory variables, which can help us answer the questions which are put forward at the beginning of this thesis.

First we take a look at the shape of IRFs.

Figure 9 to Figure 12 are the responses of all the four variables to unit shock on all four variables themselves. Among all the impulse response functions, we are most interested in the responses of ΔCPI to unit shocks of other three variables (we can find the variable that influences inflation most), and the responses of $\Delta LOGMB$ to shocks (which can tell us what kind of volatility can force PBC to print money).

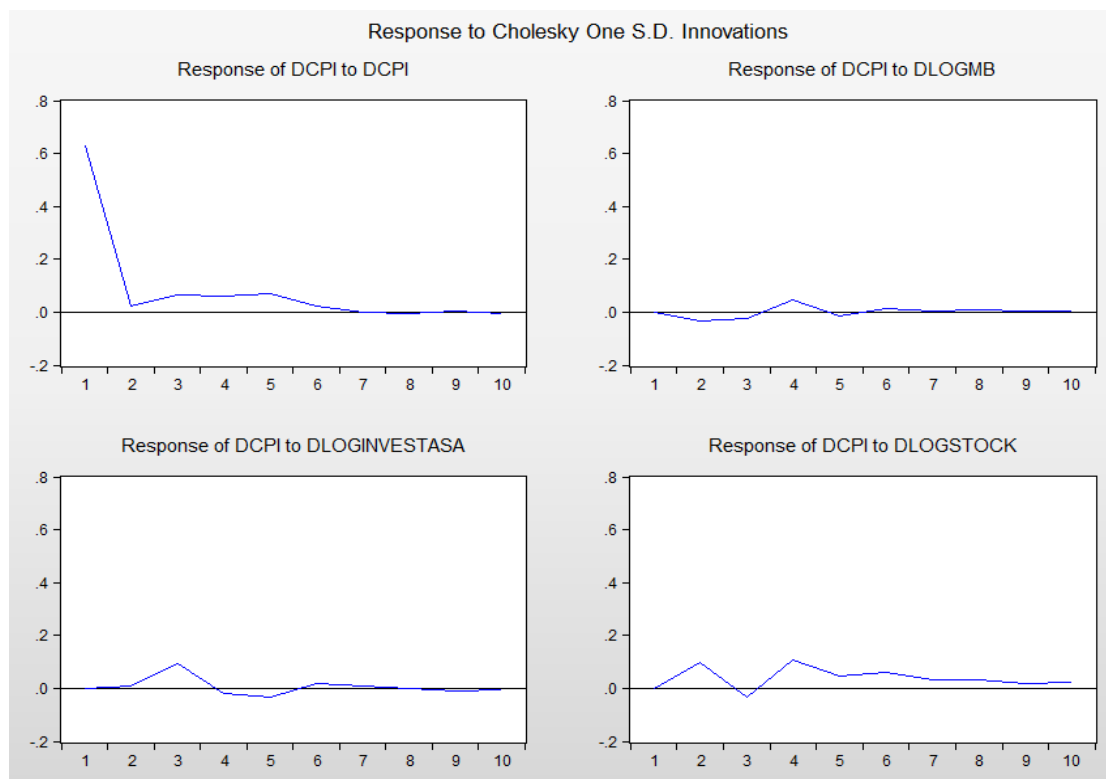
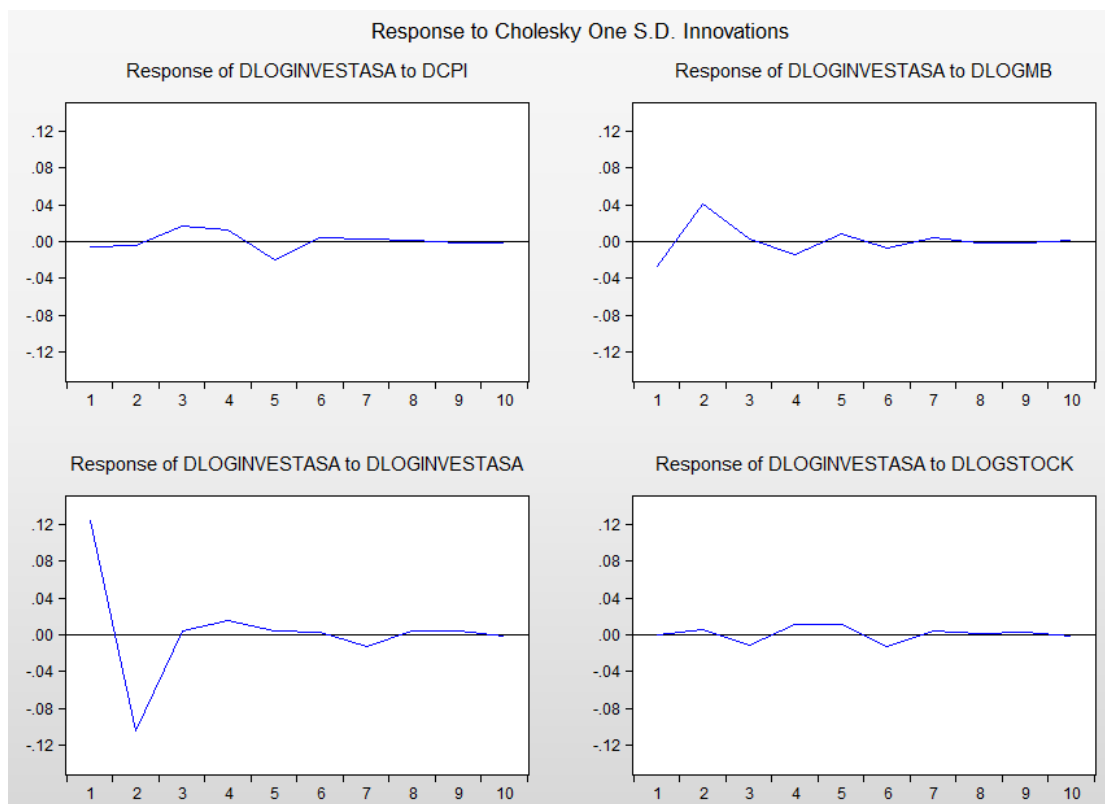
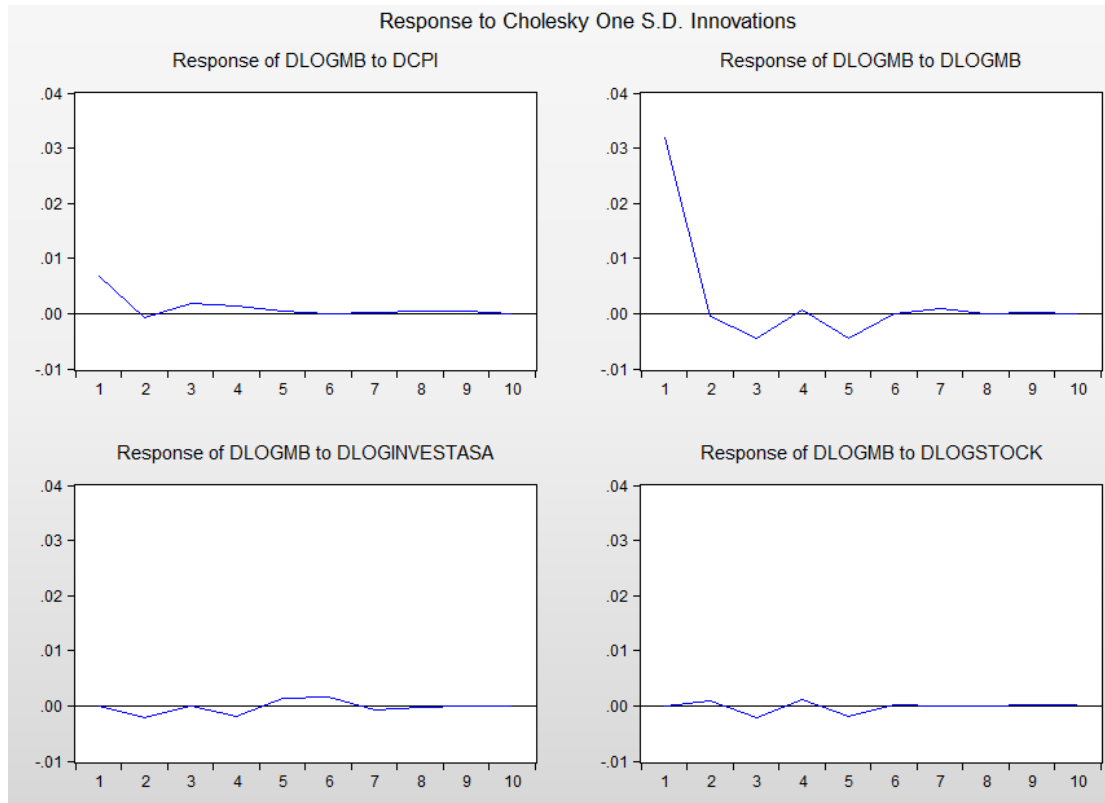


Figure 9. Responses of ΔCPI to unit shocks on all four variables



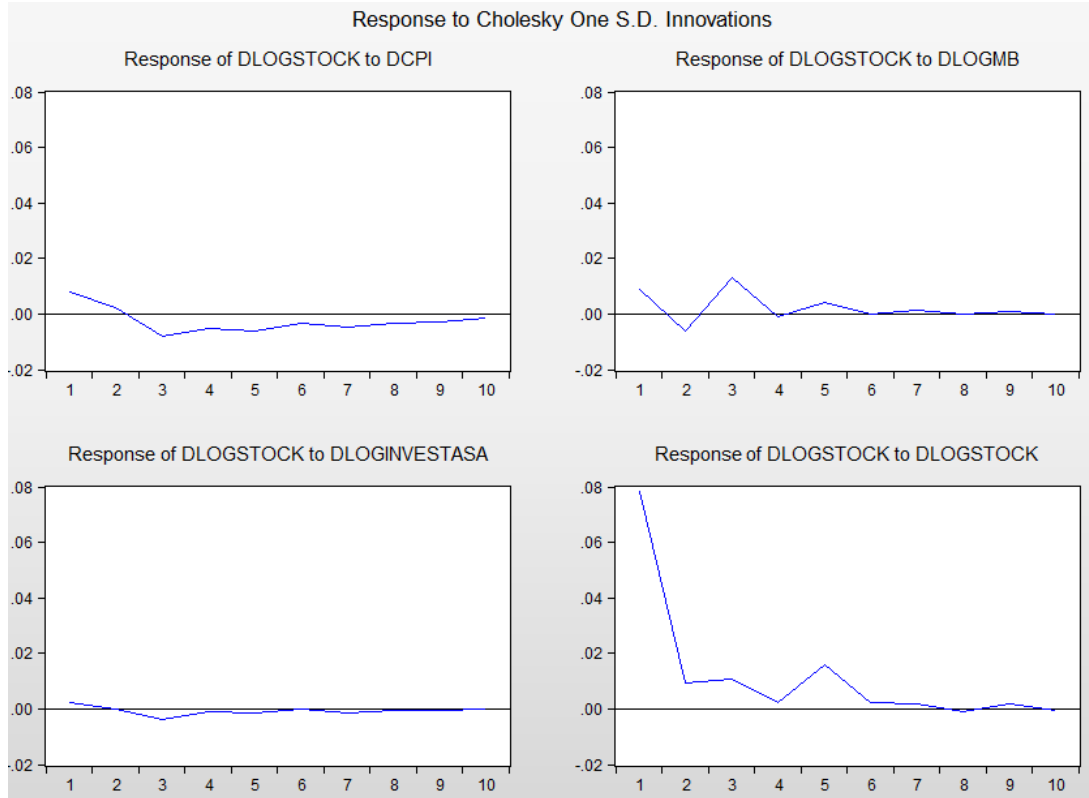


Figure 12. Responses of $\Delta \text{LOGSTOCK}$ to unit shocks on all four variables

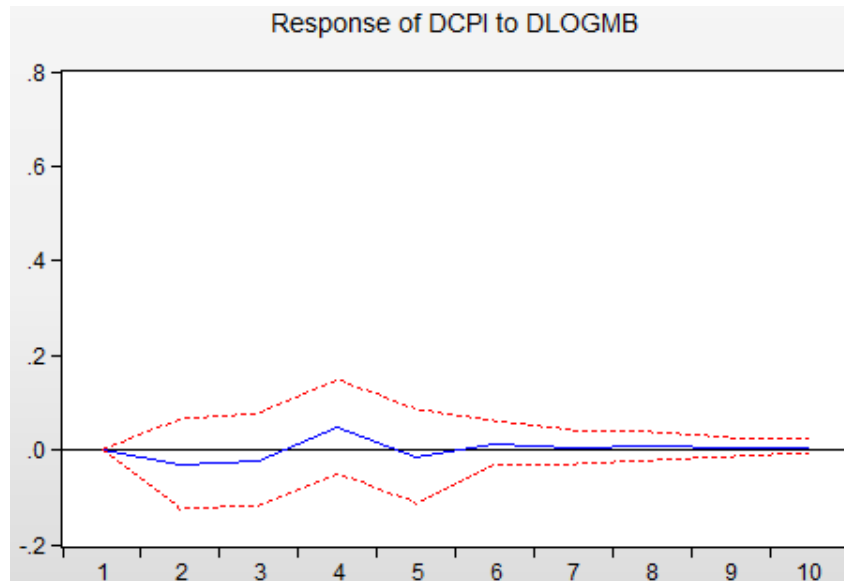


Figure 13. Response of ΔCPI to a positive shock on ΔLOGMB

From Figure 13 we can infer that when there is a positive shock on ΔLOGMB , the ΔCPI 's reaction is very weak in first 2.5 periods, then it will begin to rise slowly in the middle of 3rd period, after reaching the apex in 4th period it begins to fall and changes the direction of shock impact and become more and more stable, in long run,

the shock impact tends to zero.

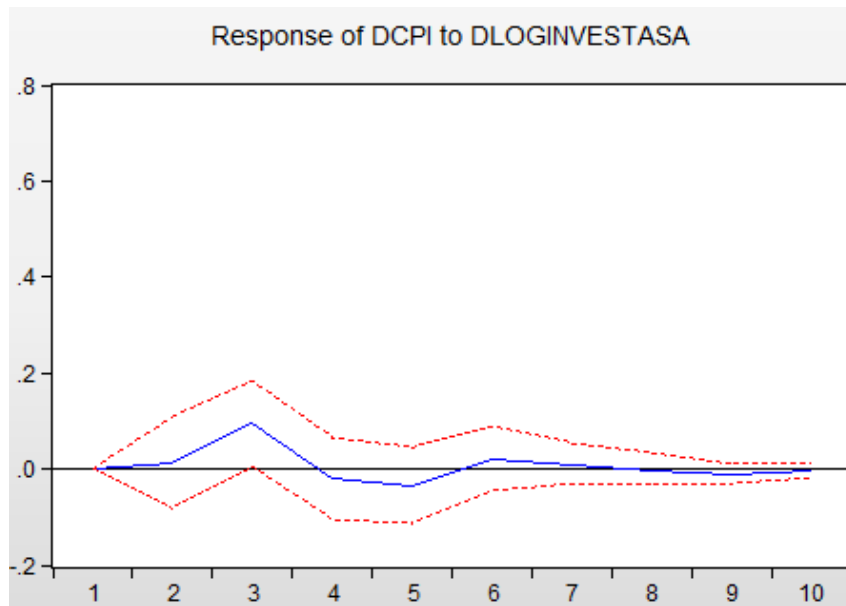


Figure 14. Response of ΔCPI to a positive shock on $\Delta LOGINVESTASA$

From Figure 14 we can infer that when there is a positive shock on $\Delta LOGINVESTASA$, the ΔCPI 's begins to rise in the second period and reaches its apex in the 3rd period, after then it begins to fall and changes the direction in middle of the 4th period. In long run, the shock impact tends 0.

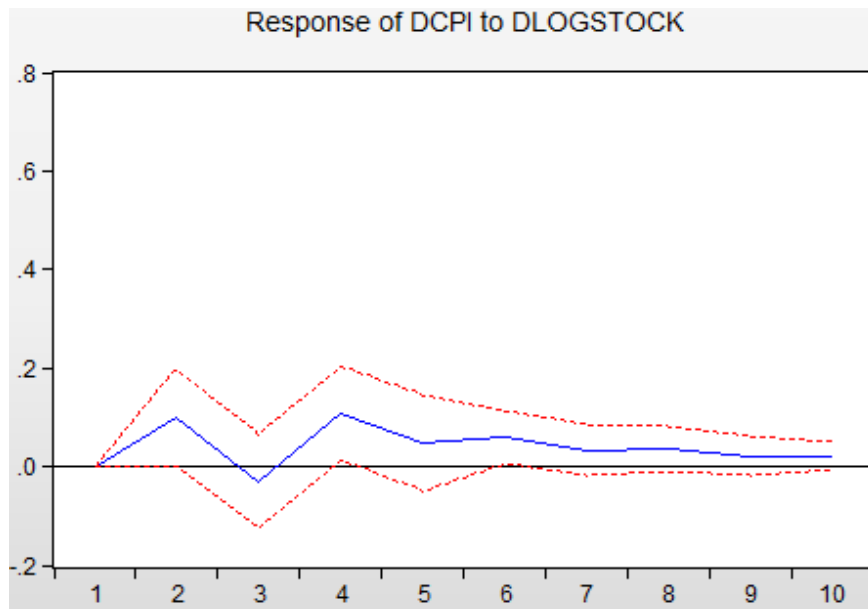


Figure 15. Response of ΔCPI to a positive shock on $\Delta LOGSTOCK$

From Figure 15 we can infer that when there is a positive shock on $\Delta LOGSTOCK$, the ΔCPI will begin to rise immediately and reaches its apex in the middle of 2nd period, after then it decreases and changes the direction in middle of 3rd period and changes the direction once again, in 4th period it reaches the apex once again and decreases mildly until the impact of the shock diminishes in long run.

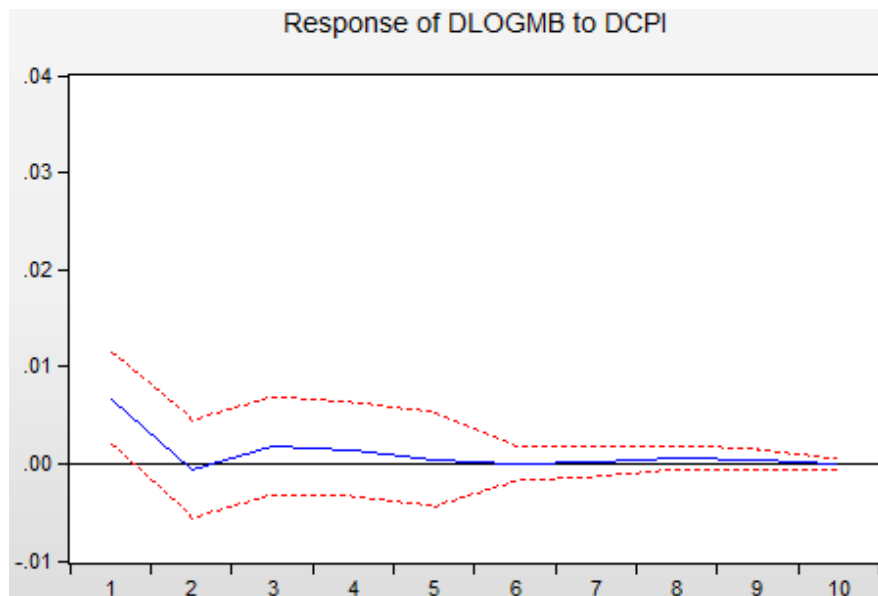


Figure 16. Response of $\Delta LOGMB$ to a positive shock on ΔCPI

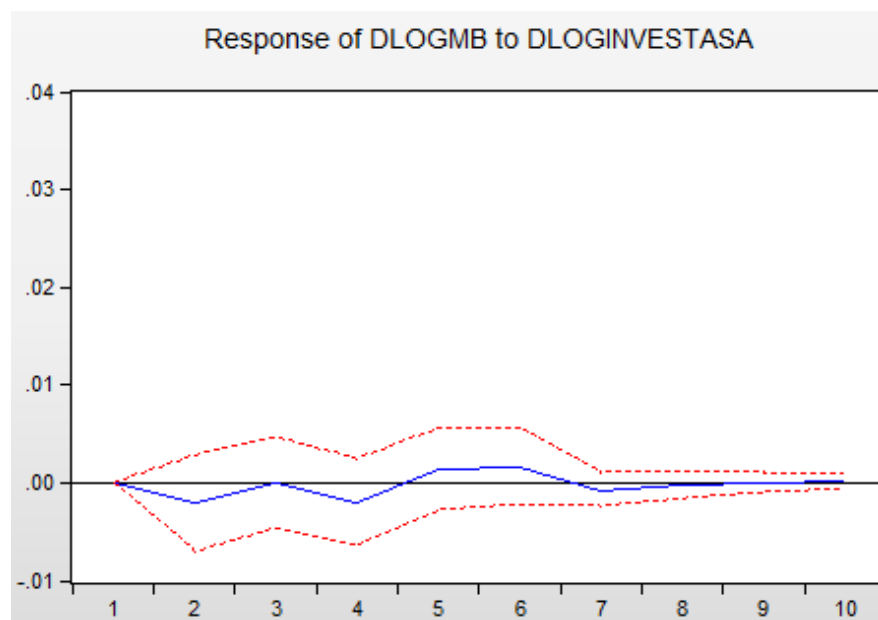


Figure 17. Response of $\Delta LOGMB$ to a positive shock on $\Delta LOGINVESTASA$

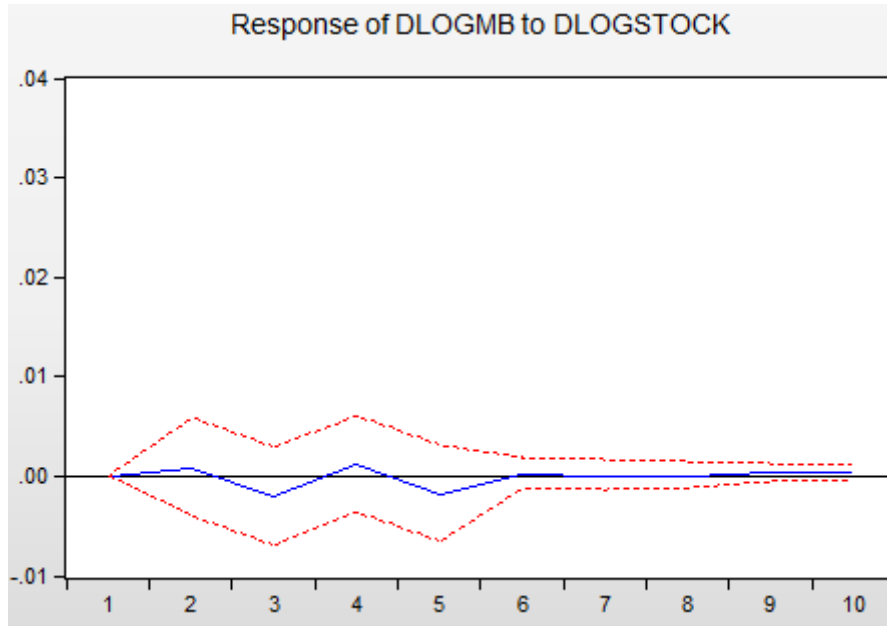


Figure 18. Response of $\Delta LOGMB$ to a positive shock on $\Delta LOGSTOCK$

From figure 16-18, we can infer that, the $\Delta LOGMB$ reacts weakly to shocks on $\Delta LOGSTOCK$ and $\Delta LOGINVESTASA$ though it shows some mild fluctuations at the beginning of the shock, when the shock comes from ΔCPI , the $\Delta LOGMB$ rises sharply at beginning but soon back to the original level after some mild fluctuations.

The most interesting phenomena we can observe from our model is: the reaction of monetary base to shocks in real estate market is much weaker than the reaction of CPI to the same shock.

Related with the most recent crisis in Chinese stock market, PBC faces a problem: the nominal interest rate of one-year deposit has decreased to 1.5% with CPI of 1.5% at the same time. Economic theories told us that usually even the real interest rate is 0 or negative, the central bank can also reduce nominal interest rate to stimulate the economy if the nominal interest rate is still positive, but the Chinese situation is a little different which makes PBC hesitated when decides if reduce the real interest rate below 0: China has super high gross saving rate (GSR), in 2014 the GSR of China was 49% and the GSR of USA was only 18%¹⁹ at the same time. So if the real interest rate fall

¹⁹ <http://data.worldbank.org/indicator/NY.GNS.ICTR.ZS>

below 0, it will release much more money from the bank system than any other country in the world. If the money released from bank system can flood into the stock market, maybe it can still become an attractive option to PBC. But as we have mentioned above, usually the money will enter the real estate market which is helpless to the current crisis in stock market.

So every time when China faces such economic difficulties and announces its aggressive new policies, we can always hearing some people claiming that “Ah, the Chinese QE is coming!”^⑭

But the quantitative easing is still harmful to the economy: if central bank issues large amount of banknotes with such high GSR, it will greatly dilute the wealth of the people which may lead to other serious problems, for example, a run on foreign currency.

By watching at the figures we can get some preliminary conclusions, but if we want some more accurate results with stronger statistical support, we have to analyze the multipliers.

3.2.4 The multipliers

In this section we will analyze the multipliers associated with inflation in our linear VAR system. In particular, we would like to know what happens to inflation (and here we should recall the reader that our variable is DCPI), when there is one shock to the other three variables, one by one. These other variables are the Monetary Base (DLOGMB), the Residential Investment (DLOGINVEST), and the Stock Market Index (DLOGSTOCK). For this purpose we will take into account the Impulse Response Functions (IRF) associated with each shock. Formally this multiplier (m) can be written down as:

$$m_i(t) = \frac{\Delta DCPI(t)}{\Delta i(t)} \quad (5)$$

^⑭ For example, the Wall Street journal-<http://www.wsj.com/articles/chinas-central-bank-expands-new-style-easing-1444649102>

Or Bloomberg- <http://www.bloomberg.com/news/articles/2015-08-09/quantitative-easing-with-chinese-characteristics-takes-shape>

Too much news and predictions about this, if you understand Chinese you can find more.

Where i stands either for Monetary Base, the Residential Investment or the Stock Market, and t as a time quarter index.

In the two following figures we present, firstly, the IRFs from each shock, and secondly the multipliers will be displayed. While a simple visual inspection of the evolution of the multipliers looks a little bit confusing, the sum over the period of nine quarters of each multiplier does not leave much room or doubts, which is presented next:

$$\Sigma_{t=0}^9 m_{INVEST} = 2.5712 \quad (6)$$

$$\Sigma_{t=0}^9 m_{MB} = 14.5316 \quad (7)$$

$$\Sigma_{t=0}^9 m_{Stock} = -2.2956 \quad (8)$$

These cumulative values of the multipliers allow us to conclude that a positive shock to the Stock Market (DLOGSTOCK) will produce a negative impact upon inflation (DCPI) by a degree of -2.2956. On the other hand, an increase in Residential Investment will lead to a positive impact upon inflation of a magnitude close to 2:5. However, the variable that shows a huge impact upon inflation in this our linear VAR model is the Monetary Base. In our case, if the logarithmic value of the Monetary Base increases by one standard deviation, the change in the CPI will be increased by 14.53 after just nine quarters.

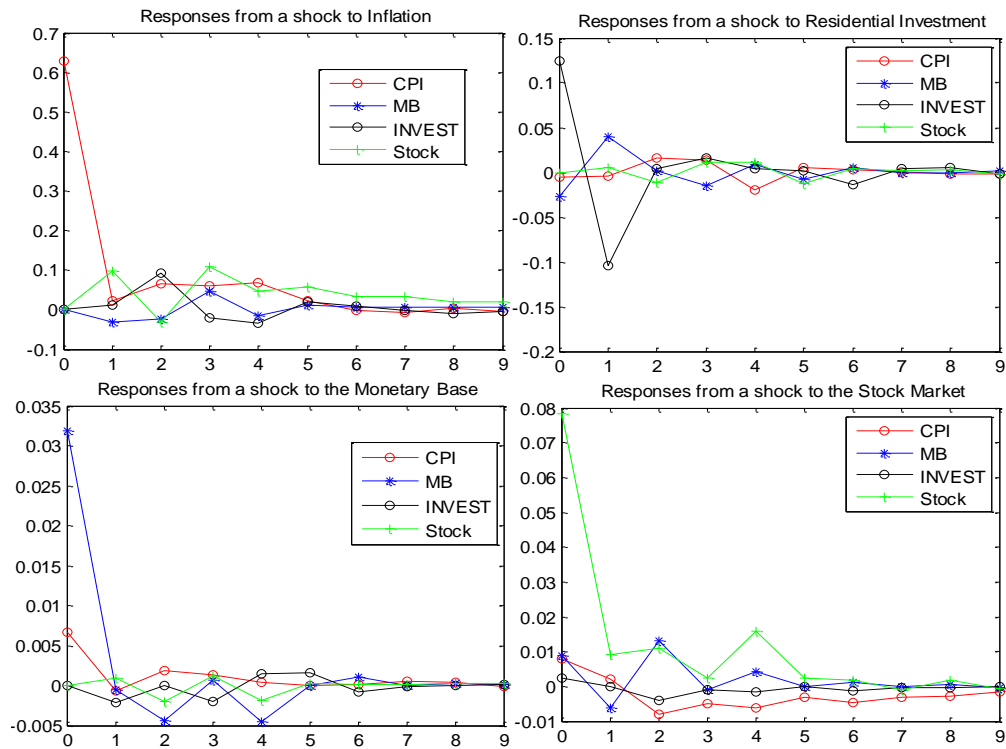


Figure 19 The IRFs of inflation associated with each individual shock.

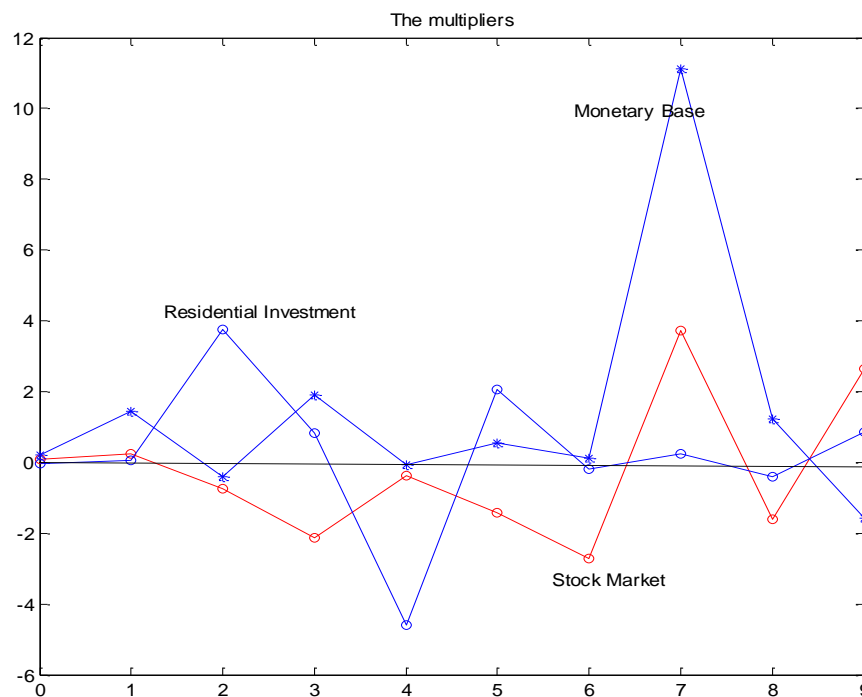


Figure 20 The multipliers

Apparently, these results seem to show some support to the quantity theory of money in China. Real variables, like residential investment show a rather small

positive impact upon inflation, and wealth variables (like the stock market index) do show a rather negative small impact upon such variable. This last result looks interesting, because one would expect capital gains (in the stock market) to be positively correlated with inflation, but that is not the case in our model. This may look the result of a similar situation that we have observed in economies under large QE interventions (as is the US case), where the liquidity trap and deflation redirect investments into the stock market, leading to a situation in which we have deflation and rising stock market indexes.

However, the case of China does not allow us to infer that QE suffers from the same limitations as in the US. If our linear model is consistent and robust enough (we could not afford to go into more sophisticated nonlinear VAR analysis due to time limitations associated with a thesis of this nature) with the reality in the Chinese economy, there seems to exist plenty of scope to use monetary policy in China in order to avoid deflation and the slowdown of the Chinese economy, because the monetary base multiplier shows a remarkable cumulative value of 14.5 in just 9 quarters. Therefore, and in the period considered in this study, the limitations of QE as we start to feel in the western economies and Japan, do not apparently apply to the Chinese economy.

4. Concluding Remarks

So let us answer the three questions at the beginning of this thesis.

1. Are the policies pursued by PBC QE? Theoretically, the answer is “No”. We know that the central bank threaten to abandon conventional monetary policy to adjust the economy, in practice they even printed some money but behaved extremely restraint to reduce the negative effect as much as possible. So it seems that PBC prefers Krugman’s suggestion in theory but Japan’s strategy in practice: printing money may acceptable, but the final goal is to produce inflationary expectation of the market, so if possible, the less additional money the better. When a central bank is losing its credit, it has to behave as mad as possible to convince the public again, but the situation of PBC seems better, so even it didn’t have much space to reduce the nominal interest rate, it can still produce inflationary expectation by printing less money than western countries. If the conventional monetary policy is still in effect, why should we use QE?
2. Did they achieve the goal of alleviating the crisis? Yes, after announcing the aggressive economic policy, the stock market stopped its sharp fall in a week.
3. In which situation PBC will consider using real QE? Because deflation and the stringent limitations of monetary policy in the Zero Lower Bound do not seem to be applying to the Chinese economy by now, as well as the near future is concerned. At least we can say, in the near future within two years (we just calculated nine quarters’ accumulative multipliers, so we can just predict the situation of next two years), and PBC doesn’t have the motivation to apply QE policy when the conventional monetary policy is still strong enough to control the economy.

So, here we can conclude the behavior pattern of PBC: when there is a shock-could be in any important economic area, it tends to threaten the market by announcing very aggressive attitude, for example, a large scale QE (they never call it QE, even all economists suspect it is QE in fact, this is a kind of fuzz strategy to stimulate the economy while keeping the confidence of market at the same time) to show its steady will to stabilize the market, but act as conservative as possible in real operation. Until

now, we can't see any sign of the arrival of Chinese QE policy, at least in the near future, China can still act as one of the main growth point of global economy even it faces risks in some important areas.

5. Appendix

Null Hypothesis: CPI has a unit root
Exogenous: Constant
Lag Length: 12 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.604681	0.0939
Test critical values: 1% level	-3.467418	
5% level	-2.877729	
10% level	-2.575480	

Figure 1 ADF test result of CPI in level

Null Hypothesis: CPI has a unit root
Exogenous: Constant
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.793087	0.0611
Test critical values: 1% level	-3.465014	
5% level	-2.876677	
10% level	-2.574917	

Figure 2 PP test result of CPI in level

Null Hypothesis: CPI is stationary
Exogenous: Constant
Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.312537
Asymptotic critical values*: 1% level	0.739000
5% level	0.463000
10% level	0.347000

Figure 3 KPSS test result of CPI in level

Null Hypothesis: INVEST_SA has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.971119	0.6128
Test critical values: 1% level	-4.007882	
5% level	-3.434036	
10% level	-3.140923	

Figure 4 ADF test result of INVEST-SA in level

Null Hypothesis: INVEST_SA has a unit root
 Exogenous: Constant, Linear Trend
 Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.379811	0.3889
Test critical values: 1% level	-4.007347	
5% level	-3.433778	
10% level	-3.140772	

Figure 5 PP test result of INVEST-SA in level

Null Hypothesis: INVEST_SA is stationary
 Exogenous: Constant, Linear Trend
 Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.402111
Asymptotic critical values*: 1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 6 KPSS test result of INVEST-SA in level

Null Hypothesis: M2 has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 13 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-0.648656	0.9745
Test critical values: 1% level	-4.011044	
5% level	-3.435560	
10% level	-3.141820	

Figure 7 ADF test result of M2 in level

Null Hypothesis: M2 has a unit root
 Exogenous: Constant, Linear Trend
 Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-0.616588	0.9766
Test critical values: 1% level	-4.007347	
5% level	-3.433778	
10% level	-3.140772	

Figure 8 PP test result of M2 in level

Null Hypothesis: M2 is stationary
 Exogenous: Constant, Linear Trend
 Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.428281
Asymptotic critical values*:	
1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 9 KPSS test result of M2 in level

Null Hypothesis: MB has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 13 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.343659	0.4079
Test critical values:		
1% level	-4.011044	
5% level	-3.435560	
10% level	-3.141820	

Figure 10 ADF test result of MB in level

Null Hypothesis: MB has a unit root
 Exogenous: Constant, Linear Trend
 Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.026782	0.5826
Test critical values:		
1% level	-4.007347	
5% level	-3.433778	
10% level	-3.140772	

Figure 11 PP test result of MB in level

Null Hypothesis: MB is stationary
 Exogenous: Constant, Linear Trend
 Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.388434
Asymptotic critical values*:	
1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 12 KPSS test result of MB in level

Null Hypothesis: STOCK_MARKET has a unit root
 Exogenous: Constant
 Lag Length: 2 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.373917	0.1506
Test critical values: 1% level	-3.465392	
5% level	-2.876843	
10% level	-2.575006	

Figure 13 ADF test result of STOCK MARKET in level

Null Hypothesis: STOCK_MARKET has a unit root
 Exogenous: Constant
 Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-2.238365	0.1936
Test critical values: 1% level	-3.465014	
5% level	-2.876677	
10% level	-2.574917	

Figure 14 PP test result of STOCK MARKET in level

Null Hypothesis: STOCK_MARKET is stationary
 Exogenous: Constant
 Bandwidth: 10 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.543489
Asymptotic critical values*: 1% level	0.739000
5% level	0.463000
10% level	0.347000

Figure 15 KPSS test result of STOCK MARKET in level

Null Hypothesis: D(CPI) has a unit root
 Exogenous: Constant
 Lag Length: 11 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.064600	0.0000
Test critical values: 1% level	-3.467418	
5% level	-2.877729	
10% level	-2.575480	

Figure 16 ADF test result of CPI in first order difference

Null Hypothesis: D(CPI) has a unit root
 Exogenous: Constant
 Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-13.30924	0.0000
Test critical values: 1% level	-3.465202	
5% level	-2.876759	
10% level	-2.574962	

Figure 17 PP test result of CPI in first order difference

Null Hypothesis: D(CPI) is stationary
 Exogenous: Constant
 Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.050492
Asymptotic critical values*: 1% level	0.739000
5% level	0.463000
10% level	0.347000

Figure 18 KPSS test result of CPI in first order difference

Null Hypothesis: D(INVEST_SA) has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 1 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-15.50227	0.0000
Test critical values: 1% level	-4.007882	
5% level	-3.434036	
10% level	-3.140923	

Figure 19 ADF test result of INVEST-SA in first order difference

Null Hypothesis: D(INVEST_SA) has a unit root
 Exogenous: Constant, Linear Trend
 Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-26.28307	0.0000
Test critical values: 1% level	-4.007613	
5% level	-3.433906	
10% level	-3.140847	

Figure 20 PP test result of INVEST-SA in first order difference

Null Hypothesis: D(INVEST_SA) is stationary
 Exogenous: Constant, Linear Trend
 Bandwidth: 24 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.120191
Asymptotic critical values*:	
1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 21 KPSS test result of INVEST-SA in first order difference

Null Hypothesis: D(M2) has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 12 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.978851	0.1412
Test critical values:		
1% level	-4.011044	
5% level	-3.435560	
10% level	-3.141820	

Figure 22 ADF test result of M2 in first order difference

Null Hypothesis: D(M2) has a unit root
 Exogenous: Constant, Linear Trend
 Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-14.88914	0.0000
Test critical values:		
1% level	-4.007613	
5% level	-3.433906	
10% level	-3.140847	

Figure 23 PP test result of M2 in first order difference

Null Hypothesis: D(M2) is stationary
 Exogenous: Constant, Linear Trend
 Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.068843
Asymptotic critical values*:	
1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 24 KPSS test result of M2 in first order difference

Null Hypothesis: D(MB) has a unit root
 Exogenous: Constant, Linear Trend
 Lag Length: 12 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	0.119072	0.9973
Test critical values: 1% level	-4.011044	
5% level	-3.435560	
10% level	-3.141820	

Figure 25 ADF test result of MB in first order difference

Null Hypothesis: D(MB) has a unit root
 Exogenous: Constant, Linear Trend
 Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-15.38012	0.0000
Test critical values: 1% level	-4.007613	
5% level	-3.433906	
10% level	-3.140847	

Figure 26 PP test result of MB in first order difference

Null Hypothesis: D(MB) is stationary
 Exogenous: Constant, Linear Trend
 Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.197076
Asymptotic critical values*: 1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 27 KPSS test result of MB in first order difference

Null Hypothesis: D(STOCK_MARKET) has a unit root
 Exogenous: Constant
 Lag Length: 1 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.241810	0.0000
Test critical values: 1% level	-3.465392	
5% level	-2.876843	
10% level	-2.575006	

Figure 28 ADF test result of STOCK MARKET in first order difference

Null Hypothesis: D(STOCK_MARKET) has a unit root
 Exogenous: Constant
 Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-12.77375	0.0000
Test critical values:		
1% level	-3.465202	
5% level	-2.876759	
10% level	-2.574962	

Figure 29 PP test result of STOCK MARKET in first order difference

Null Hypothesis: D(STOCK_MARKET) is stationary
 Exogenous: Constant
 Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.044175
Asymptotic critical values*:	
1% level	0.739000
5% level	0.463000
10% level	0.347000

Figure 30 KPSS test result of STOCK MARKET in first order difference

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4217.603	NA	1.96e+17	51.17094	51.24624*	51.20151*
1	-4196.045	41.80907	1.84e+17	51.10357	51.48005	51.25640
2	-4174.877	40.02718	1.73e+17	51.04093	51.71859	51.31601
3	-4144.390	56.16921	1.45e+17	50.86533	51.84418	51.26268
4	-4131.197	23.66649	1.50e+17	50.89936	52.17939	51.41897
5	-4116.969	24.83506	1.54e+17	50.92084	52.50205	51.56270
6	-4097.062	33.78233	1.47e+17	50.87347	52.75587	51.63760
7	-4088.332	14.38995	1.62e+17	50.96161	53.14518	51.84799
8	-4076.958	18.19961	1.72e+17	51.01767	53.50243	52.02632
9	-4061.337	24.23537	1.75e+17	51.02227	53.80821	52.15318
10	-4046.739	21.94214	1.80e+17	51.03926	54.12638	52.29243
11	-4030.451	23.69106	1.82e+17	51.03577	54.42407	52.41120
12	-3968.836	86.63511	1.06e+17	50.48285	54.17234	51.98055
13	-3951.862	23.04319	1.07e+17	50.47105	54.46172	52.09100
14	-3931.528	26.61886	1.04e+17	50.41852	54.71037	52.16073
15	-3921.608	12.50445	1.15e+17	50.49222	55.08526	52.35670
16	-3905.864	19.08370	1.20e+17	50.49533	55.38954	52.48206
17	-3877.641	32.84152	1.07e+17	50.34717	55.54257	52.45616
18	-3858.185	21.69642	1.08e+17	50.30528	55.80186	52.53653
19	-3843.230	15.95231	1.15e+17	50.31794	56.11570	52.67145
20	-3826.184	17.35594	1.20e+17	50.30526	56.40421	52.78103
21	-3800.917	24.50174	1.14e+17	50.19293	56.59306	52.79096
22	-3771.984	26.65252	1.05e+17	50.03618	56.73749	52.75647
23	-3756.422	13.58146	1.15e+17	50.04148	57.04398	52.88404
24	-3715.478	33.74840*	9.38e+16*	49.73912*	57.04280	52.70394

Figure 31 Lag length analysis of VAR model with first order differences of CPI, M2, INVEST-SA and STOCK MARKET under different criterias

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:37
Sample: 2000M03 2015M12
Included observations: 186

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	2.848004	NA*	2.863399	NA*	NA*
2	7.068632	NA*	7.129903	NA*	NA*
3	11.32561	NA*	11.45666	NA*	NA*
4	34.45481	0.0047	35.09421	0.0039	16
5	52.38372	0.0130	53.51838	0.0099	32
6	81.95849	0.0016	84.07898	0.0010	48
7	90.48196	0.0163	92.93578	0.0105	64
8	108.0208	0.0202	111.2628	0.0119	80
9	121.7808	0.0389	125.7225	0.0226	96
10	136.8764	0.0552	141.6759	0.0304	112
11	158.8847	0.0333	165.0676	0.0152	128
12	241.7067	0.0000	253.6014	0.0000	144

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 32 Portmanteau test result of VAR model with first order differences of CPI,
M2, INVEST-SA and STOCK MARKET of three lags

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:39
Sample: 2000M03 2015M12
Included observations: 183

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.995837	NA*	1.001309	NA*	NA*
2	3.009340	NA*	3.037060	NA*	NA*
3	6.338918	NA*	6.422131	NA*	NA*
4	8.602945	NA*	8.736751	NA*	NA*
5	12.86552	NA*	13.11906	NA*	NA*
6	21.32060	NA*	21.86075	NA*	NA*
7	30.29735	0.0165	31.19453	0.0127	16
8	46.04485	0.0515	47.66192	0.0369	32
9	61.02775	0.0982	63.41980	0.0671	48
10	76.02879	0.1443	79.28795	0.0943	64
11	105.5677	0.0294	110.7159	0.0131	80
12	190.8653	0.0000	201.9994	0.0000	96

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 33 Portmanteau test result of VAR model with first order differences of CPI,
M2, INVEST-SA and STOCK MARKET of six lags

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:40
Sample: 2000M03 2015M12
Included observations: 179

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	1.552935	NA*	1.561660	NA*	NA*
2	6.824597	NA*	6.892888	NA*	NA*
3	12.35760	NA*	12.52021	NA*	NA*
4	14.55734	NA*	14.77022	NA*	NA*
5	17.96750	NA*	18.27838	NA*	NA*
6	20.90513	NA*	21.31789	NA*	NA*
7	25.52309	NA*	26.12379	NA*	NA*
8	29.02797	NA*	29.79264	NA*	NA*
9	37.37116	NA*	38.57752	NA*	NA*
10	49.05421	NA*	50.95188	NA*	NA*
11	73.35123	0.0000	76.83978	0.0000	16
12	134.4849	0.0000	142.3662	0.0000	32
13	147.6755	0.0000	156.5899	0.0000	48
14	164.4215	0.0000	174.7568	0.0000	64
15	178.4376	0.0000	190.0548	0.0000	80
16	186.3418	0.0000	198.7349	0.0000	96
17	199.6244	0.0000	213.4114	0.0000	112
18	209.6630	0.0000	224.5722	0.0000	128
19	222.0766	0.0000	238.4599	0.0000	144
20	244.8375	0.0000	264.0838	0.0000	160
21	266.5468	0.0000	288.6786	0.0000	176
22	278.8513	0.0000	302.7073	0.0000	192
23	303.0061	0.0000	330.4234	0.0000	208
24	313.9107	0.0001	343.0164	0.0000	224

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 34 Portmanteau test result of VAR model with first order differences of CPI,
M2, INVEST-SA and STOCK MARKET of ten lags

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:41
Sample: 2000M03 2015M12
Included observations: 177

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	6.052819	NA*	6.087210	NA*	NA*
2	10.59390	NA*	10.68019	NA*	NA*
3	14.28114	NA*	14.43100	NA*	NA*
4	19.88010	NA*	20.15942	NA*	NA*
5	23.65936	NA*	24.04854	NA*	NA*
6	27.88822	NA*	28.42578	NA*	NA*
7	35.12766	NA*	35.96332	NA*	NA*
8	42.20537	NA*	43.37607	NA*	NA*
9	49.89397	NA*	51.47656	NA*	NA*
10	61.41433	NA*	63.68675	NA*	NA*
11	68.72682	NA*	71.48381	NA*	NA*
12	82.74283	NA*	86.51917	NA*	NA*
13	96.61184	0.0000	101.4875	0.0000	16
14	108.9502	0.0000	114.8856	0.0000	32
15	122.5887	0.0000	129.7869	0.0000	48
16	128.7408	0.0000	136.5504	0.0000	64
17	150.3565	0.0000	160.4628	0.0000	80
18	165.5296	0.0000	177.3537	0.0000	96
19	185.4771	0.0000	199.6999	0.0000	112
20	201.6038	0.0000	217.8809	0.0000	128
21	220.1376	0.0000	238.9097	0.0000	144
22	234.5781	0.0001	255.3997	0.0000	160
23	241.0867	0.0008	262.8805	0.0000	176
24	253.8225	0.0019	277.6140	0.0001	192

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 35 Portmanteau test result of VAR model with first order differences of CPI,
M2, INVEST-SA and STOCK MARKET of twelve lags

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:42
Sample: 2000M03 2015M12
Included observations: 169

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	1.177540	NA*	1.184549	NA*	NA*
2	4.347482	NA*	4.392454	NA*	NA*
3	10.16833	NA*	10.31850	NA*	NA*
4	15.41749	NA*	15.69491	NA*	NA*
5	22.66000	NA*	23.15823	NA*	NA*
6	27.70652	NA*	28.39051	NA*	NA*
7	35.44266	NA*	36.46092	NA*	NA*
8	46.00222	NA*	47.54519	NA*	NA*
9	59.80744	NA*	62.12695	NA*	NA*
10	66.84448	NA*	69.60657	NA*	NA*
11	83.65475	NA*	87.58718	NA*	NA*
12	96.11996	NA*	101.0051	NA*	NA*
13	106.5052	NA*	112.2558	NA*	NA*
14	116.0535	NA*	122.6665	NA*	NA*
15	123.6433	NA*	130.9957	NA*	NA*
16	129.3682	NA*	137.3192	NA*	NA*
17	136.8040	NA*	145.5866	NA*	NA*
18	144.6154	NA*	154.3292	NA*	NA*
19	151.9112	NA*	162.5491	NA*	NA*
20	155.6227	NA*	166.7588	NA*	NA*
21	172.1252	0.0000	185.6029	0.0000	16
22	179.8256	0.0000	194.4558	0.0000	32
23	193.4161	0.0000	210.1872	0.0000	48
24	209.3219	0.0000	228.7256	0.0000	64

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 36 Portmanteau test result of VAR model with first order differences of CPI,
M2, INVEST-SA and STOCK MARKET of twenty lags

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:43
Sample: 2000M03 2015M12
Included observations: 165

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	4.248814	NA*	4.274722	NA*	NA*
2	8.733496	NA*	8.814430	NA*	NA*
3	19.65704	NA*	19.94026	NA*	NA*
4	26.03816	NA*	26.47992	NA*	NA*
5	31.17025	NA*	31.77239	NA*	NA*
6	38.38046	NA*	39.25468	NA*	NA*
7	47.36382	NA*	48.63604	NA*	NA*
8	54.77278	NA*	56.42252	NA*	NA*
9	68.03493	NA*	70.44980	NA*	NA*
10	87.94575	NA*	91.64519	NA*	NA*
11	102.2388	NA*	106.9591	NA*	NA*
12	106.7211	NA*	111.7930	NA*	NA*
13	119.1852	NA*	125.3231	NA*	NA*
14	131.9830	NA*	139.3075	NA*	NA*
15	140.0359	NA*	148.1657	NA*	NA*
16	149.8491	NA*	159.0326	NA*	NA*
17	160.4758	NA*	170.8800	NA*	NA*
18	171.9820	NA*	183.7951	NA*	NA*
19	178.8078	NA*	191.5092	NA*	NA*
20	188.4653	NA*	202.4987	NA*	NA*
21	203.1633	NA*	219.3402	NA*	NA*
22	209.6402	NA*	226.8135	NA*	NA*
23	218.5430	NA*	237.1584	NA*	NA*
24	228.3168	NA*	248.5958	NA*	NA*
25	244.5926	0.0000	267.7780	0.0000	16
26	262.9081	0.0000	289.5194	0.0000	32
27	273.5183	0.0000	302.2055	0.0000	48
28	292.4023	0.0000	324.9490	0.0000	64
29	314.9329	0.0000	352.2839	0.0000	80
30	324.6404	0.0000	364.1487	0.0000	96

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 37 Portmanteau test result of VAR model with first order differences of CPI, M2, INVEST-SA and STOCK MARKET of twenty-four lags

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4118.875	NA	5.94e+16	49.97424	50.04953*	50.00480*
1	-4097.935	40.61040	5.59e+16	49.91436	50.29084	50.06719
2	-4077.527	38.59043	5.30e+16	49.86093	50.53859	50.13601
3	-4065.098	22.89871	5.54e+16	49.90422	50.88306	50.30156
4	-4053.943	20.01122	5.89e+16	49.96295	51.24297	50.48255
5	-4046.646	12.73680	6.56e+16	50.06844	51.64964	50.71030
6	-4029.647	28.84602	6.51e+16	50.05633	51.93872	50.82046
7	-4013.939	25.89438	6.57e+16	50.05987	52.24344	50.94626
8	-4001.778	19.45846	6.93e+16	50.10640	52.59115	51.11505
9	-3986.180	24.20088	7.02e+16	50.11127	52.89721	51.24218
10	-3967.927	27.43441	6.91e+16	50.08396	53.17108	51.33713
11	-3950.481	25.37542	6.89e+16	50.06644	53.45474	51.44187
12	-3891.060	83.54934	4.14e+16	49.54013	53.22961	51.03782
13	-3857.105	46.09637	3.40e+16*	49.32249	53.31316	50.94244
14	-3842.201	19.51070	3.53e+16	49.33578	53.62763	51.07799
15	-3830.018	15.35871	3.80e+16	49.38204	53.97507	51.24651
16	-3815.593	17.48423	4.01e+16	49.40113	54.29535	51.38787
17	-3795.350	23.55592	3.96e+16	49.34970	54.54510	51.45869
18	-3790.165	5.781998	4.71e+16	49.48079	54.97737	51.71204
19	-3780.384	10.43333	5.35e+16	49.55617	55.35393	51.90968
20	-3761.460	19.26748	5.47e+16	49.52073	55.61968	51.99651
21	-3744.034	16.89879	5.74e+16	49.50344	55.90357	52.10147
22	-3729.704	13.20020	6.31e+16	49.52369	56.22500	52.24399
23	-3690.653	34.08141	5.19e+16	49.24428	56.24677	52.08683
24	-3645.320	37.36524*	4.01e+16	48.88873*	56.19240	51.85354

Figure 38 Lag length analysis of VAR model with first differences of CPI, MB, Invest-SA and Stock Market under different criteria

VAR Residual Portmanteau Tests for Autocorrelations					
Null Hypothesis: no residual autocorrelations up to lag h					
Date: 07/19/16 Time: 23:47					
Sample: 2000M03 2015M12					
Included observations: 188					
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	3.118257	NA*	3.134932	NA*	NA*
2	41.65544	0.0004	42.08649	0.0004	16
3	62.56322	0.0010	63.33332	0.0008	32
4	84.66428	0.0009	85.91484	0.0006	48
5	98.69168	0.0035	100.3255	0.0025	64
6	122.4569	0.0016	124.8742	0.0010	80
7	145.3824	0.0009	148.6863	0.0005	96
8	170.4438	0.0003	174.8616	0.0001	112
9	184.2132	0.0008	189.3233	0.0003	128
10	211.5840	0.0002	218.2318	0.0001	144
11	241.1713	0.0000	249.6578	0.0000	160
12	335.3345	0.0000	350.2412	0.0000	176

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 39 Portmanteau test result of VAR model with first differences of CPI, MB, INVEST-SA and STOCK MARKET of one lag

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:50
Sample: 2000M03 2015M12
Included observations: 187

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.905113	NA*	0.909979	NA*	NA*
2	4.467518	NA*	4.510897	NA*	NA*
3	24.67344	0.0758	25.04626	0.0690	16
4	44.86010	0.0652	45.67416	0.0555	32
5	58.50689	0.1424	59.69586	0.1199	48
6	82.97788	0.0556	84.97805	0.0409	64
7	107.9526	0.0204	110.9240	0.0126	80
8	127.4817	0.0175	131.3259	0.0097	96
9	143.6938	0.0233	148.3577	0.0122	112
10	160.1107	0.0287	165.7021	0.0139	128
11	191.0263	0.0053	198.5500	0.0018	144
12	278.5953	0.0000	292.1237	0.0000	160

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 40 Portmanteau test result of VAR model with first differences of CPI, MB,
INVEST-SA and STOCK MARKET of two lags

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 07/19/16 Time: 23:50
Sample: 2000M03 2015M12
Included observations: 186

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.482536	NA*	0.485145	NA*	NA*
2	2.602996	NA*	2.628653	NA*	NA*
3	5.348592	NA*	5.419258	NA*	NA*
4	27.26652	0.0386	27.81890	0.0332	16
5	39.36170	0.1737	40.24820	0.1502	32
6	63.10507	0.0707	64.78301	0.0534	48
7	87.40932	0.0276	90.03772	0.0177	64
8	105.0483	0.0317	108.4695	0.0188	80
9	119.1590	0.0548	123.2977	0.0317	96
10	139.9836	0.0378	145.3055	0.0188	112
11	169.7276	0.0080	176.9191	0.0027	128
12	250.7970	0.0000	263.5794	0.0000	144

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

Figure 41 Portmanteau test result of VAR model with first differences of CPI, MB,
INVEST-SA and STOCK MARKET of three lags

Null Hypothesis: D(LOGINVESTSA) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 10 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-9.015491	0.0000
Test critical values: 1% level	-4.010440	
5% level	-3.435269	
10% level	-3.141649	

Figure 42 ADF test result of LOGINVESTA in first order difference

Null Hypothesis: D(LOGINVESTSA) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 54 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-64.37474	0.0001
Test critical values: 1% level	-4.007613	
5% level	-3.433906	
10% level	-3.140847	

Figure 43 PP test result of LOGINVESTA in first order difference

Null Hypothesis: D(LOGINVESTSA) is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 59 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.160172
Asymptotic critical values*: 1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 44 KPSS test result of LOGINVESTA in first order difference

Null Hypothesis: D(LOGMB) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 12 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.407861	0.8556
Test critical values: 1% level	-4.011044	
5% level	-3.435560	
10% level	-3.141820	

Figure 45 ADF test result of LOGMB in first difference

Null Hypothesis: D(LOGMB) has a unit root
 Exogenous: Constant, Linear Trend
 Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-14.49822	0.0000
Test critical values: 1% level	-4.007613	
5% level	-3.433906	
10% level	-3.140847	

Figure 46 PP test result of LOGMB in first difference

Null Hypothesis: D(LOGMB) is stationary
 Exogenous: Constant, Linear Trend
 Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

	LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic	0.214351
Asymptotic critical values*: 1% level	0.216000
5% level	0.146000
10% level	0.119000

Figure 47 KPSS test result of LOGMB in first difference

Null Hypothesis: D(LOGSTOCK) has a unit root
 Exogenous: Constant
 Lag Length: 1 (Automatic - based on SIC, maxlag=14)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.533293	0.0000
Test critical values: 1% level	-3.465392	
5% level	-2.876843	
10% level	-2.575006	

Figure 48 ADF test result of LOGSTOCK in first difference

Null Hypothesis: D(LOGSTOCK) has a unit root
 Exogenous: Constant
 Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*
Phillips-Perron test statistic	-12.46516	0.0000
Test critical values: 1% level	-3.465202	
5% level	-2.876759	
10% level	-2.574962	

Figure 49 PP test result of LOGSTOCK in first difference

Null Hypothesis: D(LOGSTOCK) is stationary		
Exogenous: Constant		
Bandwidth: 8 (Newey-West automatic) using Bartlett kernel		
		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.057247
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

Figure 50 KPSS test result of LOGSTOCK in first difference

VAR Residual Portmanteau Tests for Autocorrelations					
Null Hypothesis: no residual autocorrelations up to lag h					
Date: 04/19/16 Time: 04:14					
Sample: 2000M03 2015M12					
Included observations: 185					
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.605881	NA*	0.609174	NA*	NA*
2	2.327087	NA*	2.349190	NA*	NA*
3	7.751599	NA*	7.863118	NA*	NA*
4	12.70212	NA*	12.92304	NA*	NA*
5	21.19187	0.1713	21.64861	0.1549	16
6	36.98642	0.2495	37.97259	0.2157	32
7	57.42580	0.1654	59.21577	0.1286	48
8	81.07016	0.0735	83.92880	0.0481	64
9	96.36979	0.1026	100.0108	0.0645	80
10	112.6481	0.1179	117.2193	0.0696	96
11	133.2093	0.0837	139.0804	0.0423	112
12	221.9811	0.0000	234.0098	0.0000	128

Figure 51 Portmanteau test result of VAR model with first order differences of
LOGINVESTA, LOGSTOCK, LOGMB and CPI

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