Housing Price Ripple Effect Caused by Monetary Policy: A Regional Heterogeneity Perspective

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Abstract: This paper theoretically analyzes and empirically studies the ripple effect of regional house price caused by monetary policy using the quarterly data of 35 large and medium cities in China over a period from 2001Q1-2014Q3 from a regional heterogeneity perspective based on GVAR model. Our empirical results show that house prices heterogeneously respond to the shock from common monetary policy among regions. With time goes by, the heterogeneity will gradually converge and generate the ripple effect of house prices among regions. Ripple effect caused by interest rate is more apparent than that caused by M2. On long terms, the ripple effect caused by monetary policy is weak, the heterogeneity how regional house prices response to shock from common monetary policy still exists.

Keywords: GVAR, monetary policy, regional heterogeneity, ripple effect

1 Introduction and review

In past 40 years, the real estate market in many countries had two periods of prosperity[1]. The house prices have experienced several ups and downs. Because real estate assets are an important part of the family property, the changes of house prices will at on hand affect the family fortune and individual consumption with a further affection of the real economy; on the other hand, it will affect the house owner’s ability to consume and to produce under loan and then affects the financial system[2].The role played by house prices in the macroeconomics and financial system has caused many scholars’ interests to research. The academic circles have done lots of research centered on house prices, such as the decisive factors of house prices, the relations between house prices and macroeconomics, early warnings of house prices bubbles and so on. Among these scholars, some has noticed the regional differences and the spatial diffusion phenomenon of house prices, some of them calls this kind of spatial effect of house prices as the ripple effect, and thinks the right reorganization of the ripple effect of regional house price can be used to help the government to make regional heterogeneity policy, to initiate the adjustment of regional house prices by modifying partial house prices and generate an positive affections on the macroeconomic[3].

Results of researches conducted by most scholars proved the existence of the ripple effects of house prices by studying the data of the spatial effect of house prices in UK, USA, Australia and other economic systems of EU. Holmans (1990) was the first one who discovered the ripple effect of the house prices in UK dated back in the late 1960s which showed a diffusion from southeast of UK to the central region and then to the northern part[4]. Brady (2014) used the auto regression model of the space vector and the data of 48 states’ house prices from 1975Q1 to 2011Q3 to study the diffusion effect of house prices in different states. The results showed the statistic significant and sustaining diffusion effect of house prices did exist among different states[5]. Chen and Wang (2012) used a general spatial dynamic panel data model and provincial panel data from 2002Q1 to 2012Q3 to prove the existence of spatial effect on real estate prices in different regions of China[6]. Wang (2008) also proved the typical ripple effect of house prices between internal cities in northern coastal area, central coastal area and the central area of China by the methods of Cointegration test, Granger causality test, Impulse response function[7].

Many researchers have given different explanations of the mechanism of formation of spatial diffusion effect of house prices. Besley and Case (1995) thoughts it was the result of employment migration, spatial arbitrage and geographical “yardstick” competition[8]; Meen (1999) thought that four factors caused this, which are migration, transfer of wealth, space arbitrage, and spatial factor’s heterogeneous response[9]; Oikarinen (2008,2009a,b) thought that domain structural differences, economic dependence and information factors and so on caused the joint response of regional house prices[10-12]; Isabel Vansteenkiste, Hiebert(2011) thought that it was the coordination of the basic factors of state housing market (like income and interest rate), financial integration and periodic recession of house prices caused the joint...
Many scholars who paid attention to the ripple effect of policy can significantly affect the prices of real estate. When Vansteenkiste and Hiebert (2011) studied America’s spatial diffusion effect of interstate house rates of the traditional mortgage as one of the regressive empirical models. Brady(2014) used the actual interest considered monetary policy as one of the variables of the diffusion effect of regional house prices, they usually prices. And when they conducted an empirical study to policy had a significant influence on regional house price also realized that the monetary reasons of the ripple effect of regional house prices is rare. After reviewing the literatures it is known that there could be multiple reasons for the ripple effect of regional house prices, each of them deserves attention and research. This paper conducts a empirical study of if monetary policy caused the ripple effect of regional house price from the following three considerations:

First, being a capital-intensive industry, realty business need the support of finance, thus, the monetary policy can significantly affect the prices of real estate. Many scholars who paid attention to the ripple effect of regional house price also realized that the monetary policy had a significant influence on regional house prices. And when they conducted an empirical study to the diffusion effect of regional house prices, they usually considered monetary policy as one of the variables of the empirical models. Brady(2014) used the actual interest rate of the traditional mortgage as one of the regressive variables of the spatial regression model to study America’s spatial diffusion effect of interstate house prices[5]. When Vansteenkiste and Hiebert (2011) studied the spillover effect of the house prices of the countries within EU, they introduced the actual interest rate into the GVAR model as a weak exogenous variable and researched on the heterogeneous response of house prices in different countries to the shock from the uniform monetary policy of EU[13]. Miao et al. (2010) specifically pointed out that the right knowledge of the correlative dependent relationship among different real estate markets and the trans-regional flow of information could be very important for the constitutor of the monetary policy[15].

Secondly, the viewpoint that integration of financial system and synchronization of monetary policy would bring the ripple effect of regional house prices has been accepted by numerous scholars. Merikas et al. (2012) thought the international transmission of the changes of house prices was caused by synchronization of monetary policy, liberalization of finance, integration of international financial market, the periodic relations of international business and some other factors[16]. Otrok and Terrones (2004, 2005) attributed the joint changes of house prices in developed countries to the linked changes of the transnational interest rate[17-18]. Vansteenkiste and Hiebert (2011) thought that the international joint changes of house prices were the subordinations of the joint changes of fundamental (like income, interest rate) of real estate market in different countries. Füss et al. (2011) and the others thought that similar economic conditions and environment of mortgage market promoted the trans-regional diffusion of bubbles of house prices[19]. The convergence of monetary policies in different countries and the gradual integration of financial market could even promote the spatial diffusion of house prices of different regions, no mention of the role uniformed monetary policy carried out in different regions played in the ripple effect of house prices.

Finally, China has a large span of geographical position, unbalanced economic development of each region, different economic development level of real estate market in different regions caused by different requirement of housing, the common monetary policy will generate a heterogeneous influence on and different regulations of the house prices in different regions, moreover generate the ripple effect of regional house prices. Meen (1999) thought that spatial heterogeneous responses could bring the ripple effect of house prices, in other words, house prices in different regions took the shock of some certain common explanatory variables of house prices (like monetary policy, land policy) differently, which further caused the ripple effect of house prices between different regions[20]. By establishing the spatial heterogeneous response model of the regional house prices, Zhang(2010) proved the response of house prices in different regions to the shock of interest rate and monetary supply is significantly different, combined with the different response to other common variables, she thought there did exist the ripple effect of house prices in a national range in China, but was quite weak [14]. Liang (2007) and the others by analyzed the annual data of 28 provinces, cities and autonomous regions of China during 1999-2006, on the basis of error correction model called panel date model empirically proved that there were regional differences of the influence monetary policy caused on house prices in China. This difference might also cause the transmission of the ripple effect of house prices between regions in China from eastern area to the central and western parts[20].

However, so far there has been no literature had carried out a systematic analysis on the mechanism of action of ripple effect of regional house prices caused by monetary policy. The empirical research mainly was about the heterogeneous influence on regional house prices caused by monetary policy, and estimated the ripple effect of regional house prices caused by the heterogeneous influence of common monetary policy.
according to the convergent tincture of regional house prices. Regarding whether monetary policy causes the ripple effect of regional house prices, there is lack of relevant research. And the methods of research mostly were the vector auto-regression (VAR) models, with no considerations of spatial externality. This paper primarily will establish the theoretical framework of the mechanism of action of monetary policy takes in the ripple effect of regional house prices, by referring to the Global Vector Auto-regression, (GVAR) model advanced by Pesaran and the others, based on the relevant real estate data of 35 large and medium cities of China, to launch an empirical inspection on the ripple effect of regional house prices caused by monetary policy. Finally provide the regional government with suggestion on relevant policies of the differentiation of monetary policy according to the results of the empirical study.

2 Mechanism

Through summing up the current relevant literatures about real estate spatial effect and regional effect of monetary policy, this paper holds the thoughts of that the heterogeneous responses of real estate market of each region towards the shock caused by common monetary policy finally causes the ripple effect of regional house prices. The detailed mechanism of action is as Fig.1 shows, including 3 stages:

![Fig.1 Action mechanism of the monetary policy in the ripple effect of regional house price](image)

In stage 1, the monetary policy generates the heterogeneous influence to market demand and supply of real estate markets in each region. Currently the most extensively used monetary policy tools are Interest Rate (price-based monetary tools) and Money Supply (quantitative monetary tools). The application of these two kinds of monetary policy tools will both affect the demand and supply of the real estate market. Theoretically, loose monetary policy such as lower interest rate and expansion of money supply, on one hand, will lower the cost of house purchase, increase banks’ housing loan and the demand of real estate market; on the other hand, will lower the real estate agents’ cost of investment, increase development capital, and increase the supply of real estate market. So the demand and supply will be increased at the same time. Likewise, tight monetary policy will simultaneously increase the costs of the house purchaser and developer; cause the decrease of demand and supply of real estate. However, the elasticity of demand and supply of real estate of every region is not the same, this will cause the difference of degrees and speed and ways of response of real estate demand and supply, when facing with the shock of the changes of common monetary policies in different regions.

In stage 2, the different response of regional real estate markets’ demand and supply cause the heterogeneity of response of house prices. The prices of real estate market are ultimately determined by the balance of the demand and supply of the market, so the degree of the influence of monetary policy placed on house prices also is decided by how severe the demand and supply of real estate react to the change of monetary policy.

The heterogeneity of response of real estate market’s demand and supply in regions will finally appear as the heterogeneity of response degree, response speed and response orientation of house prices. And this is the first necessary condition of the generation of the ripple effect of regional house prices.

In stage 3, with time passes, the heterogeneous response will gradually converge. Heterogeneous response of house prices to the change of common monetary policy in all regions will cause the house prices into a lead-lag relationship. As time goes by, the differences between responses of change of common monetary policy will become smaller and smaller, this is the second necessary condition of the generation of the ripple effect of regional house prices.

China has large territoriality; the unbalanced economic development between regions causes different degrees of development in real estate market, financial market and land market. Under this kind of macroeconomic circumstances, will the implement of common monetary policy bring the heterogeneous influence to the demand and supply of real estate in different regions and further cause the heterogeneous response of house prices in different regions? Will the heterogeneous response of house prices in each region to monetary policy cause the ripple effect of regional house prices? The rest of this paper will use Chinese data to conduct an empirical study of the 2 questions above.

3 Model and data

3.1 The GVAR model

This paper will use GVAR model to empirically study the ripple effect of regional house prices caused by monetary policy. GVAR model was first brought by
Pesaran and the others (2004) with the purpose to study the interrelation and correlative dependence between national and international factors\textsuperscript{[21-22]}. Dees and the others (2007) expanded GVAR model and researched the shock effect America’s economic crisis to European and the other countries’ economic development\textsuperscript{[23-24]}. Favero (2013) used GVAR model to research the diffusion effect of governmental bond margins of Euro countries, as well as in their responses to debt crisis happened in Greece\textsuperscript{[25]}. Zhang (2012) systematically elaborated on this model and empirically analyzed the interaction between China’s economy and world’s economy\textsuperscript{[26]}. GVAR model joins VARX models and VECMX models of each economic system into a global model through corresponding weight matrix. It not only could show the spatial connections of the endogenous variables of economic systems, but also could analyze the responsive degree caused by the endogenous variables of economic systems to global variables’ shock. Regarding the researching subject of this paper, it is to research the interactive effect of house prices between different regions by GVAR model, as well as the ripple effect of spatial diffusion of house prices between regions caused by heterogeneous responses of house prices in regions facing the shock of common monetary policy.

First establish the VARX model of a single city by using the modeling method of Dees and the others (2007).

\[
x_{it} = \alpha_{it} + \beta x_{i,t-1} + \lambda_0 x_{it-1}^* + \lambda_1 x_{i,t-1}^* + \gamma_d d_{it-1} + \gamma_d d_{it-1} + \gamma_d d_{it-1} + \epsilon_i - iid(0, \Sigma)
\]

Suppose the number of cities is N, indexed by \(i=1,2,3,\ldots,N\), the number of each cities’ endogenous variables is \(k_i\), and the number of the exogenous variables is \(s_i\), then \(x_{it}^*\) is a \(k_i \times 1\) vector of variables of city \(i\), \(x_{it}^*\) is the vector of exogenous variables of the city, which is the weighted average of the vector of variables corresponding to \(X_{it}\) of other cities’ (except city \(i\)).

\[
x_{it}^* = \sum_{j=1}^{N} w_{ij} x_{j}(i \neq j), \quad w_{ij} \text{ is the specific weight coefficient matrix of cities,}
\]

\(d_{it}\) is the vector of global variables, which means vectors of the common exogenous variables of each city. \(x_{it}^*, d_{it}\) respectively are \(k_i \times 1\) \(s_i \times 1\) vectors of the weak exogenous variables. \(E_{it}\) is a \(k_i \times 1\) vector of residual, which denote idiosyncratic country-specific shocks. We assume in this model, \(E_{it}\) are serially uncorrelated with mean zero.

According to the opinion of Pesaran et al. (2004), there were three major channels through which the variables of different cities connected together: (1) Contemporaneous independence of the cities’ variable \(X_{it}\) toward the cities’ exogenous variables \(X_{it}^*\) and \(X_{it-1}^*\), such as the influence caused by the weighted value of the other cities to the house prices of the target city. (2) Current shock effect of variables of city \(i\) to variables of city \(j\), which were valued by the variance covariance matrix of \(E_{it}\). For example, the current shock effect of city \(i\) to city \(j\) reflects the interactions of house prices of different cities; (3) Different influence the global variable does to city endogenous variable, for examples, the heterogeneous affections monetary policy does to house prices of each city. The connection between different city variables is showed by the city’s specific weight coefficient matrix. And with the help of city’s specific weight coefficient matrix, GVAR model of a signal city can be jointed to form GVAR model:

\[
G X_i = \alpha_0 + H X_{t-1} + \gamma_d d_{t-1} + \gamma_d d_{t-1} + \epsilon_i, \quad \epsilon_i \sim iid(0, \Sigma)
\]

\(G, H\) are both full rank matrixes, which are variable coefficient matrixes contains city’s specific weight coefficient matrix. Then equation(2) can be changed into:

\[
X_i = G^{-1}\alpha_0 + G^{-1}H X_{t-1} + G^{-1}\gamma_d d_{t-1} + \mu_i
\]

if \(G^{-1}\alpha_0 = b_0, F = G^{-1}H, \theta_i = G^{-1}\gamma_d (i = 0,1), \mu_i = G^{-1}\epsilon_i\), then equation (3) can be simplified into:

\[
X_i = b_0 + FX_{t-1} + \theta_d d_{t-1} + \theta_d d_{t-1} + \mu_i
\]

Equation (4) is GVAR model of China finally established by this paper. In order to avoid the many problems of the estimated coefficient in tradition way, this paper will borrow the idea from Garratt and the others (2006)\textsuperscript{[27]}, which is respectively estimating the vector of VARX model of each city and according to the process of the derivation to get the variable vector of GVAR model.

3.2 Variables and data

We choose China 35 large and medium cities’ quarterly data over the period 2001Q1-2014Q3 into GVAR model and empirically analyze these cities which are divided into 3 groups, the eastern cities, the central cities and the western cities according to the geographic positions and development level of real estate market. Among them, the eastern cities are Beijing, Tianjin, Shijiazhuan, Shenyang, Dalian, Shanghai, Nanjing, Hangzhou, Ningbo, Fuzhou, Xiamen, Ji’nan, Qingdao, Guangzhou, Shenzhen, Haikou; the central cities are Taiyuan, Changchun, Ha'erbin, Hefei, Nanjiang, Zhengzhou, Wuhan, Changsha; the western cities are Hubeihaoe, Nanning, Chongqing, Chengdu, Guiyang.

\textsuperscript{1} The detailed process of derivation can be found the works of Pesaran and others, and will not be repeated in this article.
Kunming, Xi’an, Lanzhou, Xi’ning, Yinchuan and Wulumuqi. The factors have an influence on house prices include two aspects, demand and supply. Combining with other scholars’ research, availability of data and the calculation of the model parameter, this paper chooses three variables: prices of houses of each city, prices of land (supplementary factor), and disposable income of urban citizens. Because of the better ability to eliminate influence on base value compared index variable to absolute value variable, when lateral comparing between cities, the exponential form of the above three factors, index of house prices (on same comparing basis) HP, index of land trading prices (on same comparing basis) LP, and index of disposable income of urban citizens (on same comparing basis) PCI, are chose into GVAR model as endogenous variables of cities. The corresponding exogenous variables of cities, HPS, LPS, and PCIS also are chosen into GVAR model as weak exogenous variables. From the first season in 1998, China began to publicly issue the index of house prices in 35 large and medium cities, and segmented the index in the first season in 2011. Therefore, the research in this paper has adopted the arithmetical average value of price indexes of new residents and secondhand residents instead of the index of house prices. Index of land trading prices and disposable income of urban citizens were taken respectively by arithmetical results of the absolute value of land prices and disposable incomes of urban citizens. Index of house prices, index of prices of new residents, index of prices of secondhand residents come from the website of State Statistics Bureau, land prices and disposable incomes of urban citizens are from the WIND data base.

Variables of monetary policy will respectively adopt the price-based monetary tool - interest rate IR and quantitative monetary tool - money supply M2 as mentioned in the previous theoretical framework as the weak exogenous variables into GVAR model. Considering the fact that time limit for real estate loan is long, IR is actually the loan rate For CNV over 5 years despite of inflationary factors. The nominal loan rate is from the website of People’s Bank of China. M2 enter the model in exponential form with a same constructional method of the previously mentioned exponential constructional method of the variables of supply and demand. The original value of M2 is from the WIND data base.

### 3.3 City weight coefficient matrix

GVAR model uses city weight coefficient matrix to join city models of each cities together. City external variable $x_{it}$ is calculated by the endogenous variable $x_{it}$ and corresponding city weight coefficient matrix. So city weight coefficient matrix is vital to the results of GVAR model. This paper borrows the idea of Pan (2012) that with the distance increases between cities, the influence of house prices in other cities places on this city decreases, and adopt the reciprocal of the straight-line distance between cities to establish city weight coefficient matrix.

### 3.4 Model testing

Firstly use ADF way to inspect the stability of all variables, according to the principle of least SC to determine the lag order number, and choosing model with intercept but no trend term, the result shows that variables in all city models are I (0) or I (1) sequence. Because there are three variables in single city VARX model established in this paper, it is possible to form low order integer variables through linear combination. Therefore when running the Johansen coordination inspection to all cities’ variables, in models using IR as the variable of monetary policy, Beijing, Nanjing, Zhengzhou, Changsha, Guangzhou, Nanning, and Xi’an showed the uncoordinated relations; while in models using M2 as the variable of monetary policy, Beijing, Shijiazhuaung, Nanjing, Qingdao, Zhengzhou, Nanning and Xi’an showed no uncoordinated relations, and the other cities all have one or two coordinated relations. In the opinions of Pesaran(2009) and Gen Peng (2009) and the other, regarding cities with no coordinated relations could establish DGV AR model (with a longest lag phase of 1) to fully consider the uncertainty. Thus, establish the first-order differential variable DGVAR model regarding cities with no coordinated relations like equation (5) and GVAR model concluding VEC regarding cities with coordination relations like equation (6).

$$\Delta x_{it} = \alpha_{i0} + \beta_{i1} x_{i,t-1} + \lambda_{i1} \Delta x_{i,t-1} + \gamma_{i0} \Delta d_{i,t} + \gamma_{i1} \Delta d_{i,t-1} + \epsilon_{i,t}$$

$$\Delta x_{it} = \alpha_{i0} + \phi_{i1} \Delta x_{i,t-1} + \lambda_{i1} \Delta x_{i,t-1} + \gamma_{i0} \Delta d_{i,t} + \gamma_{i1} \Delta d_{i,t-1} + \varphi_{i} \Delta x_{i,t-1} + \varphi_{i} \Delta d_{i,t} + \epsilon_{i,t}$$

In further inspection to the exogenesis of all city exogenous variables $\Delta x^*$ and global variable, everything is good. That is to say the long term feedback of the existence of $\Delta x^* \rightarrow \Delta x \rightarrow \Delta d \rightarrow \Delta x^*$ does exist, but no long term feedbacks of $\Delta x \rightarrow \Delta x^* \rightarrow \Delta x \rightarrow \Delta d$. Thus the results of GVAR model of this paper do mean something.

### 4 Results

This paper first analyzes the ripple effect of regional house prices, and then moves to the analysis of issue if the monetary policy causes the ripple effect of regional house prices. This paper takes the method of using...
generalized impulse responding GIRF to make the comparison between response results to the impulse. This paper standardizes all response results to the impulse, turns the brought by the positive shock of a standard deviation of a certain variable into one unit of response degree of relevant variables brought by positive shock.

4.1 The ripple effect of regional house prices

Fig.2 shows the response of regional house prices to one unit incremental shock of the house prices from other regions, it also analyzes if the ripple effect exists, being the results of interactions among regional house prices.

![Fig.2 House price response from one unit incremental shock to house prices in other regions](image)

In the eastern regions, one unit incremental shock of eastern regional house prices brings positive effect to the house prices both of the central and western regions. The response values reach their peak values in the 5th period and become stable after 20 periods. Compared with the house prices in the central area, the response strength of the house prices in western area are stronger, with a biggest response value of 0.90 and a response value of 0.71 after stabilized, while the corresponding values of the house prices in central area are 0.70 and 0.54. In the central area, one unit incremental shock of its regional house prices brings positive effect to the house prices both in the eastern and western regions. The response values reach their peak values in the 5th period and become stable after 20 periods. The peak number and stabilized response value of the eastern area and western area are respectively 0.27/0.25 and 0.25/0.22. The response strengths are almost the same. The fluctuation of the influence of one unit shock of house prices in western region to house prices in eastern and central areas is comparatively large. The largest response values of house prices in eastern and central areas are 0.48 and 0.31 in the 2nd period and the smallest are -0.09 and -0.06 in the 7th period, and become stable after 28 periods as 0.11 and 0.06.

It can be clearly seen that there are interactions among the house prices in eastern, central and western areas, house prices of each region affect each other. In long term, the house prices in eastern area cause the strongest influence on the other two, house prices in central area are the second strongest and the house prices in western area cause the least strong influence to others. It is in general accordance with the level of economic development and real estate market. Regional prices in China have apparent ripple effect.

4.2 The ripple effect of regional house prices caused by monetary policy

Fig.3 shows the response of regional house prices to one unit shock of different monetary policies. This paper pays close attention to the heterogeneous responding process of regional house prices and if the heterogeneous response will gradually converge, in other words, if the heterogeneity will become smaller and smaller.

Giving one unit shock to interest rate (tight monetary policy), the response values of house prices of all three regions, eastern central and western areas, all reach their peak number in the 2nd period, the values are respectively 6.20, 3.40, 5.62, and hit bottoms in the 7th period, which are -2.96, -2.26, -0.80. In this process, house prices in eastern areas have the largest fluctuation, house prices in western areas to be the next and then house prices in central areas. In short term, response to interest rates shock in decreasing order is the eastern, western, central, and with a quite severe fluctuation. In long term, response to interest rates shock in decreasing order is the western, eastern, central, and among them, the responses of house prices in eastern and central areas are negative while there is positive response of house prices in western areas; it means the rigid demand in
western areas is more apparent. Looking from the whole process of the response of house prices, before the 2nd period, the strongest response happen in eastern area, which is most severely influenced by the shock of interest rate with a largest gap of response value among house prices in all three regions of 2.8. From the 3rd period the response value of house prices in western areas to interest rate over-crosses the eastern areas; from the 5th period, the response value of house prices in central areas to interest rate also over-crosses the eastern areas. In this process the responses of house prices in three regions gradually converge, the smallest response gap among house prices in three regions is 1.87 in the 5th period. By now, the response heterogeneity among house prices in three regions has been significantly decreased. Especially after 15 periods, the responses of house prices in eastern and central areas toward the shock of interest rate almost become the same. This shows the factor that there will be different responses of house prices in different regions to the same shock of interest rate, and these differences between responses will gradually become smaller and the regional house prices will gradually converge. In another word, interest rate will bring the ripple effect to regional house prices.

Giving one unit shock to M2 (loose monetary policy), the response values of house prices of all three regions, eastern central and western areas, all reach their peak number in the 5th period, the values are respectively 2.25, 1.39 and 1.73, and hit their bottoms in the 10th period with the values 1.60, 0.93, and 1.1, all these responses are positive. In this shock-responding process, the house prices in eastern areas responses most strongly, house prices in western areas being the next and then house prices in central areas. The order of fluctuation range (discrepancy between the largest and smallest response value) of response is house prices in eastern, western and central areas. The largest gap between house prices in three regions appears in the 5th period which is 0.86. And it becomes smaller and smaller with the smallest gap of 0.66 in the 9th period. After the impulse response, the discrepancy stabilizes at 0.72 between house prices in three regions. This means, the shock of M2 will give house prices in different regions different response degree, fluctuation range; but as time passes, the responses of house prices in different regions will converge. M2 also brings the ripple effect to regional house prices.

From the above analysis, the shock of interest rate and M2 will generate heterogeneous response to regional house prices. Generally speaking, the response strength and fluctuation range of shock of monetary policy ranks as house eastern western and central regions. The main reason why the house prices in eastern areas can be easily influenced by monetary policy is that the house price and land price is higher in the eastern areas, both the consumers and the developer have a stronger demand to financial credit and money and are more reliant on the monetary policy. Because of its narrow external financing channels, the western areas react quite strongly on the changes of monetary policy. The strength of the shock of house prices in central areas is the smallest, it means its development of real estate market relies more on the development of local economy, and is less sensitive to the changes of monetary policy. And it satisfies one of the necessary conditions of the generation of the ripple effect of regional house prices.

The heterogeneous responses of house prices in each region to the shock of common monetary policy gradually become smaller and converge as time goes by; shock of monetary policy causes the ripple effect of regional house prices. Comparing with M2, interest rate caused a faster diffusion of regional house prices. Comparing with M2, interest rate caused a faster diffusion of regional house prices (the time period between the largest and smallest response values), especially, the responses of interest rate shock almost remain the same in house prices in eastern and central areas after 15 periods. However, looking to the differences of long-term response strength of house prices to monetary policy, though it will bring the ripple effect to regional house prices, but this ripple effect is quite weak. The differences between the responses to house prices in eastern, central and western areas to interest rate and to M2 still are quite large.

5 Conclusions

We use quarterly data of China’s 35 large and medium cities over the period 2001Q1-2014Q3 to establish GVAR models, from the perspective of
heterogeneous responses of regional house prices to the shock caused by monetary policy, empirically study the ripple effect of regional house prices caused by monetary policy. The main conclusions are as follows: (1) There are apparent ripple effects of house prices among regions in China, regional house price interact with each other, whose shock to other areas’ housing prices from the most strongly to the least, in turn, the eastern, central and western. (2) There are heterogeneous response of house price to the shock cause by monetary policy among regions. The response value of eastern and western areas to monetary policy shock is strong, while the response value of central areas is comparatively weak; the long term response of the western areas to uprising of interest rate is positive because the rigid demand in these areas. (3) Diffusion of regional house prices caused by price-based monetary policy tool, interest rate, is faster compared to quantitative monetary policy tool, M2, and the interest rate causes a more apparent ripple effect. (4) The ripple effect of regional house prices caused by monetary policy is comparatively weak, and has heterogeneous effect on house prices among regions in a long term.

In order to prompt the Coordination of regional real estate market in China, for the ripple effect of regional house prices, and the heterogeneous responses to monetary policy in different regions and the differences between Ripple effects caused by different types of monetary policy tool, the following suggestions are proposed: (1) Increase the housing supply and construction of the indemnificatory housing in western areas according to the rigid demand of real estate market there. (2) The government should more often use the price-based monetary policy, interest rate, to adjust the real estate market to promote the ripple effect of regional house prices, further spur on the coordination of regional house prices. (3) Because the ripple effect is quite weak, differentiated monetary policy should be implemented in different regions, and should give the executors of monetary policy some certain freedom and break the limits on regional flow of production factors and enhance the connections between regions to achieve the purpose of transition of monetary policy in regional real estate markets and to ease the unbalanced development of real estate market in different regions.

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