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Monetary Policy and Housing Market in China

By

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A Thesis Submitted to

Department of Economics

Skidmore College

In Partial Fulfillment of the Requirement for the B.A Degree

Thesis Advisor: Qi Ge

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Abstract

This paper studies the interaction effects between monetary policy actions and house price changes in China. I focus on the impact of M2 money supply on house prices in Beijing, the capital of China. A VAR model is constructed and shows that an M2 money supply shock has a significant positive impact on Beijing house prices from the fifth to the ninth month, whereas a house price shock has no significant impact on M2 money supply. To verify whether the impact of money supply is robust in different Chinese cities, I develop another VAR model to observe the housing market in Shenzhen, a first-tier city in southern China. The results show that an M2 money supply shock has only a small significant positive impact on Shenzhen house prices at one month, suggesting that the effect of money supply can vary due to institutional differences.

1. Introduction

Since the 2008 financial crisis, China has implemented fiscal stimulus programs and monetary policy to keep a rapid pace of economic growth. In 2009 and 2010, the annual economic growth rates of China were 9.2% and 10.4%, which were significantly higher than the growth rates of other countries during the recession. However, the loose monetary policy leads to a rapid expansion of lending by commercial banks, since state-owned enterprises (SOEs) borrow excessively for real-estate developments and infrastructure projects. Also, industries produce much more than the economy can demand to achieve high gross domestic product (GDP) growth, leading to a problem with overcapacity. Moreover, the Chinese government increases priority on low-skilled sectors to stimulate growth in the short term, allocating investment toward low-skilled industries and causing misallocation of resources. China's housing market is one of the sectors that reflects the issues with credit booms, overcapacity, and capital misallocation.

Since China implemented a housing privatization reform and transferred the property rights from the state to individuals in 1998, China's housing market had grown, and house prices in the first-tier cities, such as Beijing, Shanghai, and Shenzhen, had more than tripled by 2010. When the Chinese stock market was nearing its peak in 2015, the increase in house prices accelerated. In 2016, based on the research by the economic consultancy firm Longview Economics, only housing in Silicon Valley was more expensive than that in Shenzhen. A typical home in Shenzhen costed approximately $800,000, while the ratio of house price to yearly income was 70 times, compared with around 27 times in London where housing is also known to be expensive (Clinch, 2016).

The share of investment in China's GDP is extraordinarily high. Lien, Wang, and Zhang (2016) state that China's investment rate increased from 35.3 percent in 2000 to 48.6 percent in 2010, while the average investment rate among the forty largest world economies excluding China

was just 22.4 percent in 2009. Housing investment occupies a large proportion in China's investment, and the housing market has contributed significantly to China's economic growth. As Yao, Luo, and Wang (2014) illustrate, when combined with the construction industry, the housing market contributes to more than 10 percent of GDP each year. However, although the rapid economic expansion has raised people's living conditions and income levels, the growth of house prices outpaces the increase in income and excludes many people from the housing market.

The surging house prices have been concerning Chinese residents and economists. In addition to the high economic growth and the increases in income levels, China's monetary policy actions are believed to impact the housing market. The People's Bank of China (PBOC), namely the China's central bank, is responsible for implementing the monetary policy of China under the leadership of the central government. While the Chinese government attempts to achieve high economic growth, Lien et al. (2016) argue that the government investment policies are leading to capital misallocation, because policy makers tend to distribute subsidies to prioritized industries, such as physical infrastructure and housing which heavily rely on low-skilled labor. For example, in 2008, the Chinese government launched the $586 billion fiscal stimulus package to address the financial crisis by increasing spending in infrastructure and housing. Meanwhile, the PBOC frequently increases the money supply, allowing commercial banks to issue more loans to stimulate economic growth. Nonetheless, the state-owned enterprises (SOEs) have more access to the loans and have greater overinvestment than non-SOEs. The SOEs tend to direct the funds to inefficient projects including real estate investment. The policy priority toward low-skilled sectors not only distorts China's housing market, but also leads to inefficient education and job choices. As Lien et al. (2016) illustrate, the wage gap between high- and low-skilled workers in China's

labor market is shrinking. The demand for low-skilled migrant workers has increased rapidly, and workers with high school degrees are the most desirable group in the labor market.

The performance of the housing market not only influences the wealth and the consumption decisions of households, but also implies the wellbeing of the economy. Understanding the factors that impact house prices is important for recognizing the implications behind the house price fluctuations. In addition, knowing whether monetary policy actions have a significant impact on house prices is essential for the government to make prudent decisions on policy settings. In this paper, I study the dynamic effects and causality between monetary policy and housing market in China. Specifically, I focus on how changes in M2 money supply influence the house prices in Beijing. As opposed to second- and third-tier cities, Beijing is a city where the demand for housing is notoriously high and house prices are conceivably sensitive to policy changes; thus, the housing market in Beijing serves as a representative of the housing markets in top-tier cities. I use 2006-2016 monthly data on house prices in Beijing and money supply along with other macroeconomic variables, including lending rates, government expenditure, and exchange rates, to build the VAR model. After that, I conduct two robustness checks. First, I replace Beijing house price data with Shenzhen house price data to develop another VAR model. Compared with Beijing, Shenzhen is a southern first-tier city with less pollution and higher per capital income; therefore, one can make a comparison between the results from the two housing markets. Second, I replace money supply with consumer price indices (CPI) in both models to observe whether the impacts of CPI and other variables are consistent with the original results. Furthermore, this paper makes additional contributions to the research on China's housing market. It is worth noting that fiscal stimulus plans and exchange rate fluctuations also occurred in China between 2006 and 2016; therefore,

this study takes these two factors into account, investigating whether the house price fluctuations are due to changes in money supply or in fiscal policy and exchange rates.

The results show that money supply has a positive effect on house prices, although the size of the effect varies due to institutional differences between cities. In Beijing housing market, a money supply shock has a significant positive impact from the fifth to the ninth month; however, a house price shock has no significant effect on money supply. These findings suggest that a unilateral relationship from money supply and house prices exists in China. When compared with Beijing house prices, Shenzhen house prices are more sensitive to lending rates than money supply; lending rates have a significant negative impact on Shenzhen house prices from the second to the seventh month, while a money supply shock has only a small positive impact which becomes statistically insignificant after one month. When money supply is replaced with CPI in both models, most of the results are similar to those of the original models. In addition, this paper contributes to previous studies by revealing that a government spending shock has a positive impact on Beijing house prices, while the shock has insignificant effect on Shenzhen house prices. Also, both models show that there is no pronounced relationship between exchange rates and house prices.

The rest of the paper is organized as follows. Section 2 presents literature that discusses the determinants of house prices. Section 3 discusses methodology including theoretical framework, data, and model. Section 4 presents the results including the impulse responses and the variance decomposition. Section 5 conducts robustness checks. Section 6 discusses the policy implications of the study. Section 7 concludes and points out the limitations of the study.

2. Literature review

Numerous factors can affect house prices. Kholodilin and Ulbricht (2015) study the urban house prices in 48 large European cities, showing that population density, mortgage per capita, and income inequality have positive effects on house prices, whereas unemployment has a negative effect. Also, Fierro, Fullerton, and Doujuan-Callejo (2009) find that lot size, floor space, number of bathrooms, parking spaces, guard posts, and proximity to commercial centers significantly increase house prices. Hindsley, Hamilton, and Morgan (2012) study the influence of Gulf of Mexico, namely an ocean basin, on house prices in Pinellas County, Florida. They show that homebuyers prefer larger total views and larger continuous view segments, and homes in closer proximity to the Gulf of Mexico have higher view valuations. However, only considering these non-policy factors is not sufficient to explain the drastic increase in China's house prices in recent decade. China's monetary policy is also believed to influence the housing market.

China has frequently implemented fiscal stimulus plans and monetary policy changes since the 2008 financial crisis. The two main monetary policy instruments that the PBOC relies on are reserve requirement ratio (RRR) cuts and open market operations (OMOs). An RRR cut is to lower the amount of reserves that commercial banks are required to hold; in March of 2016, RRR was moved down to 17% from 19.5% due to slowing economic growth and continued capital outflows. However, a low RRR can trigger currency depreciation and thus capital outflows. When China experienced yuan's declines in 2016, the PBOC became reluctant to cut the RRR and relied more upon the OMOs, injecting or withdrawing cash from the banking system through bond repurchase agreements with commercial banks. Both monetary policy actions play important roles in increasing money supply. It is conceivable that house prices tend to increase with money supply in China. As Chang et al. (2013) argue, because the Chinese government tends to achieve fast economic growth in the short run, the government provides explicit and implicit guarantees for

loans to SOEs to boost economic activities; nevertheless, the SOEs tend to invest in the property market due to the high profit. Consequently, an increase in money supply encourages the SOEs to participate in the housing market. Meanwhile, local governments own the land and tend to generate high revenues from the sale of land use rights. When housing investment and demand increase, the shortage of land leads to a rise in land prices, which in turn causes an increase in house prices.

The following subsections review literature that discusses the influences of money supply, credit constraints, and other non-monetary policy parameters on house prices in China. It is worth noting that the concepts of monetary growth and an easing of credit constraints may overlap, but they differ in whether new money is provided in the economy.

2.1. Money supply

Lastrapes (2002) estimates the dynamic effects of money supply shocks on aggregate house prices using 1963-1999 monthly data on the US housing market and the macro economy. He first employs a VAR model, which is useful for studying the correlations between economic variables, to show that a money supply shock increases new house prices by 0.1% initially and by 0.7% after a year and a half. However, the response of new house sales is much larger than that of prices; new houses sold rise by 2.5% at the time of the shock and by 3.5% in three to four months. After new house data are replaced with sale and price data for existing owner-occupied homes, results from a similar approach show that existing home prices respond quicker, but existing home sales respond slower, to money supply shocks. Next, Lastrapes (2002) develops a dynamic equilibrium model to interpret the transmission channels of money supply shocks. The simulated theoretical responses of house prices to money supply shocks reveal that money supply shocks raise real house prices via effects on interest rates and inflation; low interest rates encourage people to borrow more

to purchase houses, and high inflation motivates people to invest in housing to secure their wealth. In response to the increase in housing demand, house prices rise immediately and then decline gradually to a steady-state level higher than the pre-shock values.

Although Lastrapes (2002) provides an understanding about the relationship between monetary policy and housing market, the paper does not analyze the China's housing market, which may be different than the housing markets in the US and European countries due to the economic conditions and the policies in China. Koivu (2012) and Tan and Chen (2013) study the housing markets and the wealth channel, namely the effect of asset prices on consumption, in China. They investigate whether China's monetary policy impacts either housing or stock prices, which in turn influence household consumption. Both studies employ a structural VAR model with variables such as household income, household consumption, CPI, an indicator of monetary policy, and asset prices. While studies on developed economies use a policy interest rate as the monetary policy indicator, Koivu (2012) and Tan and Chen (2013) argue that interest rates have limited effects on Chinese economy, because China's interest rates have been under administrative control. Lending decisions of commercial banks depend more on official authorities than on interest rates. Moreover, investment decisions of individuals and firms are barely affected by lending rates due to the high profit; house prices never fall whenever PBOC raises the rates in recent ten years. Instead of interest rates, M2 is used as the indicator of monetary policy in Koivu (2012) and Tan and Chen (2013), because the PBOC closely monitors movements in M2 for its quarterly reports. The results from Koivu (2012) show that money supply is reduced after a positive shock in CPI, a rise in real income or consumption, or a positive shock in either stock or residential prices, suggesting that a loosening of China's monetary policy leads to higher asset prices. Nevertheless, the effects of asset prices on household income and consumption are small, implying that higher

house prices may force households to save more income to buy an apartment and hence decrease consumption. Similarly, Tan and Chen (2013) reveal that when M2 increases by 1%, house prices rise by about 0.5%, compared with CPI by 0.2% and GDP by 0.05%. In addition, a house price shock increases M2, GDP, and CPI, and the effect on M2 is much larger than on GDP and CPI, highlighting the interaction effects between monetary policy and house prices.

One remark is that the results from Tan and Chen (2013) and Koivu (2012) are obtained before 2015, when the PBOC controlled interest rates by setting a deposit rate ceiling and a lending rate floor; however, the caps were removed in 2015, after which the rates were more market-based and expected to have a greater influence on the economy. Hence, the conclusions about interest rates in both studies may not be relevant to the current Chinese economy. In addition, both studies do not take into account the effects of fiscal stimulus plans. The Chinese government implemented a large fiscal stimulus program in 2008 to increase spending in infrastructure and housing; therefore, fiscal policy may also play an important role in influencing the housing market.

2.2. Credit constraints

While Koivu (2012) and Tan and Chen (2013) argue that interest rates have no effect on Chinese economy, some studies show that credit constraints can influence house prices. Chen, Chou, and Wu (2013) observe the recent house price fluctuations in the UK and the US. They hypothesize that reactions of house prices to monetary policy changes in an economy depend on the tightness of the credit market. They construct a simple dynamic general equilibrium model to observe how borrowers, lenders, and the central bank make decisions based on various economic variables. The model shows that the effects of monetary policy on house prices vary under the normal credit regime and the credit boom regime. A temporary expansionary monetary shock can

lead to an easing of credit constraints, allowing a borrower to negotiate more loans for investment in housing; thus, the shock initially has a positive effect on house prices, and the effect is larger under the credit boom regime. However, in the next period when the shock ends, borrowers are highly indebted, so they curtail investment in housing. The anticipated cutbacks in housing investment cause a decline in house prices, and this decline is faster under the credit boom regime. Chen et al. (2013) use the threshold vector autoregression (TVAR) model to further demonstrate the impacts of the tightness of the credit market on house prices. They study the UK housing market using 1993-2008 data for output, short-term interest rates, CPI, real house prices, and a measure of credit conditions. The results confirm that in the credit boom periods, a monetary policy shock generates stronger initial impacts but has less persistent effects on house prices.

Similar to Chen et al. (2013), Carrington and Madsen (2014) study how willingness to lend affects house prices. They obtain data for willingness to lend of domestic banks and foreign banks' agencies in the US from 1966 to present and investigate how credit constraints influence house prices. They develop a Tobin's Q model, which represents house investors who face credit and income constraints in their optimization problems. This theoretical model shows that during an unanticipated expansion in credit supply, demand for housing increases. Because housing stocks have not adjusted, house prices initially rise and exceed the cost of building. However, the profit causes housing stocks to gradually increase and eventually meet the excess demand; thus, in the long run, total housing stock increases, but the value of housing declines. In other words, interest rate and demand shocks triggered by a credit expansion have only temporary effects on house prices, whereas a permanent easing of credit constraints can permanently lower house prices.

While the findings from Carrington and Madsen (2014) are relevant to the US housing market, they may not be applicable to the China's housing market, in which house prices continue

to rise regardless of the tightness of the credit market in recent decade. Shen, Lee, Wu, and Guo (2016) focus on the housing market in China. Generally, credit booms are believed to cause the increases in house prices; nevertheless, Shen et al. (2016) argue whether the housing boom leads to the credit boom or it is the other way around. It is reasonable that a credit boom can induce a housing boom because large amounts of funds are injected into the housing market, and a housing boom can lead to credit growth because the demand for credit increases with the demand for housing. Shen et al. (2016) first reveal that a cointegrated relationship exists between the credit-to-GDP ratio and house prices; that is, the two variables follow random walks but exhibit a relationship when formed as a linear combination. The cointegration suggests the use of a panel error correction model. After that, 1999-2012 credit and housing data from Chinese provinces and municipalities is collected. Results show that the bi-directional causality exists between the credit and housing markets; however, the effect of property prices on credit appears to be stronger than the effect of credit on property prices. It is conceivable that the Chinese government tends to permit the growth of the housing market by allowing credit expansions. Because the surging house prices can lead to a housing bubble, the government needs to inject considerable amount of funds to save the housing market, resulting in a credit boom. One drawback is that the paper fails to analyze whether the changes in credit and house prices are caused by the missing third variable. If a third variable, such as the population size or the policy setting, is impacting the credit and housing markets, then the relationship between the two markets found in the paper may be invalid.

2.3. Non-monetary policy factors

Besides monetary policy shocks and credit expansions, non-monetary factors such as marriage and the lack of investment opportunities also increase housing demand in China. Zhang,

An, and Yu (2012) examine the effect of marriage on house prices. China has faced a growing gender imbalance in newborns since the 1980s due to the traditional preference for the birth of boys. As the sex ratio, namely the male-to-female ratio, rises, Chinese parents with a son raise their savings for housing purchases to improve their son's attractiveness for marriage, because owning a house is a symbol of social status and a pre-requisite for marriage. It is feasible that China's gender imbalance causes the increases in saving rate and house prices. Zhang et al. (2012) first observe the relationship between sex ratios and house price movements. Results from a linear regression show that a rise in the sex ratios, as well as income and population, has no significant effect on variations in house prices in China during 1998-2009. Zhang et al. (2012) explain that parents' decisions on housing purchases do not depend on marriage, because parents are uncertain where their son will work and thus unable to buy houses in advance. However, this explanation is not convincing, since parents can purchase houses only when their son decides to get married. Also, one can argue that sex ratios cannot be an indicator of the competition in marriage market; thus, using sex ratios to conclude the effect of marriage on house prices may lead to biases.

People believe that purchasing houses is one of the safest ways to invest in China. Chen and Wen (2014) investigate the rising housing investment and highlight the puzzling combination of three features in China's economy: real house prices outpacing income for a decade, a high vacancy rate, and a high rate of return to capital. They use a two-period overlapping-generations model to describe a house price bubble that grows faster than GDP and develop a theory for China's housing boom. The model shows that due to the expected strong future housing demand, the expectation that holding housing today can yield large capital gains tomorrow encourages housing investment. The rate of return to capital is high because labor is being reallocated from unproductive to productive firms. However, cheap surplus labor is expected to be exhausted, and

a decrease in returns to capital will follow. Such trajectory of returns to capital leads entrepreneurs to invest in the housing market and view housing as an alternative store of value; therefore, house prices continue to grow faster than aggregate income before the labor reallocation ends. Chen and Wen (2014) further assert that such a growing housing bubble may crowd out productive capital investment; nevertheless, it may not be desirable to burst the bubble since the housing market serves as a store of value and hence secures the wealth of entrepreneurs.

While many studies investigate the housing markets at the national or provincial levels, Huang, Leung, and Qu (2015) focus on research at a more disaggregated level, observing the cross-sectional variations in house prices in different Chinese cities. As previously mentioned, physical and locational attributes can affect the price of a housing unit. Huang et al. (2015) study not only the relationship between credit growth and house prices, but also the effects of local amenities, such as climatic and geological environments and access to education and healthcare. Amenities can directly affect house prices, because people are willing to pay for better amenities. Likewise, amenities can indirectly affect house prices, since better amenities attract more capable people and raise the aggregate income of the city. To distinguish the direct and the indirect effects, a two-step regression is applied. To measure the quality of amenities, Huang et al. (2015) use data on factors such as temperature, days with good air quality, number of universities, and number of doctors. The regression results show that crime rate, education quality, green space coverage, and urban crowding have highly significant effects on house prices. Meanwhile, credit and real income have positive effects on house prices, but long-term interest rates have no significant effect, which supports the argument from Koivu (2012). Furthermore, credit and amenities are interrelated. The influence of credit on housing prices varies across the levels of amenity, and house prices are less sensitive to credit expansion in cities with better amenities. Nonetheless, this finding implies that

instead of money supply and credit shocks, the levels of amenity cause the surging house prices in top-tier Chinese cities which provide better education and healthcare, contradicting the expectation that monetary policy is the main driving factor of house prices.

2.4. Contributions to previous studies

Following by Koivu (2012) and Tan and Chen (2013), I apply a VAR model with data on M2 money supply to study the house price fluctuations in Beijing. Because Beijing is a first-tier city where housing demand is notoriously high and house prices are conceivably sensitive to policy changes, the housing market in Beijing serves as a representative of the housing markets in top-tier cities. In addition, although both Koivu (2012) and Tan and Chen (2013) argue that interest rates are directed by Chinese authorities and hence have limited effect on the economy, I include interest rates in this study due to two reasons. First, interest rates can reflect the tightness of credit, which, as Chen et al. (2013) and Carrington and Madsen (2013) illustrate, can influence house prices. Second, the Chinese government has ended its administrative control of interest rates since 2015, so interest rates should have a greater influence on the current China's economy.

Although numerous studies discuss the effects of money supply and credit constraints, few of them have models that include the exchange rates of RMB to dollar, which can affect foreign investment that may flow to the housing market. Only Liu and Hu (2011) use a VAR model to reveal a unilateral causal relationship from house price changes to RMB exchange rate movements, suggesting that the housing market can impact foreign investment and hence the demand for the yuan. In addition, Nakamura (2008) investigates the exchange rate pass-through, namely the responsiveness of prices to exchange rates, in retail and wholesale. She uses data on price and quantity series for about 7,000 grocery stores across the US to observe the price variation across

products, stores, and cities. The variance decomposition, which determines the variation in prices that each factor accounts for, shows that retail-level demand and supply shocks can explain the price fluctuations. Importantly, retail prices are not closely linked to standard price determinants in macroeconomics and international economics such as wages, productivity, and exchange rates. Although Nakamura (2008) does not analyze the influences of exchange rate fluctuations on a housing market, the results imply that the variation in house prices may be caused by changes in domestic demand and supply rather than exchange rate movements. Nevertheless, house prices may be different than retail and wholesale prices, because housing is a durable good that can be viewed as an investment. Further research on the relationship between exchange rates and house prices is needed. China has experienced depreciation in currency and capital outflows since 2015; therefore, I include the exchange rates of Chinese yuan to US dollar in my model to not only investigate the exchange rate pass-through into house prices, but also examine whether the changes in house prices are due to money supply or exchange rate fluctuations.

Moreover, Tan and Chen (2013) and Koivu (2012) fail to take into account the impacts of fiscal stimulus programs on the housing market in China, while those fiscal policies are aimed to increase spending in housing. Previous studies have investigated the impact of fiscal policy in different countries. Afonso and Sousa (2009) collect quarterly data spanning from 1970 to 2007 on government spending and revenue, GDP, unemployment rate, average cost of financing the debt, and house prices, and they apply a structural VAR model to investigate the link between fiscal policy shocks and movements in asset markets. Results show that a government spending shock has a large and persistent positive impact on house prices in the US, the UK, and Italy. Nonetheless, few studies are concerned about the fiscal policy in China, while China's fiscal stimulus plans may play an important role in driving the house prices. It is possible that the surging

house prices are caused by fiscal policy instead of monetary policy; thus, I include government expenditure in my model to measure the impact of fiscal policy.

3. Data and methodology

3.1 Theoretical framework

Because of the monetary transmission mechanism, monetary policy decisions are believed to influence asset prices, namely stock and house prices, and general economic conditions. Specifically, monetary policy decisions often influence aggregate demand, interest rates, and amounts of money and credit, which in turn affect the housing market. For example, the monetary transmission mechanism can occur through the interest rate channels; changes in interest rates, namely the costs of borrowing, can influence decisions on consumption and investment in the housing market. As previously mentioned, both Koivu (2012) and Tan and Chen (2013) assert that house price fluctuations are related to monetary policy changes. Their findings are consistent with the monetary transmission mechanism. There are two prevalent phenomena in China. First, due to the continued price increase in the past decade and the high return of buying a house, people form a belief that purchasing houses is one of the safest ways to invest. Second, the Chinese government provides explicit and implicit guarantees for loans to SOEs and directs capital into physical infrastructure and housing to achieve fast and visible output results. These phenomena imply that when the PBOC adopts a loosening of monetary policy by implementing RRR cuts or OMOs, the increase in money supply and the easing of credit constraints are expected to drive the housing demand and investment, which in turn cause an increase in house prices.

Similar to Tan and Chen (2013) and Koivu (2012), I consider M2 money supply as the proxy for China's monetary policy. As illustrated before, the two main monetary policy instruments

of the PBOC are RRR cuts and OMOs, both of which are aimed to increase the supply of money in the economy. Meanwhile, the PBOC relies less upon adjustments on interest rates. Although interest rates are not the focus in this study and not considered as the optimal proxy, changes in interest rates are still viewed as monetary policy actions and expected to influence the housing demand. I apply a vector autoregression (VAR) model to study the relationship between monetary policy and house prices in China. A VAR model is ideal for this study when there exists feedback mechanism and dynamic effects among different variables. For example, while house prices may be affected by money supply and interest rates, money supply and interest rates can also be influenced by house prices. In addition, A VAR model relies on empirical data and less considers, although still needs to justify, theoretical approaches when investigating correlations between economic variables over time; thus, the model is useful when existing theories are inaccurate or based upon unrealistic assumptions. Although the monetary transmission mechanism may not apply to China where the financial sector is underdeveloped, the VAR model is effective in revealing the impacts of monetary policy actions on house prices. In particular, I study the housing market in Beijing. It is conceivable that the monetary transmission mechanism is more pronounced in top-tier cities than in low-tier cities. Because Beijing is a first-tier city where housing demand and supply are sensitive to policy changes, analyzing the housing market in Beijing can help to understand the relationship between monetary policy and house prices.

3.2 Data and variables

2006-2016 monthly data on M2, HPI in Beijing, government expenditure, and CPI are retrieved from the National Bureau of Statistics of China (NBS), and 2006-2016 monthly data on exchange rates of Chinese yuan to one US dollar are retrieved from the Federal Reserve Economic

Data (FRED). Because the monthly lending rates in China are not available on several websites including NBS, the FRED, and the World Bank Data, I manually insert the lending rates into the data set by searching for the historical adjustments on the one-year lending rates between 2006 and 2016. It is worth noting that the PBOC has adjusted the rates 25 times during that period. Both M2 money supply and government expenditure are accumulated values measured in 100 million yuan. As Figure 1 shows, M2 money supply increased persistently between 2006 and 2016, and the increase accelerated after 2008. Government expenditure serves as a proxy for fiscal policy; a rise in government expenditure is often accompanied by proactive fiscal stimulus plans.

The HPI are the sales price indices of newly constructed commercialized buildings in Beijing on a month-on-month basis; a month-on-month variable means that each index is obtained by considering the index in the preceding month as 100. Similarly, CPI are the national consumer price indices including all items on a month-on-month basis. However, these two variables are not the desirable time-series variables. Both variables only compare the values in two consecutive months, but cannot compare, for example, the values in January and June; thus, both variables need to be converted. I subtract 100 from each index to obtain the growth rates. Next, I set the index in January 2006 to be 100. Then, I multiply 100 by the proper growth rates to obtain the HPI and CPI for other observations. After this process, HPI and CPI become variables where the base year is 2006. Figure 2 shows the changes in the adjusted HPI in Beijing between 2006 and 2016; house prices in Beijing has more than doubled since 2006. In addition, the increase in house prices accelerated in 2012 and in 2015, when the PBOC implemented RRR cuts to increase the supply of money. This observation implies that house prices may increase with money supply.

The exchange rate indicates the ratio of Chinese yuan to one US dollar. Figure 3 shows the exchange rate movement between 2006 and 2016. Although the yuan had been appreciating by

2015, at the end of 2016, the yuan dropped to 6.94 against the dollar, which was nearly eight-year low. Meanwhile, the increase in Beijing house prices decelerated. This observation implies that a yuan's decline may negatively impact house prices. Certainly, only examining the figures cannot lead to a convincing conclusion. A model is needed for further analysis.

While some studies include a variable of GDP, income, or CPI in their VAR models, none of them are included in this paper, because they have high correlations with M2. The high correlations will result in two problems when building the VAR model. First, the collinearity will result in a singular matrix, namely a matrix in which two or more rows, or columns, are a linear combination of each other. The singular matrix will disrupt the implementation of the VAR model. Second, the collinearity will disrupt the interpretation of the variance decomposition. The concept of variance decomposition will be explained later in this paper; in short, the model will fail to correctly explain which variable has a greater influence on the changes in house prices because of the collinearity. Although the CPI and GDP variables are excluded, after using the M2 variable to construct two VAR models, I replace M2 with CPI to conduct robustness checks to observe whether the results are consistent with those of the original models. Table 1 shows the descriptive statistics of each variable, and the sample size is 132. However, since the variable of government expenditure has five missing values, five observations have to be discarded.

One caveat is that time-series variables whose statistical properties such as mean, variance, and autocorrelation change over time are non-stationary variables. In a VAR model, non-stationary variables are often transformed into stationary variables. An augmented Dickey-Fuller (ADF) test is implemented to test the stationarity of each variable. The null hypothesis is that a unit root, which implies non-stationarity, is present in the time series sample, and the alternative hypothesis is that the time series is stationary. Table 2 shows the results of the ADF test. The test fails to reject

the null hypothesis when checking the variables of M2 and lending rates, indicating that the two variables are non-stationary. As a result, a differencing technique is used to transform M2 into a stationary variable. Such transformation takes the first differences of M2 between two consecutive observations. After the transformation, the ADF test is conducted again, which shows that the M2 variable is now stationary. Nevertheless, lending rates are not converted. The non-stationarity of lending rates is not severe; in fact, the modified Dickey Fuller test, which is known as the DF-GLS test, shows that the variable of lending rates is stationary at the 5% level. Furthermore, although both HPI and government expenditure are stationary variables, they are transformed into natural logarithms; the purpose of this transformation is to aid in the interpretation of the results of the VAR model instead of reducing stationarity. As Table 2 shows, the ADF test suggests that both HPI and government expenditure are still stationary after transformed into logs.

3.3 The setup of a VAR model

A VAR model describes the evolution of variables over the same sample period as a linear function of their past values. The model in this study includes five variables: HPI, M2, lending rates, government expenditure, and exchange rates. To understand the setup of the VAR model, I first denote the five variables as $y_{t,1}$, $y_{t,2}$, $y_{t,3}$, $y_{t,4}$, and $y_{t,5}$, where $y_{t,1}$ is the HPI at time t. If I assume that the VAR model only uses one lag, then the model creates the following regression function to estimate the effects of the lagged values of all the five variables on HPI:

$$y_{t,1} = c_1 + \beta_{11} y_{t-1,1} + \beta_{12} y_{t-1,2} + \beta_{13} y_{t-1,3} + \beta_{14} y_{t-1,4} + \beta_{15} y_{t-1,5} + w_{t,1}$$

In this function, c_1 is the constant term, $w_{t,1}$ is the error term, and β's are the coefficients (Greene, 2012). The coefficients can be estimated by the appropriate approach, such as the ordinary least squares (OLS) estimator or the generalized method of moments (GMM) approach;

the latter is used in this study. I repeat replacing $y_{t,1}$ with the other four variables; as a result, I end up with five equations that estimate how the lagged values of all variables influence the five dependent variables. If I combine the five equations, I obtain the following function:

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t$$

This is the initial setup of a VAR model. y_t is a 5×1 vector that collects the five variables. y_{t-I} is called the I-th lag of y, representing the I-periods back observation. The A_i are 5×5 coefficient matrices, which represent the magnitude of the effects of the independent variables. c is the constant term, and e_t is the error term assumed to have no correlation across time. The vector form of the left-hand side y_t implies that each of the five variables is a dependent variable in turn.

The VAR model in this paper is different from those in Koivu (2012) and Tan and Chen (2013), who instead apply structural VAR models. A structural VAR model typically has two features. First, a structural model requires additional identifying assumptions based on institutional knowledge or economic theory, such as the utility maximization problem. Second, a structural model introduces economic structural shocks, which ensure that the error terms are uncorrelated. The uncorrelated error terms ensure that a shock to a variable is not influenced by shocks to other variables; thus, the model can estimate the effect of a shock while holding all other shocks constant. However, this study does not focus on the structural factors, and having inappropriate identifying assumptions cannot improve the performance of the model. Hence, this study uses an unstructured VAR model to merely examine how monetary policy and house prices affect each other.

3.4 The GMM approach

As mentioned above, I apply the GMM approach to estimate the coefficients in the VAR model. The GMM approach is useful when there exists endogeneity between variables; an

endogeneity problem occurs when an explanatory variable is correlated with the error term. One common cause of endogeneity is that at least two variables are codetermined, with each affecting the other. Because there exists feedback mechanism among the variables used in this study, the endogeneity problem is present. Also, in a time series analysis, the value of a variable in period t may be dependent on the values of other variables in period $t-1$. For example, it is feasible that government expenditure is independent of other variables within a given period, but influenced by changes in house prices in the preceding period. In this instance, government expenditure is endogenous over time. One can notice that because of the endogeneity problem, the OLS estimator cannot be used in this study, because it leads to biased estimates of the regression coefficients.

To understand the implementation of the GMM, one can suppose that a population is defined, and the population data is in normal distribution such that the mean is u and the variance is σ^2. Then, one of the moments, or properties, of a normal distribution is that the expected value of a variable X is u, namely $E[X] = u$. After a sample from the population is acquired, the moment conditions need to be recreated in the sample. That is, given data on the observable variables, the GMM finds values for the model parameters such that the sample moment conditions, such as $E[X] = u$, are as close as possible to the population moment conditions (Greene, 2012).

3.5 Lag length selection

Furthermore, the number of lags, namely p, needs to be determined. Several techniques can be used to identify the appropriate lag length; for example, the Akaike information criterion (AIC), the Schwarz criterion (SBIC), and the final prediction error criterion (FRE). When more parameters are added to a model, the model will provide a better fit for the data points; however, adding excessive parameters result in a problem with overfitting and losing information about the

real underlying pattern. Choosing the optimal model requires considering the balance between the simplicity and the predictive performance of the model. In particular, the AIC method takes the balance into account when selecting among a finite set of models. Table 3 shows the results of the lag selection from different methods. In this case, both FRE and AIC suggest using a lag length of four, namely $p = 4$. However, I use three lags, instead of four lags, in the VAR model due to two reasons. First, since the sample in this paper only has a size of 127, using fewer lags can prevent the model from overfitting. Second, $p = 3$ is the next best choice proposed by FRE and AIC, so using three lags should not deteriorate the performance of the model. Hence, the estimation of the VAR model will be based on the evolution of the variables over the last three months.

3.4 Formal hypothesis

This study focuses on the relationship between M2 money supply and house prices and hypothesizes that M2 has a positive effect on house prices, because a loose monetary policy can increase housing demand. For the same reason, lending rates are expected to have a negative effect. In addition, government expenditure is often associated with an increase in spending in housing and hence expected to have a positive effect on house prices. The effect of exchange rates is uncertain. On one hand, appreciation in currency may attract foreign investment flowing to the housing market. On the other hand, the appreciation may also discourage foreign investors due to the increase in prices. This study also observes the effects of house prices on the macroeconomic variables. The effects of house prices on M2, lending rates, and government spending are expected to be insignificant. Huang et al. (2015) and Shen et al. (2016) illustrate that an increase in house prices often leads to monetary and credit growth; however, the Chinese government has not explicitly adjusted the monetary and fiscal settings for the housing market before 2017, and most

of the policy decisions are aimed to stimulate economic growth. Furthermore, house prices are expected to cause a depreciation in yuan. Housing can be viewed as a store of value for entrepreneurs; hence, when house prices decrease, entrepreneurs may shift their investments from housing to foreign assets, causing capital outflows and yuan's declines.

4. Empirical results[1]

4.1 Explanations about impulse responses

The VAR model describes the changes in variables as a linear function of their past values, so the model generates five linear equations whose dependent variables are HPI, M2, lending rates, exchange rates, and government expenditure, respectively. Because it is difficult to interpret the coefficients in the equations, we take a closer look at the impulse response functions, which describe the reaction of a variable to a shock in another variable over a time period. To understand how an impulse response is developed, we consider the equation of evolution with only one lag:

$$y_t = Ay_{t-1} + e_t$$

Again, y_t is a 5×1 vector that collects all variables, and e_t is the error term. Next, we can rewrite the one period lagged equation of evolution as follows:

$$y_{t-1} = Ay_{t-2} + e_{t-1}$$

After that, we replace y_{t-1} in the original equation of evolution to obtain:

$$y_t = A^2y_{t-2} + Ae_{t-1} + e_t$$

Then, we repeat using the twice lagged equation of evolution, namely $y_{t-2} = Ay_{t-3} + e_{t-2}$, and replace y_{t-2} in the above equation of evolution to obtain:

[1] I use Stata to build the VAR model and produce the results. The Stata code is provided by pvar2.ado, a program originally written by Inessa Love and revised by Ryan Decker. Love's program was employed in Love and Ziccino (2006) and other papers. The built-in command used in this paper is: pvar2 varlist, gmm monte 500 decomp 12 1.

$$y_t = A^3 y_{t-3} + A^2 e_{t-2} + A e_{t-1} + e_t$$

From this, if we want to find the effect of the j-th element of the vector of shocks on the i-th element of the vector two periods later, the effect is represented by the i, j element of the matrix A^2. One can notice that an impulse response is an induction process.

Figure 4 shows all the impulse responses generated by the VAR model. The error bands in each impulse response indicates the 95% confidence interval. The Monte Carlo simulation is used to generate the error bands. In this paper, this method estimates the error bands by calculating the results 500 times. The impulse responses are statistically significant if the confidence interval does not contain zero, namely the horizontal axis. In Section 4.2, I first analyze the effects of money supply, lending rates, and government expenditure on house prices. Then, I observe the impacts of house prices on the three variables. Lastly, I examine the impacts of exchange rates.

4.2 Dynamic effects between macroeconomic factors and house prices in Beijing

The impulse responses show that both monetary policy actions and fiscal stimulus plans influence the house prices. As Figure 5 shows, a money supply shock has a positive impact on house prices, and the impact is borderline significant from the fifth to the ninth month. This result supports the findings from Tan and Chen (2013) and Koivu (2012) that money supply positively impacts house prices. A lending rate shock has a positive impact on house prices, but the impact is small and becomes statistically insignificant after three months. This positive impact contradicts the hypothesis that higher lending rates will tighten the borrowing constraints and thus decrease the housing demand. One explanation is that interest rates play an insignificant role in the housing market; as Tan and Chen (2013) mention, people will invest in the housing market regardless of whether the lending rates are high. While previous studies fail to rule out the effects of fiscal policy

on the housing market, this paper shows that a government spending shock has a positive impact on house prices, and the impact is borderline significant seven months after the shock. This result is consistent with the hypothesis that the increase in spending on housing triggered by a fiscal stimulus plan should push the prices up. The positive impacts of money supply and government expenditure suggest that when an expansionary monetary or fiscal policy is implemented, an increasing amount of funds will be directed to the housing market, because SOEs and individuals tend to invest in housing due to the high profit. Such capital flows inevitably result in an increase in house prices. Furthermore, it is interesting to observe the dynamic effects among money supply, interest rates, and government expenditure. As Figure 6 shows, a money supply shock has no significant impact on government expenditure, implying that China's fiscal policy is not attuned to its monetary policy. Similarly, the money supply shock has no significant effect on lending rates, contradicting the expectation that monetary growth is often associated with a loose monetary policy that leads to reductions in interest rates. Likewise, a lending rate shock has no stable or pronounced impact on money supply. The unexpected interaction effects between money supply and lending rates suggest that the money supply and the interest rate may be considered as separate tools rather than complementary monetary instruments in China.

Figure 7 shows the impacts of house prices on China’s monetary policy. The impulse responses show that a house price shock has no significant effect on money supply, which contradicts the finding from Koivu (2012) that money supply is reduced after a shock in residential prices. Meanwhile, the house price shock has no significant impact on lending rates; this result contradicts the findings from Shen et al. (2016) that a housing boom often causes an easing of credit constraints. The weak responses of the monetary variables to the house price shock implies that there is a partial unilateral relationship from monetary policy and housing market. In fact,

instead of monetary policy actions, the Chinese government frequently raises the down payment, restricts purchases of multiple homes, and bans the sale of homes to people who have no household registration, namely the *hukou*, which determines where Chinese citizens can live. The lack of attempts to curb house prices through monetary policy actions explains the weak responses of the monetary variables to the housing market. Similarly, a house price shock has no pronounced effect on government expenditure; China's fiscal policy is barely affected by the housing market.

This paper complements other studies by considering the influence of exchange rate movement on house prices. The impulse responses in Figure 8 show that a depreciation in the yuan has neither statistically nor economically significant impact on house prices, which is in line with the results from Liu and Hu (2013) and implies the exchange rate pass-through into house prices is weak. Similarly, a house price shock has no statistically significant impact on exchange rates. The weak response of house prices to exchange rates can be explained by the ambiguous relationship between the yuan and the housing market in the recent decade. Before 2015, Although China was believed to attempt to devaluate its currency, the yuan was in fact appreciating and moving from 7.8 in 2008 to 6.1 in 2014 against the dollar. Meanwhile, house prices rose drastically between 2008 and 2014; that is, the surging house prices were accompanied by an appreciation in yuan. However, when the yuan was experiencing a depreciation in 2016, China's house prices still showed signs of increase in top-tier cities until restrictions on housing demand were imposed. The inconsistent reactions of house prices to exchange rates lead to the patterns found in the impulse responses of exchange rates and house prices. Interestingly, one impulse response reveals that a yuan’s decline leads to a decrease in money supply at one month, although the decrease is only borderline significant. This is consistent with the expectation that the PBOC tends to refrain from cutting the RRR and increasing the money supply when the yuan depreciates.

Lastly, a forecast error variance decomposition (FEVD) is implemented to aid in the interpretation of the VAR model. The variance decomposition tells how much of a change in a variable is due to its own shock and how much due to shocks to other variables. Table 6 shows the variance decompositions of all variables in the VAR. Surprisingly, a shock to house price accounts for above 84.24% of variation in house prices at one year. That is, most of the variation in house prices is due to its own shock. The belief that housing is a safe investment and the prevalence of speculation in the housing market explain why variation in house prices is mostly caused by its own shock. Since the shocks to other variables only account for small variation in house prices in the short run, I only observe the variance decompositions at one year. The results show that a shock to money supply accounts for 8.3% of variation, which is the largest among all variables except the house price variable. Likewise, a lending rate shock accounts for 1.74% of variation, and a government spending shock accounts for 5.56%. These results suggest that Beijing housing market is more sensitive to changes in money supply than changes in interest rates or fiscal policy. In contrast, a shock to exchange rates accounts for only 0.14% of the variation, suggesting that the housing market is more sensitive to policy changes than exchange rate movements.

5. Robustness checks

5.1 Replacing Beijing house price data with Shenzhen house price data

Only observing the Beijing housing market may not be sufficient to conclude the impacts of monetary policy on the general housing markets in China; thus, I conduct a robustness check by constructing another VAR model using Shenzhen house price data instead of Beijing house price data. While Beijing was one of the first postindustrial Chinese cities and is the headquarter of most of China's largest state-owned companies, Shenzhen was one of the fastest-growing cities

in the world during the 1990s and the 2000s due to China's economic reforms and is a major financial center with active private entrepreneurship and prosperous domestic high-tech firms. Figure 9 shows the changes in Shenzhen house prices between 2006 and 2016. While the increase in Shenzhen house prices was moderate before 2015, the increase accelerated abruptly in 2015. In fact, Shenzhen home prices rose the fastest in China in 2016; prices in Shenzhen, Shanghai, and Beijing rose 41.25 percent, 22.5 percent, and 15.47 percent year-on-year in July (Glenn, 2016). Another VAR model is developed by a similar approach to observe the house price fluctuations in Shenzhen. Nevertheless, while the HPI for Beijing is stationary, the ADF test suggests that the HPI for Shenzhen is non-stationary as shown in Table 4; therefore, the differencing technique is applied, after which HPI becomes stationary. Table 5 shows the results of the lag selection for the second model. In this case, both FRE and AIC suggest using a lag length of three.

The second model generates a set of impulse responses shown in Figure 10, illustrating the reactions of variables to different shocks in Shenzhen. Although both the first and the second models agree that a house price shock has no significant impacts on either monetary variables or exchange rates, several results in the second model are not in line with those in the first model. First, a money supply shock has a positive impact on house prices in Shenzhen, but the impact is smaller than that in Beijing and becomes statistically insignificant after one month. Second, a lending rate shock has a significant negative effect on house prices from the second to the seventh month, suggesting that tightening the credit market will cause a decrease in the housing demand in Shenzhen. Third, a government spending shock has no significant impact on house prices, contradicting the hypothesis that an expansionary fiscal policy causes increases in housing demand and investment due to the increase in available funds. These results imply that although money supply has a positive impact on house prices, the impact varies in different cities.

Similarly, the second model provides the variance decompositions. As table 7 shows, the variance decompositions at one year reveal that a shock to house prices accounts for 67.31% of variation in house prices. This result suggests that most of the variation in Shenzhen house prices is also due to its own shock; however, the shocks to other variables account for a sizeable amount of variation in this case. A shock to money supply only accounts for 0.75% of variation, meaning that changes in money supply has a smaller impact on Shenzhen housing market than Beijing housing market. However, a lending rate shock accounts for 27.49% of the variation, which is significantly higher than the percentage of variance that the lending rate shock accounts for in Beijing. To sum up, while the housing market in Shenzhen is also mainly influenced by the expectation that house prices will rise, the market is much more sensitive to lending rates. Meanwhile, while the impacts of money supply and government expenditure on Beijing house prices are significantly positive, they become insignificant in Shenzhen housing market.

The differences between the housing markets in Beijing and Shenzhen can be explained by the different characteristics of the cities. First, because most of the largest SOEs are located in Beijing, the impacts of money supply and government expenditure on house prices are more pronounced in Beijing since SOEs have more access to funds. In addition, as Huang et al. (2015) argue, local amenities such as air quality impact house prices. Beijing is known to be a city with serious air pollution; the World Health Organization (WHO) database in 2011 mentioned in Huang et al. (2015) shows that Beijing is the fifth most polluted city within the country. While most of the polluted Chinese cities are in the north, the south remains in relatively better condition. Since Shenzhen is near the least polluted southern city, the air quality in Shenzhen is perceptibly better than that in Beijing. As the WHO database in 2016 shows, the annual mean of PM2.5, namely the level of air pollution, in Beijing was 85 in 2014, and the annual mean in Shenzhen was 34. Huang

et al. (2015) assert that housing markets in cities with better amenities are less sensitive to monetary and credit growth, suggesting that a money supply shock accounts for less variation in Shenzhen house prices when the air quality in Shenzhen is consistently and noticeably better than that in Beijing. Furthermore, because Shenzhen has been a fast-growing city that attracts high- and low-skilled workers from around China over the last few decades, Shenzhen is one of the most crowded Chinese cities, which had a population density of 6,000 people per square kilometer in 2016, compared with 1,300 in Beijing. Both cities also differ in income levels. For example, per capita GDP in Shenzhen was 163,750 yuan in 2016, compared with 114,742 yuan in Beijing. Both the population density and levels of income imply that the housing demand in Shenzhen is stronger than that in Beijing over the last few years. The robust housing demand in Shenzhen strongly encourages speculative behaviors in the housing market. Because speculative investors are more sensitive to changes in lending rates, a lending rate shock accounts for more variation in Shenzhen house prices. To sum up, while money supply has a positive impact on house prices, the impact varies due to institutional differences and different levels of amenity.

5.2 Replacing M2 money supply with CPI

As mentioned before, CPI is not included in either the first or the second model, because CPI is highly correlated with M2. Including both CPI and M2 in a VAR model results in a problem with multicollinearity, which disrupts the development of the model and the interpretation of the variance decompositions. In other words, the VAR model may attribute the fluctuations in house prices to the changes in CPI, while the house prices are in fact influenced by M2. Although both models above exclude CPI, CPI is used for robustness checks in this section. I replace M2 with CPI in the previous VAR models to investigate whether the impacts are consistent with those of

the original models. In the interest of clarity, I denote the model that uses Beijing HPI and M2 as Model 1, the model that uses Shenzhen HPI and M2 as Model 2, the model that uses Beijing HPI and CPI as Model 3, and the model that uses Shenzhen HPI and CPI as Model 4.

The CPI variable differs from the M2 variable in that CPI is stationary; therefore, the differencing technique is not used for CPI. Instead, CPI is transformed into natural logarithm to help with the interpretation of the VAR models. After replacing M2 with CPI, I first use the HPI in Beijing to develop Model 3 and investigate the impacts of CPI and other variables on Beijing housing market. As Table 8 shows, both FPE and AIC suggest using two lags for Model 3.

Figure 11 shows all the impulse responses in Beijing housing market produced by Model 3; most impulse responses resemble the patterns of those in Model 1, although most of the impacts become statistically insignificant. For example, a CPI shock in Model 3 has a positive impact on house prices, but the impact is statistically insignificant and much smaller than that of a money supply shock in Model 1. Likewise, a government spending shock in Model 3 has a positive but economically and statistically insignificant impact on house prices, while the shock in Model 1 has a significant positive impact. In addition, a lending rate shock in Model 3 has a significant negative effect on house prices after nine months. while the shock in Model 1 has a negative but statistically insignificant impact in the long run. The comparison between the impacts of lending rates complements the results of Model 1, emphasizing that a cut in lending rates is likely to decrease house prices in the long run. Furthermore, Model 3 agrees with Model 1 that a house price shock has no significant effects on money supply, lending rates, or government expenditure. Also, there is no relationship between exchange rates and house prices in Model 3.

Next, Model 4 is constructed after the M2 variable in Model 2 is replaced with the CPI variable. Table 9 shows that both FRE and AIC suggest using three lags. Figure 12 shows all the

impulse responses generated by Model 4. Again, most impulse responses are similar to those in Model 2. For example, in Model 4, a government spending shock has no significant effect on house prices, and a lending rate shock has a significant negative impact on house prices from the second to the eighth month. However, a CPI shock has a significant negative impact on Shenzhen house prices from the fourth to the eighth month, which contradicts the finding from Model 2 that a money supply shock has a small significant positive effect on house prices. The unexpected effect of a CPI shock emphasizes that Shenzhen housing market is more sensitive to lending rates. Moreover, M2 and CPI should not be viewed as variables that are perfectly substitutable; thus, the impact of a CPI shock is inevitably different from that of a money supply shock. While an increase in money supply directly provides individuals and firms with more loans that can be invested in the housing market, an increase in CPI has no direct impact on housing demand.

6. Policy implications

6.1 Tighten money supply and credit

The results of the VAR model show that money supply has a positive impact on house prices; thus, curbing the increase in money supply is expected to suppress the growth of the housing market. As mentioned before, a money or credit expansion in China allows the SOEs to access more loans from banks. Most of the loans will be invested in the housing market, driving the land prices as well as the house prices. Tightening the money supply and controlling the funds flowing to the SOEs can reduce the incentives of those inefficient firms to invest in the housing market. Meanwhile, because the Chinese government gives priority to the SOEs, the privately-owned enterprises (POEs) need to rely on informal financial intermediaries, such as shadow banks. That is, the expansionary monetary policy also shifts the capital out of POEs, which are considered

more productive than the SOEs. This argument is in line with Chen and Wen (2014) who illustrate that a housing bubble can crowd out productive investment. Hence, shifting the capital from the SOEs to the POEs can alleviate the problem with capital misallocation while curbing the house prices. As Chang et al. (2016) illustrate, the reallocation of resources accompanied by the reduction in money supply and the tightening of credit will also raise the total factor productivity (TFP), which raises real GDP in Chinese economy. Moreover, Lien et al. (2016) mention that the wage gap between high-skilled and low-skilled workers is shrinking, because high-skilled industries are not favored by the government's investment strategy. Improving the POE sector can increase the demand for high-skilled workers; as a result, unemployment rates for educated individuals decline, and people have a greater incentive to attain higher education degrees.

In addition, Chen and Wen (2014) explain that the vacancy rates of residential homes in the first-tier, second-tier, and third-tier cities in China are 21.2 percent, 21.8 percent, and 23.2 percent respectively, implying that the supply is supposed to be accommodating the demand in the housing market. However, a homeowner's entrepreneurial status, namely whether the homeowner owns a private business, has strong predictive power on the vacancy rates of residential homes in China. That is, entrepreneurs are more likely to own vacant housing units than other types of homeowners do. Because housing is a tempting investment option, the government needs to avoid excessive speculative behaviors in the housing market. As the previous impulse responses show, house prices are more sensitive to lending rates in Shenzhen where speculative activities in the housing market are believed to be more prevalent; therefore, adjusting the interest rates may reduce the speculative activities and hence the house prices. Moreover, the Chinese government ended its administrative control of interest rates in 2015; thus, the interbank money market is expected to have a greater influence on the current market interest rates and the economy.

6.2 Reallocation of resources

China's leaders asserted that urbanization was the powerful engine to drive economic growth (Davis, 2013), reducing constraints on migration and urban registration; consequently, rapid urbanization and demographic changes are prevalent in China. A growing number of people who live in undeveloped rural regions or second- and third-tier cities migrate to first-tier cities, such as Beijing, Shanghai, and Shenzhen, in search of better education, health care, and job opportunities. The increases in population size in major cities inevitably drive the demand for housing, causing a rise in house prices. Because the demand in major cities is more robust than that in second- or third-tier cities, when new housing construction is speeding in most cities, the strong demand in major cities leads to higher house prices, whereas the weak demand in small cities lead to higher vacancy rates. If some people are willing to move to second- or third-tier cities, the increase in house prices is likely to slow down in major cities, and vacant housing units in low-tier cities can be consumed. Encouraging people to move to small cities require reallocation or resources; the government should support more developments in lower-tier cities.

Income growth also leads to surging house prices; nonetheless, the income growth is unequal for the rich and the poor (Talley, 2015). It is conceivable that low-income households suffer more from the growing house prices than high-income households do; as Chen and Wen (2014) point out, middle- and high-income households are driving forces for house prices, whereas low-income households are excluded from the housing market due to the unaffordable prices. Likewise, Yao et al. (2014) argue that China has two divided housing markets: commercial housing for the rich and low-cost housing for the poor. However, only one-third of new urban residential buildings were low-cost houses in 2012; a growing number of houses were built for

wealthy people, because low-cost housing was highly unprofitable. The shortage of low-cost housing raises the prices of low-cost houses, causing low-income households to compete for commercial houses rather than low-cost houses. It is feasible that when the government supports low-cost housing, the housing market will be more efficient, and house prices will fall.

6.3 Problems with curbing house prices

Whether to control house prices is a dilemma for the PBOC. On one hand, the problems with credit risks and overcapacity may force the PBOC to refrain from increasing money supply or releasing fiscal stimulus packages, so investment in property market will fall. On the other hand, the PBOC may consider keeping high economic growth by allowing investment in the property market. Since the share of investment in GDP is high in China, one can argue that the willingness of the Chinese government to forgo high GDP growth is influencing the house prices.

Since China's economic growth is tied to the housing market, the PBOC may be reluctant to curb house prices. Firstly, If the PBOC reduces money supply and tightens credit, even though capital can be shifted from SOEs to POEs, such reallocation is a gradual process. Secondly, as Lien et al. (2016) state, increasing spending on low-skilled sectors can deliver fast and visible output results. These two arguments suggest that the Chinese government is tempted to direct capital into physical infrastructure and housing to achieve high GDP growth. Improving the POEs may foster long-run economic growth, but such economic growth is not immediate. It takes time for POEs to develop and for high-skilled workers to be employed in these POEs. Before the transition from SOEs to POEs completes, China's economy may experience weak output growth and a high unemployment rate, which the Chinese government intends to prevent.

Moreover, although the impulse responses in the study find that house prices have no significant impact on exchange rates in recent decade, it is uncertain whether a fall in house prices will cause a yuan's decline after 2016 when China's economic growth is expected to slow down. At the end of 2016, the exchange rate of Chinese yuan to one US dollar was 6.94, which fell to nearly eight-year low. If this depreciation continues, China's economy will experience severe capital outflows again. It is conceivable that a housing market that underperforms will signal a pessimistic economic outlook that discourages housing investment and decreases the demand for the yuan. When housing is no longer an attractive investment opportunity, investors are likely to sell off their properties and transfer their money to foreign assets. If a decrease in house prices speeds up the depreciation in currency, then the PBOC may be reluctant to suppress house prices. It is possible that the PBOC will maintain the current level of house prices to attract local and foreign investment to stabilize the exchange rate fluctuations. Again, the willingness of the government to forgo high GDP growth may influence the performance of the housing market. The government needs to make prudent policy decisions when facing the surging house prices.

7. Conclusion

Because China's housing market and monetary policy are believed to influence each other, this paper studies the interaction effects and the causality between house prices and money supply in China. In particular, I observe the housing market in Beijing. Because house prices in Beijing are notoriously high and conceivably sensitive to policy changes, the housing market in Beijing can be considered as a representative of the housing markets in top-tier Chinese cities. With 2006-2016 monthly data on house price indices in Beijing, M2 money supply, lending rates, exchange rates of Chinese yuan to one US dollar, and government expenditure, a VAR model is constructed.

The impulse responses show that M2 money supply has a significant positive impact on house prices from the fifth to the ninth month, whereas house prices have no significant impact on money supply. In addition, while a lending rate shock has no economically significant effect on house prices, a government spending shock has a significant positive effect on house prices after seven months, suggesting that fiscal stimulus plans also contribute to the growth of the housing market. Meanwhile, there is no pronounced relationship between exchange rates and house prices. After observing the impulse responses, I conduct the variance decomposition to aid in the interpretation of the VAR model. The results show that in the long run, a shock to money supply accounts for 8.3% of variation in house prices, and a shock to lending rates accounts for 1.74% of variation. Also, a shock to government expenditure accounts for 5.56% of variation, suggesting again that China's fiscal policy also influences the housing market. Meanwhile, a shock to house prices accounts for 84.24% of variation, indicating that most of the variation in house prices is due to its own shock. To sum up, although monetary and fiscal policy changes, such as an increase in money supply or government spending, play important roles in the housing market, the expectation that house prices will rise is the major cause of house price fluctuations.

After that, two robustness checks are conducted. First, I develop another VAR model by replacing Beijing house price data with Shenzhen house price data. Several results of the second model are different from those of the first model. For example, although house prices in Shenzhen increase after a money supply shock, the increase is smaller than that in Beijing and becomes insignificant after one month. However, a lending rate shock has a significant negative impact on Shenzhen house prices from the second to the seventh month. In fact, the variance decomposition shows that in the long run, a money supply shock accounts for only 0.55% of variation in Shenzhen house prices, while a lending rate shock accounts for 27.49% of variation, indicating that Shenzhen

house prices are much more sensitive to changes in lending rates. These results show that although there is evidence that money supply has a positive impact on house prices, the impact can vary due to institutional details and the level of amenity of a city. Furthermore, the second robustness check replaces the M2 variable with the CPI variable in both models. Although statistically insignificant, most of the impulse responses resemble those of the original models.

To curb the house prices, the government can tighten money supply and credit constraints and reallocate resources. However, suppressing house prices causes a tradeoff between short-run economic growth and an efficient housing market. Although reducing money supply can conceivably lower house prices, China's economic growth is likely to slow down when capital is being transferred from the SOEs to private sectors. Moreover, a decline in house prices may accelerate the yuan depreciation, because investors would rather invest in foreign assets than purchase houses in China. Nonetheless, reducing investment in housing induces reallocation of capital, which increases productivity and fosters long-run economic growth. The PBOC needs to make prudent monetary policy changes when intervening in the housing market.

Several limitations in this paper should be mentioned. First, a sample size of 127 may not be sufficient. The results will be more reliable if data spanning from earlier time period to the present is available. Second, although the unstructured VAR model in this study shows that a money supply shock has a positive impact on house prices, the impact is inaccurate if a monetary policy action is purposeful and responds endogenously to the state of the economy. A structural VAR model may provide more reliable results for this study, because it can distinguish endogenous monetary policy actions from exogenous ones and ensure that the changes in house prices are due to monetary policy rather than other factors. Third, a cointegration test is needed to check whether a VAR model is the optimal choice for this study. If cointegration proves to be present between

the variables, a vector error correction model (VECM) might be a better option. Fourth, the impacts of monetary policy on Beijing house prices and Shenzhen house prices are different. It remains to be seen which of the two housing markets is a better representative of the housing markets in Chinese first-tier cities. It may be worth observing more housing markets in different Chinese cities to reach a more convincing conclusion about the relationship between monetary policy and house prices. One can improve this study by taking these issues into account.

In addition to examining various housing markets in first-tier Chinese cities, further research can also focus on the house price fluctuations in second- and third-tier cities, which also experienced rapid growth of house prices over the last few years. For example, based on the data from the National Bureau of Statistics of China, while prices in Beijing and Shenzhen rose 22.7 percent and 41.4 percent in July 2016 when compared with the prices in the preceding year, second-tier cities Nanjing and Hanzhou rose 34.9 percent and 19.1 percent. Compared with first-tier cities, second- and third-tier cities have fewer migrant workers and a smaller population size; therefore, one can argue that the housing markets in those cities are less sensitive to policy changes due to the weaker housing demand. Further research is needed to analyze whether a spillover effect exists in China's housing markets. When the housing stocks in first-tier cities are exhaustive, home buyers and speculative investors may shift their investments to housing in lower-tier cities. It is worth investigating the impacts of house price fluctuations in first-tier cities, as well as the impacts of monetary policy actions, on the housing markets in second- and third-tier cities.

7. Tables and graphs

Table 1: Mean, standard deviation, maximum, and minimum of variables

VARIABLES	(1) N	(2) Mean	(3) SD	(4) Min	(5) Max
HPI	132	159.8	39.43	100	264.9
M2	132	828735	379731	303572	1.550e+06
Lending rate	132	5.840	0.820	4.350	7.470
RMB to 1 USD	132	6.739	0.572	6.051	8.065
Government spending	127	49950	41891	1871	175768
CPI	132	120.8	11.01	99.40	137.2

Note: HPI is the house price indices in Beijing. HPI and CPI are the converted values where the base year 2016, and M2 and government spending are the original values, not in logs.

Table 2: Results of augmented Dickey-Fuller test (The stationarity test)

VARIABLES	(1) Test statistics	(2) 1% CV	(3) 5% CV	(4) 10% CV	(5) p-value	(6) Lags
HPI	-3.519	-3.500	-2.888	-2.578	0.0374**	4
HPI in log	-4.559	-4.031	-3.446	-3.146	0.0012***	4
M2	-2.166	-3.500	-2.888	-2.578	0.5091	4
M2 differences	-5.549	-3.500	-2.888	-2.578	0***	4
Lending rates	-2.916	-3.500	-2.888	-2.578	0.1572	9
Government spending	-4.131	-3.503	-2.889	-2.579	0.009***	0
Government spending in log	-6.205	-3.503	-2.889	-2.579	0***	0
Exchange rates	-3.928	-3.500	-2.888	-2.578	0.0018***	0
CPI	-3.842	-4.034	-3.447	-3.147	0.0146**	12

* indicates significance at 10% level of significance
** indicates significance at 5% level of significance
*** indicates significance at 1% level of significance

Table 3: Results of lag length selection for the VAR model of Beijing housing market

Lags	(1) LL	(2) LR	(3) df	(4) p	(5) FRE	(6) AIC	(7) HQIC	(8) SBIC
0	-1341.74				74663.9	25.4101	25.4611	25.5358
1	-548.459	1586.6	25	0	0.037837	10.9143	11.2198	11.6681*
2	-490.821	115.29	25	0	0.020501	10.2983	10.8585*	1106803
3	-458.183	65.258	25	0	0.017893	10.1544	10.9691	12.1645
4	-428.328	59.711*	25	0	0.016572*	10.0628*	11.1321	12.7011

* indicates the best choice of lag length suggested by a specific test

Table 4: Results of augmented Dickey-Fuller test for HPI in Shenzhen (The stationarity test)

VARIABLES	(1) Test statistics	(2) 1% CV	(3) 5% CV	(4) 10% CV	(5) p-value	(6) Lags
HPI	-2.488	-4.032	-3.447	-3.147	0.3339	6
HPI differences	-3.365	-3.501	-2.888	-2.578	0.0122**	2

* indicates significance at 10% level of significance
** indicates significance at 5% level of significance
*** indicates significance at 1% level of significance

Table 5: Results of lag length selection for the VAR model of Shenzhen housing market

Lags	(1) LL	(2) LR	(3) df	(4) p	(5) FRE	(6) AIC	(7) HQIC	(8) SBIC
0	-1389.64				184362	26.314	26.365	26.4397
1	-596.661	1586	25	0	0.093951	11.8238	12.129.	12.5776
2	-530.284	132.75	25	0	0.043173	11.0431	11.6032*	12.4251*
3	-499.261	62.046	25	0	0.03884*	10.9295*	11.7442	12.9396
4	-474.465	49.593*	25	0.002	0.039576	10.9333	12.0026	13.5716

* indicates the best choice of lag length suggested by a specific test

Figure 1: Changes in M2 money supply between 2006 and 2016

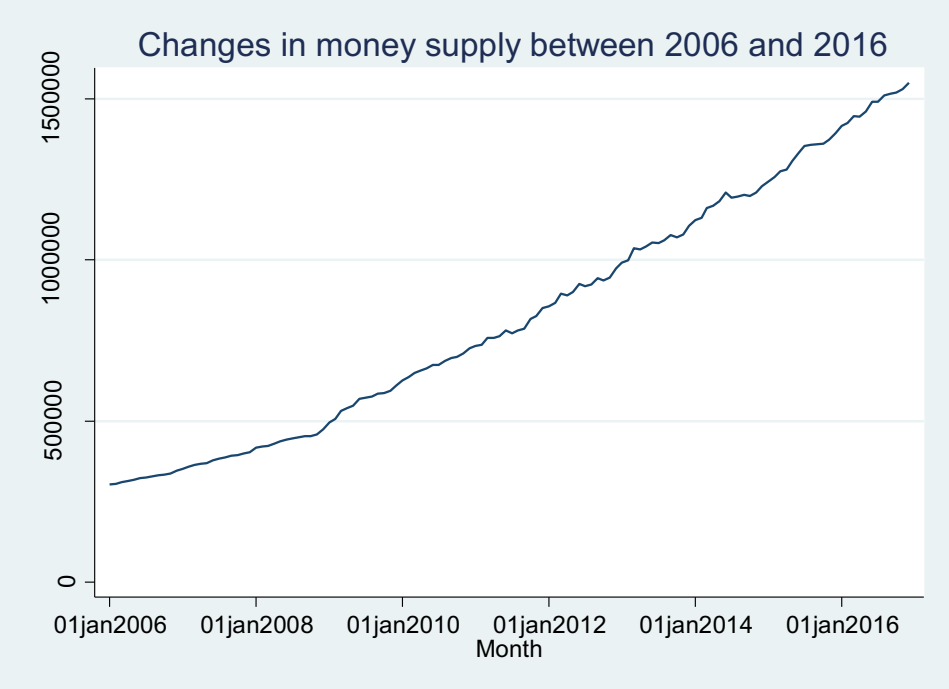


Figure 2: Changes in Beijing house prices between 2006 and 2016

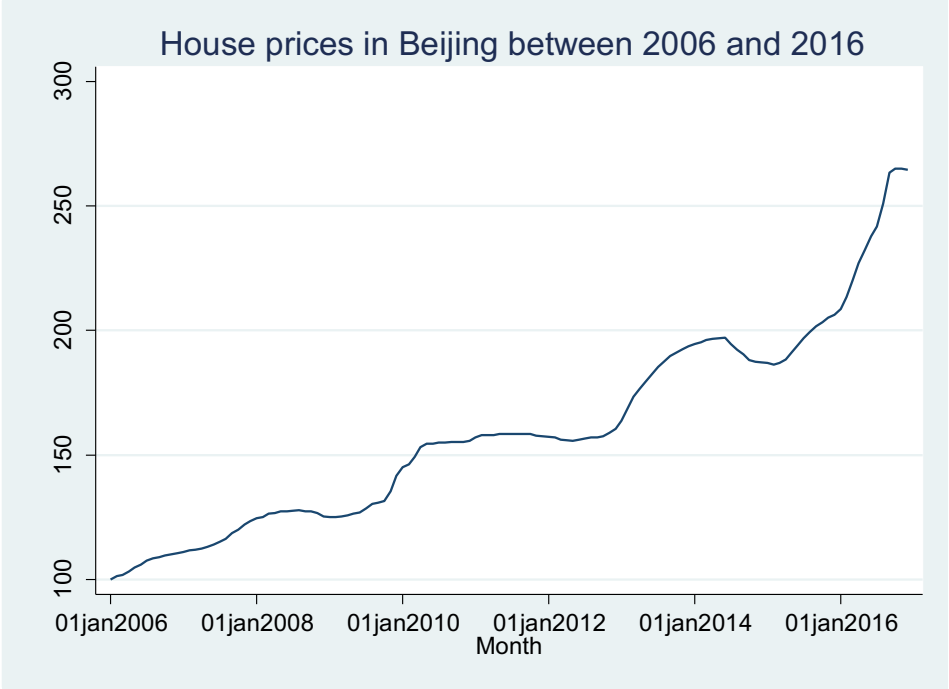


Figure 3: Exchange rate movement between 2006 and 2016

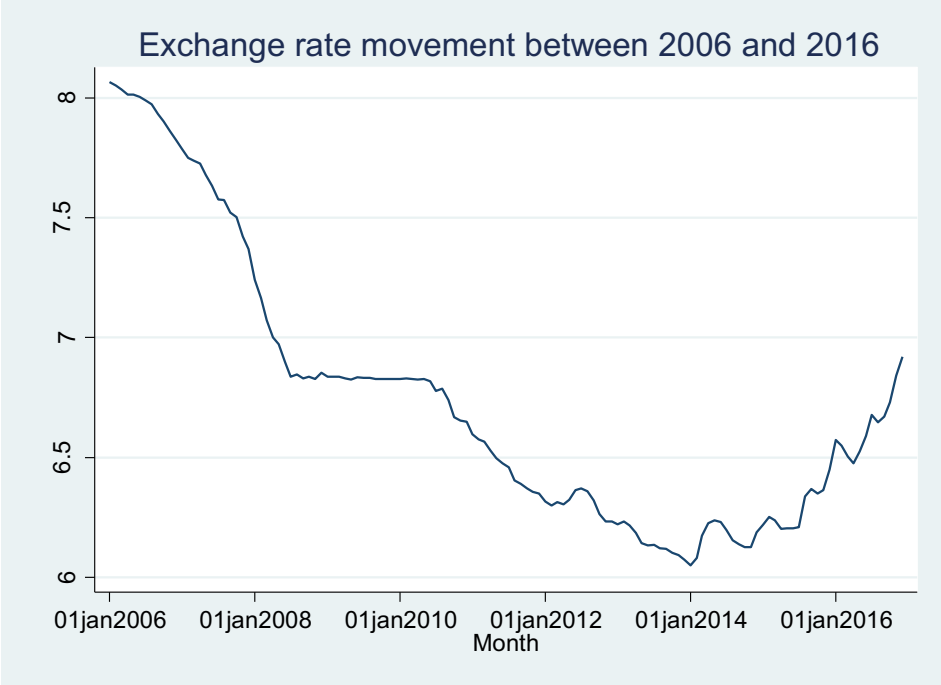


Figure 4: All impulse responses in Beijing housing market

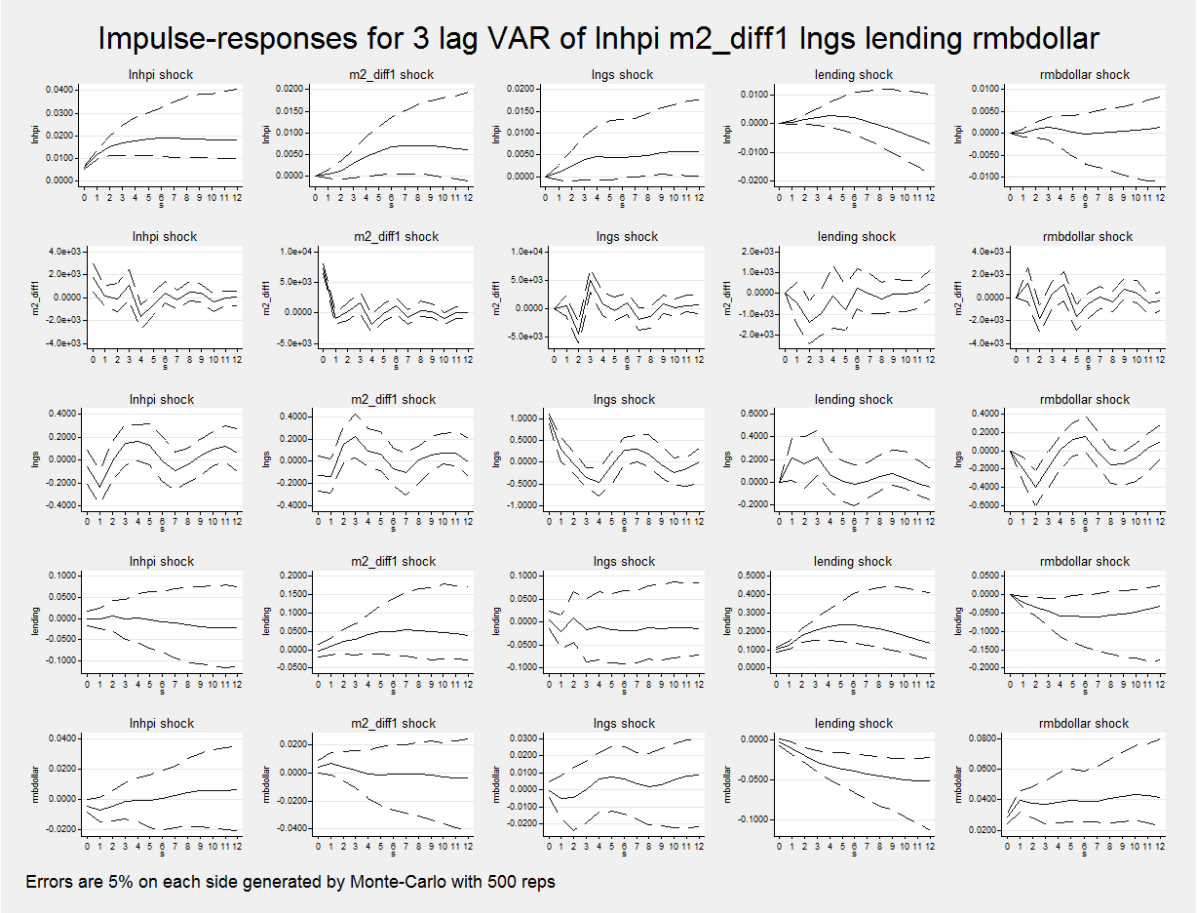


Figure 5: Impacts of monetary and fiscal variables on house prices

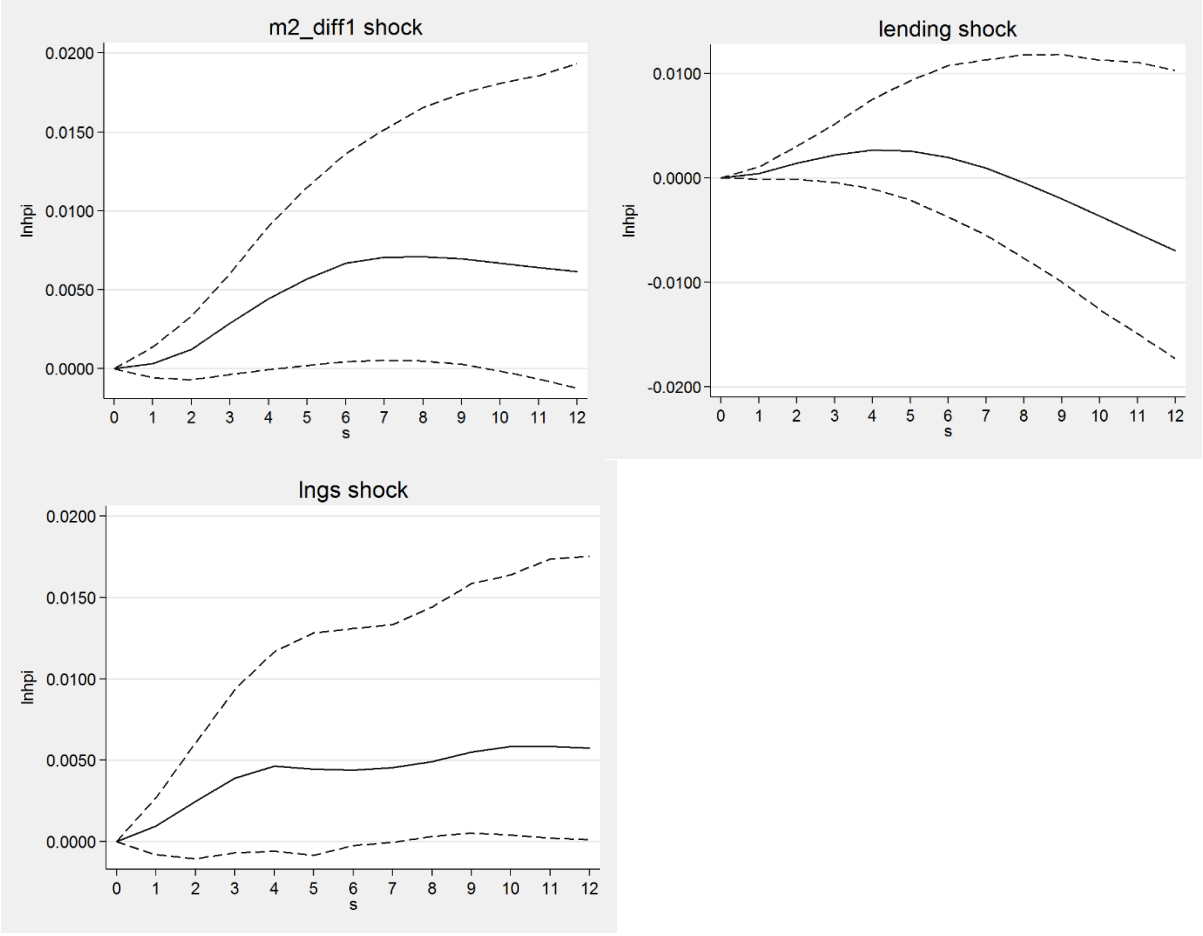
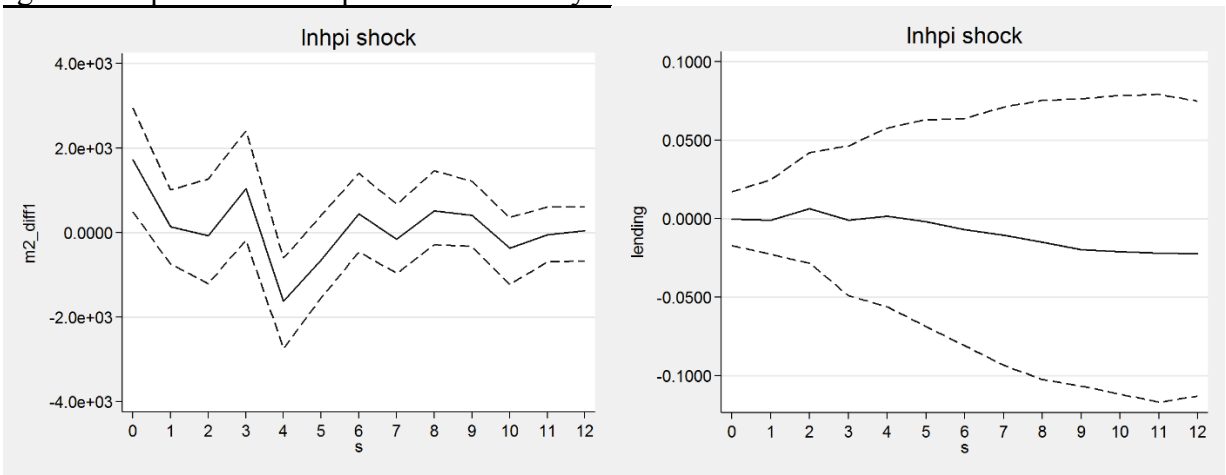


Figure 6: Impacts of house prices on monetary and fiscal variables



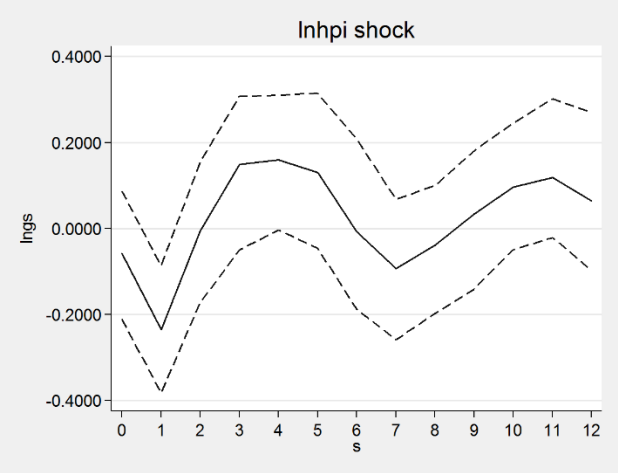
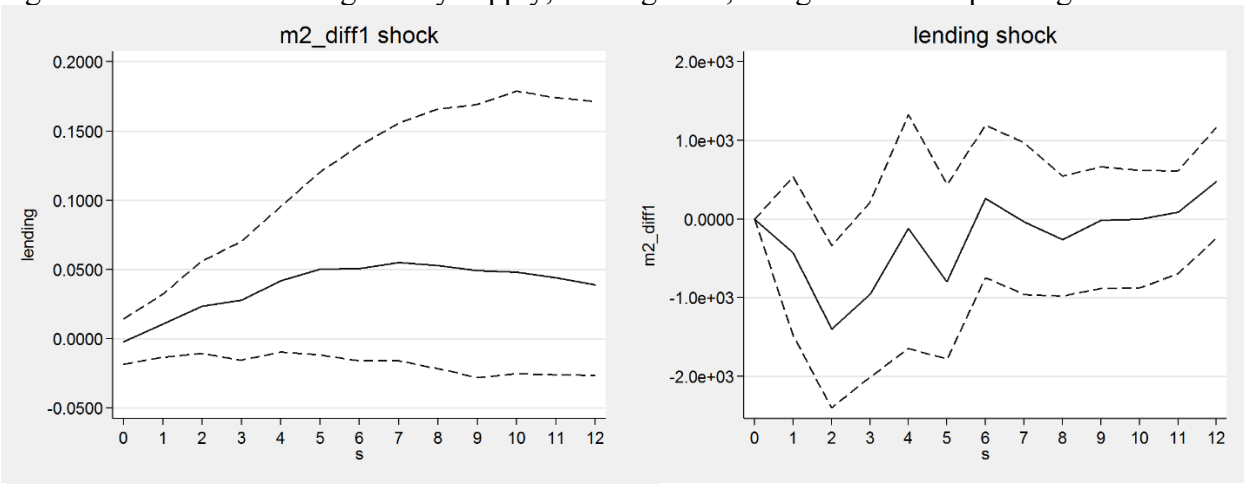


Figure 7: Interaction among money supply, lending rates, and government spending



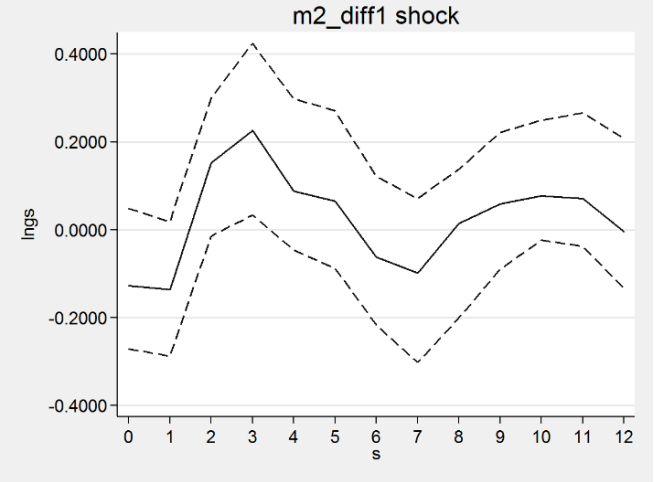


Figure 8: Interaction between exchange rates and house prices

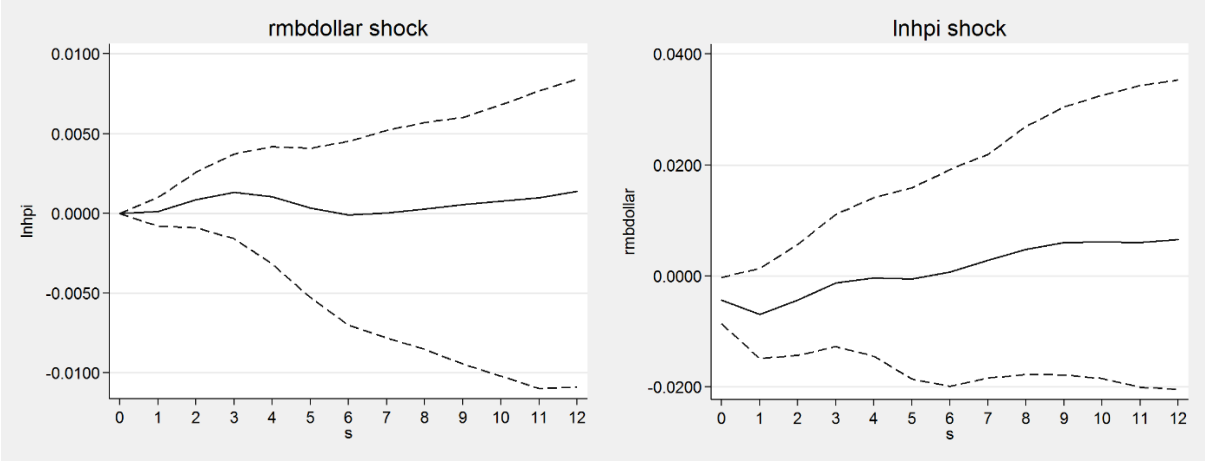


Table 6: Variance decompositions of house prices in Beijing

(1) Month	(2) HPI in log	(2) M2 differences	(3) Government spending in log	(4) Lending rate	(5) Exchange rate
1	1	0	0	0	0
2	0.992997	0.000599	0.005329	0.001012	6.3E-05
3	0.972646	0.003778	0.016832	0.004953	0.001792
4	0.944209	0.013336	0.029932	0.0092	0.003323
5	0.9186	0.026398	0.039314	0.012488	0.0032
6	0.901351	0.040758	0.041952	0.013519	0.002421
7	0.888112	0.054719	0.042736	0.012538	0.001895
8	0.878372	0.065814	0.043636	0.010625	0.001552
9	0.870148	0.073777	0.04564	0.009092	0.001343
10	0.861428	0.079129	0.049015	0.009174	0.001254
11	0.852195	0.082147	0.052622	0.011769	0.001267
12	0.842378	0.083462	0.055354	0.017434	0.001373

The values indicate the percentages of variation that the variables account for.

Figure 9: Changes in Shenzhen house prices between 2006 and 2016

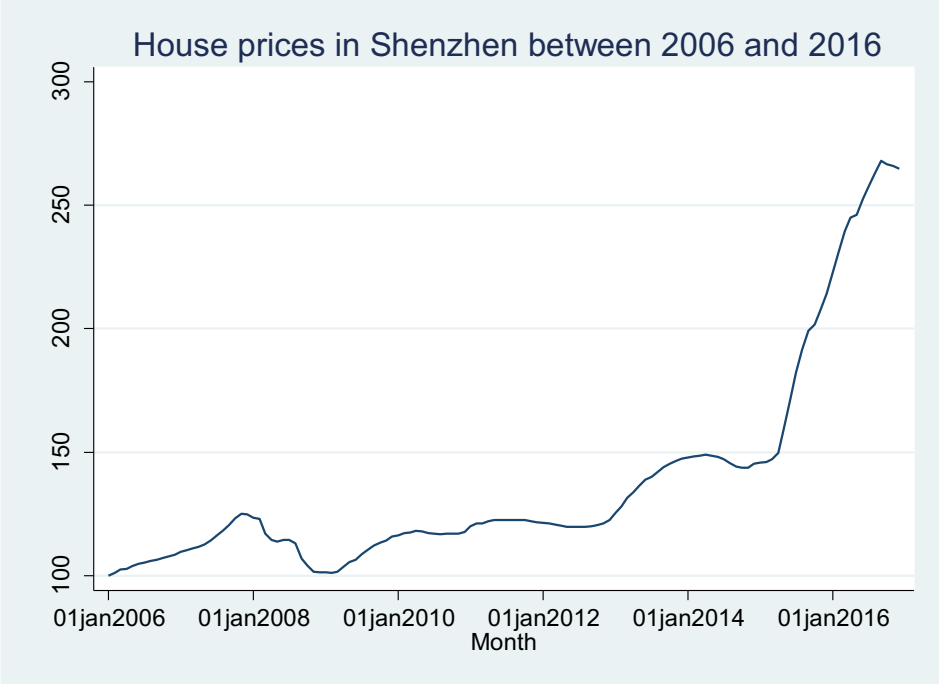


Figure 10: Impulse responses in Shenzhen housing market

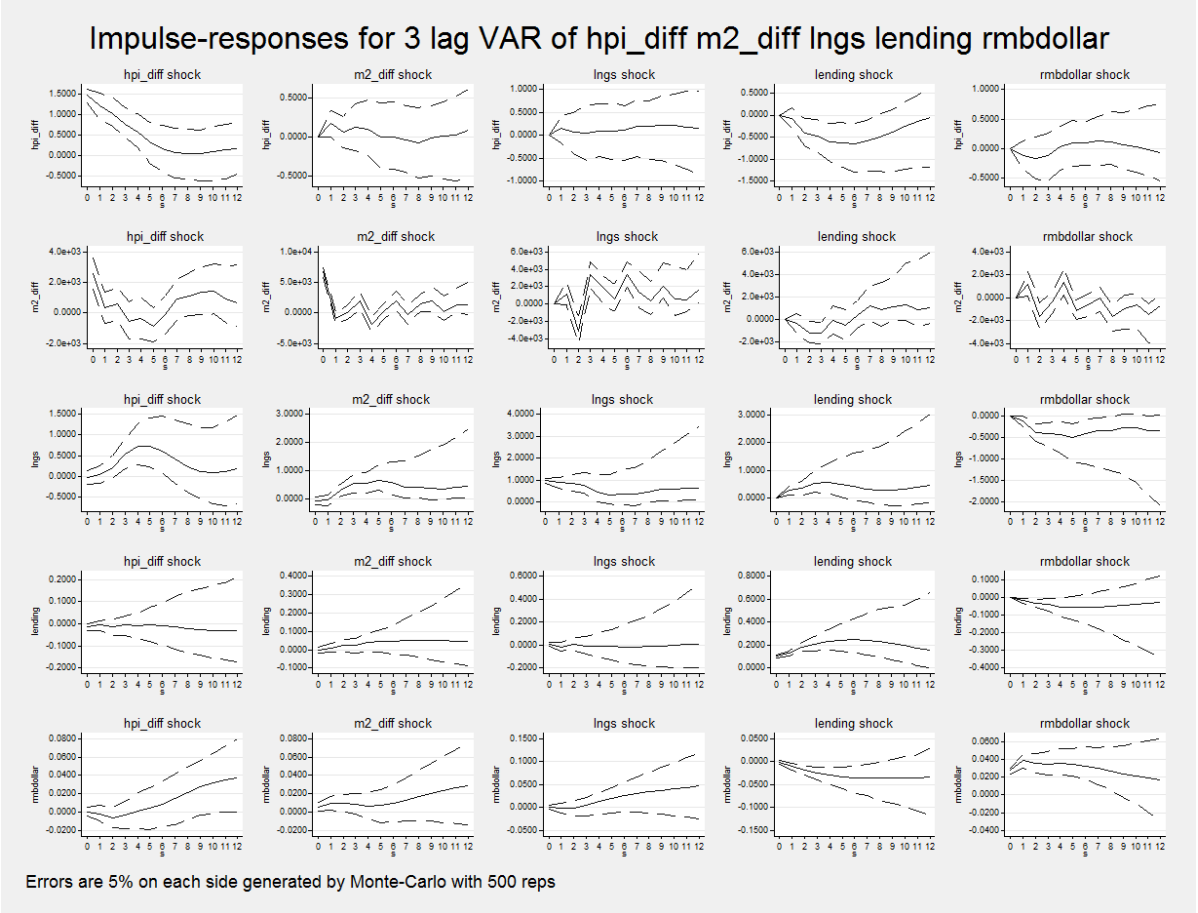


Table 7: Variance decompositions in Shenzhen housing market

(1) Month	(2) HPI in log	(2) M2 differences	(3) Government spending in log	(4) Lending rate	(5) Exchange rate
1	1	0	0	0	0
2	0.981137	0.007345	0.006162	0.001157	0.004198
3	0.947078	0.006236	0.005661	0.032731	0.008294
4	0.910768	0.00803	0.005444	0.06604	0.009718
5	0.861393	0.008675	0.006308	0.114868	0.008757
6	0.813518	0.008047	0.006884	0.162091	0.00946
7	0.765868	0.007547	0.007958	0.208482	0.010146
8	0.727896	0.007351	0.012879	0.240139	0.011736
9	0.701992	0.007757	0.016984	0.260342	0.012925
10	0.685884	0.007621	0.022219	0.271244	0.013032
11	0.676649	0.007514	0.028053	0.274837	0.012948
12	0.673056	0.007521	0.031622	0.274927	0.012874

The values indicate the percentages of variation that the variables account for.

Table 8: Results of lag length selection for the VAR model of Beijing housing market using CPI

Lags	(1) LL	(2) LR	(3) df	(4) p	(5) FRE	(6) AIC	(7) HQIC	(8) SBIC
0	66.5275				2.2e-07	-1.15005	-1.09942	-1.02515
1	993.541	1854	25	0	1.0e-14	-18.0101	-17.7063	-17.2607
2	1072.24	157.4	25	0	3.8e-15*	-19.0138*	-18.4569*	-17.64*
3	1096.92	49.353	25	0.003	3.9e-15	-19.0078	-18.1977	-17.0094
4	1120.79	47.755*	25	0.004	4.0e-15	-18.9868	-17.9235	-16.3639

* indicates the best choice of lag length suggested by a specific test

Table 9: Results of lag length selection for the VAR model of Shenzhen housing market using CPI

Lags	(1) LL	(2) LR	(3) df	(4) p	(5) FRE	(6) AIC	(7) HQIC	(8) SBIC
0	-341.965				0.000479	6.5465	6.59742	6.67213
1	429.922	1543.8	25	0	3.6e-10	-7.5457	-7.24018	-6.79189
2	473.298	86.751	25	0	2.6e-10	-7.89241	-7.33229*	-6.51043*
3	499.541	52.487*	25	0.001	2.5e-10*	-7.91587*	-7.10115	-5.90573
4	516.879	34.676	25	0.094	3.0e-10	-7.7713	-6.70198	-5.13299

* indicates the best choice of lag length suggested by a specific test

Figure 11: Impulse responses in Beijing housing market using the CPI variable

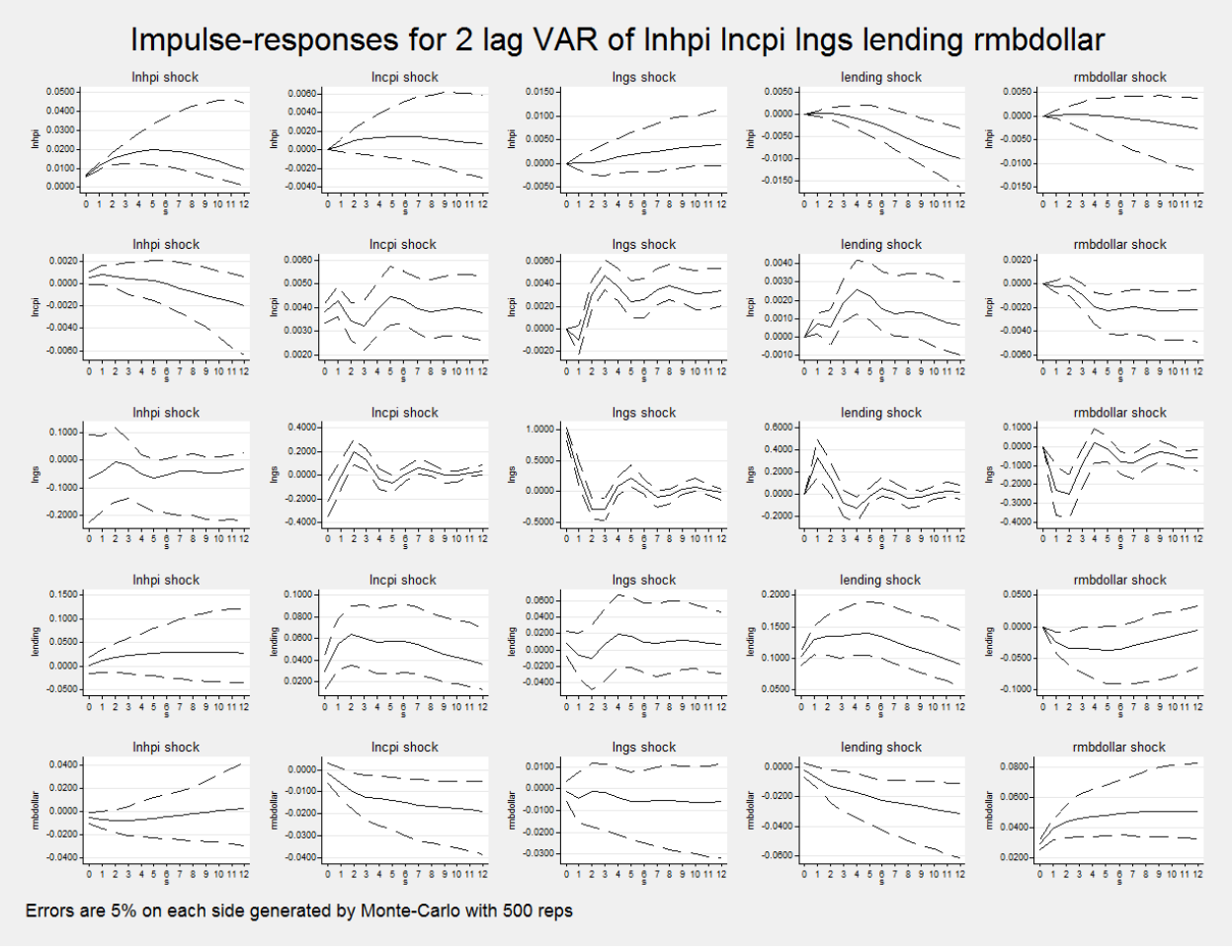
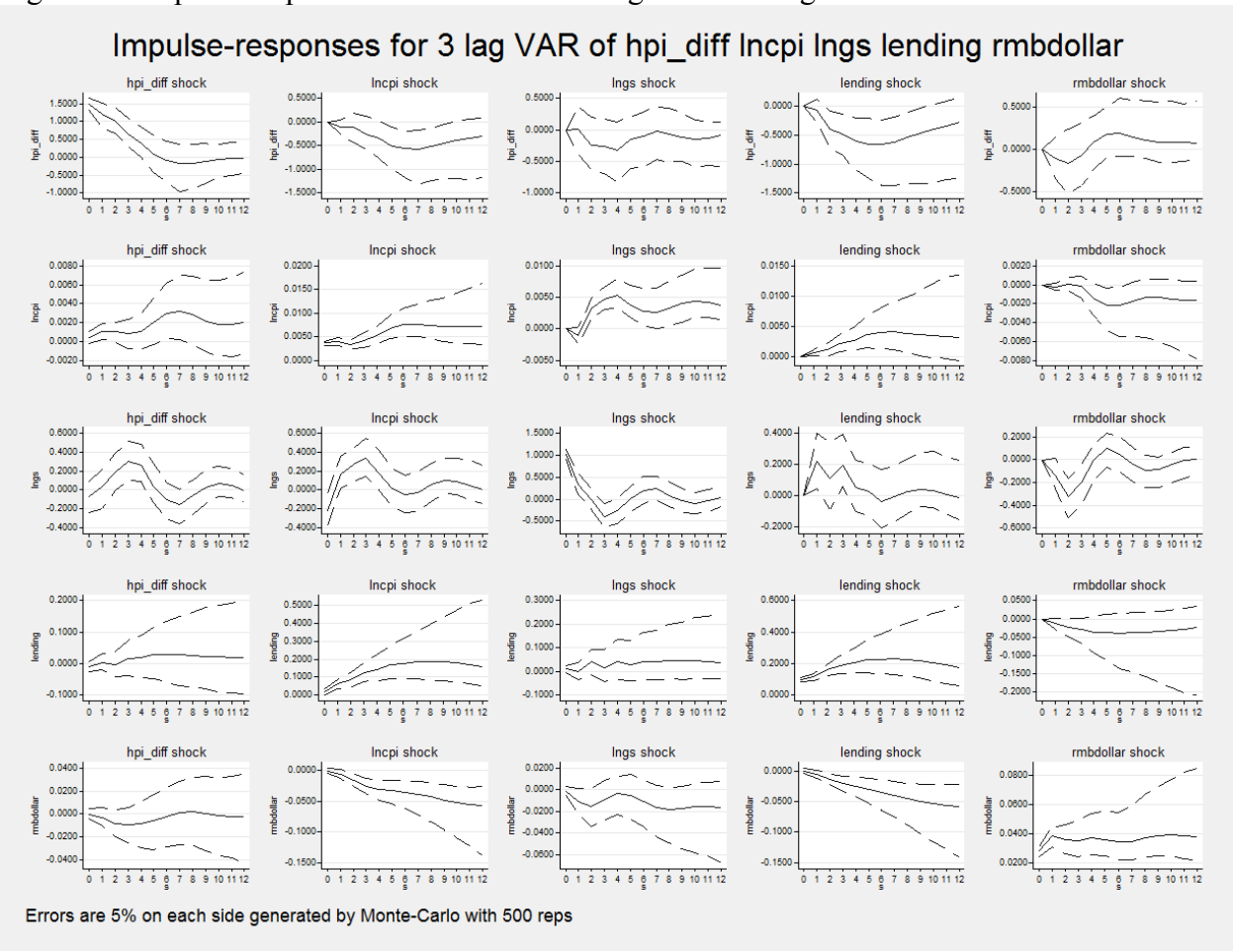


Figure 12: Impulse responses in Shenzhen housing market using the CPI variable



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