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What drives housing consumption in China? Based on a dynamic optimal general equilibrium model and spatial panel data analysis

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Abstract. This paper examines the housing sales in China from 2004 to 2015 utilizing an optimal dynamic general equilibrium theoretical framework combined with a macroeconomic model. The spatial panel econometric empirical results suggest that housing prices and economic growth have increased housing sales in China. However, since house is considered as a special commodity in China, and unemployment show negative impacts on housing sales.
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1. Introduction

Housing is a major component of wealth (Iacoviello, 2004). Since house prices fluctuate considerably over time, it is important to understand how these fluctuations affect households' consumption decisions. Economists have long known that housing prices and housing demand are positively correlated across countries (Phang, 2004).

Aoki *et al.,* (2004) consider a general equilibrium model with frictions in credit markets used by households. They show that a change would increase the effect of monetary policy shocks on consumption, but would decrease the effect on house prices and housing investment. Campbell & Cocco, (2007) find that regional house prices affect regional consumption growth. Predictable changes in house prices are correlated with predictable changes in consumption, particularly for households that are more likely to be borrowing constrained, but this effect is driven by national rather than regional house prices and is important for renters as well as homeowners.

Piazzesi *et al.,* (2007) considers a consumption-based asset pricing model where housing is explicitly modeled both as an asset and as a consumption good. Non separable preferences describe households' concern with composition risk, that is, fluctuations in the relative share of housing in their consumption basket. Since the housing share moves slowly, a concern with composition risk induces low frequency movements in stock prices that are not driven by news about cash flow.

Chen *et al.,* (2010) investigates the asymmetric effect of house prices on various categories of consumption under constrained and unconstrained regimes. They find that durable consumption exhibit a very strong asymmetric effect in response to

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changes in house prices, while other categories of consumption do not exhibit this asymmetry. Dong *et al.,* (2017) investigates the asymmetric effects of housing price on consumption in 35 major Chinese cities, having regard to heterogeneity of the housing and financial markets. The findings suggest that both markets (and their status) are vital to explain the linkage between housing price and consumption. In particular, for the regime where the housing price-to-income ratio is below 5.0882 and the indicator of financial development is above 1.8827, the wealth effect is significant. By contrast, for the regime where the housing price-to-income ratio lies between 5.0882 and 5.9625, the substitution effect will become dominant. This study provides a better understanding of the thresholds and transmission channels through which housing price affects consumption. That is largely ignored in the existing literature (Du *et al.,* 2017).

Kartashova & Tomlin (2017) evaluates the strength of the relationship between house prices and consumption, through the use of debt. Whereas the existing literature has largely studied the effects of house prices on homeowner total or mortgage debt, they focus on the non-mortgage component of household borrowing, using Canadian household-level data for 1999-2007. They rely on variation in regional house prices, home ownership status and age to establish the relationship between house prices and non-mortgage debt. Then, using direct information on debt uses, they determine that house price growth was associated with a non-trivial fraction of concurrent aggregate non-housing consumption growth.

Actually, employment and population also impacts housing consumption (Wang *et al.,* 2012). Using an overlapping generations model, Li & Shen (2013) find that there is a nonlinear relationship between the elderly dependency ratio and housing consumption in China. With the deepening of population aging, housing consumption will increase; when the elderly dependency ratio reaches a turning point, housing consumption will decrease. The turning point of the nonlinear curve also depends on population mobility. A greater degree of population mobility will result in a delayed turning point. Furthermore, the turning point of the nonlinear curve will emerge when China's elderly dependency ratio reaches a value of 32 percent in 2025. This means that over the next decade, China should continue to increase the level of housing supply.

Furthermore, Chen *et al.,* (2009) investigates the relationship between changes in asset wealth and the trend movements of household consumption in urban China. Using the vector error correction cointegration model, they demonstrate that there is a unique long-run cointegrating relationship between household consumption, disposable income, financial wealth and housing wealth in urban China. Housing wealth is the only factor that restores the long-run equilibrium relationship when the cointegrated system is disturbed by an external shock. In addition, nearly all variance in the movement of consumption is permanent, supporting the classical random walk hypothesis of consumption behavior. However, a large proportion of variance in the short-run movements of housing wealth is found to be transitory.

Zhou *et al.,* (2016) analyze consumption movements as a function of income and wealth (stocks and housing) with data from China from 1999 to 2010 using a panel vector autoregression model. They find that housing wealth has a negative impact on consumption, but the link is minor, so fluctuation in the housing market should not create sharp movements in consumption. House price control policies implemented in China may encourage limited spending on other goods. Mayo & Sheppard (1996) present results of an empirical investigation and comparison of housing supply in three rapidly growing countries: Malaysia, Thailand, and Korea. These countries offer three contrasting examples of different approaches to development control. Korea has relatively strict control of housing supply. Thailand has little effective regulation of development. Malaysia offers an intermediate case, having adopted in the mid-1970s development control legislation patterned on the British Town and Country Planning Act. The consequences of this regulatory shift for aggregate housing supply appear to have been substantial.

The rest of the paper is organized as follows. Section two presents a theoretic model of housing consumption in the presence of housing prices and unemployment in economic growth. Section three describes the data used to carry out the econometric analysis and then summarizes empirical results in section four. Section five provides the conclusions.

2. The theoretic model

2.1. Household

Considering the existence of innumerable homogeneous families in a given economic environment, each family conforms to the assumption of rational economic man. For families, consumption decision is the main factor of consideration. In this model, the income of household is mainly used for two kinds of consumption - general commodity consumption and housing consumption. Although leisure is also used as a kind of utility, this paper does not analyze it as a key point, so the utility effect of leisure is not temporarily considered in the utility equation. The utility gained by the family mainly comes from the general consumption and housing consumption, and its utility optimization faces:

$$\underset{\{c_{t+s},h_{t+s}\}}{Max}\ V_t=\sum_{s=0}^{\infty}\beta^s U\left(c_{t+s},h_{t+s}\right) \tag{1}$$

Among them, $\beta=1/(1+\theta)$ represents the discount factor, θ is the discount rate, V represents the total utility of the family, U represents the utility of single-period from general consumption and real estate consumption, c is the general consumption, h is the property consumption. Taking into account the diminishing marginal utility of consumers, the utility function to meet strict pseudo-concave, then we can get $U_c,U_h>0,U_{cc},U_{hh}\leq 0$. U_c (U_h) is the first-order conditions of the utility function to general consumption (real estate consumption) respectively. Further consideration, if $U_{ch}>0$, this indicates that the two are complementary; when $U_{ch}<0$, the two are alternative.

As an investment product (especially for China), the property itself has great value-added capabilities. It can be considered that the accumulation equation of real estate consumer goods is as follows:

$$\Delta h_{t+1}=H_t+\gamma h_t \tag{2}$$

Among them, H_t is the total investment in real estate consumption in period t, γ is the rate of increase. Furthermore, the budget constraints of the family market are considered as follows:

$$\Delta a_{t+1}+c_t+p_t^h h_t=x_t+r_t a_t+w_t n_t \tag{3}$$

In which, Δa_{t+1} represents the financial assets purchased in the current period, a_t and r_t represent the current stock of financial assets and the interest rates of financial assets respectively; p_t^h is the price of real estate relative to general commodity. Therefore, $p_t^h h_t$ represents the real estate consumption expenditure measured in general commodity prices in the current period. x_t is a dividend income for residents for the holding of shares. $w_t n_t$ is the remuneration for labor.

Based on the above conditions, we can construct a Hamilton function:

$$\mathcal{L}=\sum_{S=0}^{\infty}\{\beta^s U(c_{t+s},h_{t+s})+\lambda_{t+s}[x_{t+s}+(1+r_{t+s})a_{t+s}+w_{t+s}n_{t+s}-a_{t+s+1}-c_{t+s}-p_{t+s}^h H_{t+s+1}+p_{t+s}^h(1+\gamma)H_{t+s}]\} \tag{4}$$

From the first-order condition of c_{t+s}, h_{t+s} and a_{t+s}, it can be obtained that:

$$\beta^s U_{c,t+s} - \lambda_{t+s} = 0 \quad (5)$$
$$\beta^s U_{h,t+s} + \lambda_{t+s} p_{t+s}^h (1+\gamma) + \lambda_{t+s-1} p_{t+s-1}^h \quad (6)$$
$$\lambda_{t+s}(1+r_{t+s}) - \lambda_{t+s-1} = 0 \quad (7)$$

After simplification, formula (5) and formula (6) are Euler equations in the general sense, which can be obtained:

$$\frac{\beta U_{c,t+1}}{U_{c,t}}(1+r_{t+1}) = 1 \quad (8)$$

And an approximate solution to the utility of real estate consumption can be get:

$$U_{h,t+1} = U_{c,t+1} p_{t+1}^h (r_{t+1} - \frac{\Delta p_{t+1}^h}{p_t^h} - \gamma) \quad (9)$$

In order to facilitate analysis, the utility function is simplified as a Cobb-Douglas form:

$$U(c_t, h_t) = c_t^\alpha h_t^{1-\alpha} \quad (10)$$

In which, α is between 0 and 1.

According to the above method, Euler equation can be obtained as follows:

$$\beta \frac{\frac{c_{t+1}}{h_{t+1}}}{\frac{c_t}{h_t}})^{-(1-\alpha)}(1+r_{t+1}) = 1 \quad (11)$$

The approximate solution of the utility equation can be rewritten as:

$$\frac{c_{t+1}}{p_{t+1}^h h_{t+1}} = \frac{\alpha}{1-\alpha}(r_{t+1} + 1 - \gamma - \frac{p_{t+1}^h}{p_t^h}) \quad (12)$$

We can get the first order conditional equation of motion for h_{t+1}^{-1} with respect to p_t^h from formula (12):

$$\frac{\partial h_{t+1}^{-1}}{\partial p_t^h} = (\frac{p_{t+1}^h - 2p_t^h}{p_t^h} + r_{t+1} - \frac{\Delta p_{t+1}^h}{p_t^h} - \gamma)\frac{ac_{t+1}^{-1}}{1-a} < 0 \quad (13)$$

By formula (13), we can make the first order partial derivative of the current house price p_t^h and the future expected house price p_{t+1}^h respectively, then we can get:

$$\frac{\partial h_{t+1}}{\partial p_t^h} = -\frac{c_{t+1}(1-a)}{p_t^{h^2} p_{t+1}^{h^2} D^2 a} < 0 \quad (14)$$

$$\frac{\partial h_{t+1}}{\partial p_{t+1}^h} = \frac{c_{t+1}(1-a)(p_{t+1}^h - p_t^h D)}{p_t^h p_{t+1}^{h^2} D^2 a} > 0 \quad (15)$$

In which, $D = r_{t+1} + 1 - \gamma - p_{t+1}^h / p_t^h$.

According to the formula (14) and formula (15), the current housing price is negatively related to the expected real estate consumption in the future, and the future housing price is positively related to the future property consumption. The reason is that, given the model of developing economies in this paper, the families are more advocating the relocation of security land, regardless of renting. If current house prices rise, families may reduce their expected home consumption. However, if house prices are expected to rise in the future, due to the existence of rigid housing demand, the families will choose to increase the consumption of real estate. For some investment families, financial assets such as real estate and stock bonds are substitutable in the absence of a good financial investment channel. In order to avoid risks and ensure the appreciation of property, the consumption of real estate will also increase.

According to the formula (12), if the future price of house prices is expected to rise too fast, that is ,the value of p_{t+1}^h / p_t^h is rise, the value of the average consumer goods will be lower than that of real estate. The rational family will invest the money except for the capital for the daily necessities into the real estate in order to appreciate the assets. Therefore, we can come up with the first hypothesis:

Hypothesis 1: In the non-steady state, the real estate consumption is related to the expected house prices in the future. If the future house prices are expected to rise, the expected real estate turnover will be increased.

In the steady state, the price of the house is in equilibrium, and the change of price is very low, and it tends to 0.Then there is $\Delta c_{t+1} = \Delta h_{t+1} = -\frac{\Delta p_{t+1}^h}{p_t^h}$=0. Assuming that the interest rate is equal to the discount rate (r = θ), we can know that, in the long run, the proportion of the consumption of real estate and durable goods is:

$$\frac{c}{p_t^h h_t} = \frac{\alpha}{1-\alpha}\left(1 - \frac{\theta}{\gamma}\right) \tag{16}$$

Considering only the short-term situation, real estate is only used as fixed asset. Given the capital stock in period t, the price of real estate reflects slower than that of general consumer goods. If the household made the decision on the behavior of real estate in t period, it will lead to the change of real estate consumption next t+1 period. For example, suppose that there is a shock of the impact of income growth in the period of t, the general consumer goods will correspond to period t, while real estate consumption lags until period t+1. We can use the above equation to derive the relative expenditure equation for short-term real estate:.

$$\frac{p_t^h h_t}{c_t} = \left[\frac{\Delta c_t}{c_t} - \frac{1}{1-\alpha}(r_{t+1} - \theta) - \gamma\right]\frac{p_t^h}{c_t} H_t \tag{17}$$

As can be seen from the above equation, after given H_t, the impact of the increase in c_t on the relative expenditure is related to the sign in square brackets. When it is positive, the relative expenditure on real estate consumption increases. This also shows that the volatility of real estate consumption is greater than the average commodity.

2.2 Firm

The first consider of the firm is vendor decisions. In general, manufacturers need to make decisions on product quantities, factor inputs, product prices, and so on. In addition, the manufacturer should also consider the structure of its assets and the profit level of paying dividends. We assume that the firm will select the optimal output, capital, elements, and debt financing to pursue the current and long-term maximization of profits. Therefore, the profit maximization equation is:

$$\text{Max } \sum_{s=0}^{\infty}(1+r)^{-s}\pi_t \quad (18)$$

In which, $\pi_t = y_t - w_t n_t - i_t + \Delta b_{t+1} - b_t.w_t$ is the real wage,$n_t$is labor input, b_t is the debt stock that is not paid by the manufacturer at the beginning of the t period. Since we are analyzing the two sectors of the economy, the creditor is the resident. Because we are considering the actual amount, the price level is set to 1.

The production function depends on the two factors of labor and capital:

$$y_t = F(k_t, n_t) \quad (19)$$

And, the capital accumulation equation is: $\Delta k_{t+1} = i_t - \delta k_t$

Manufacturers will choose $\{n_{t+s}, k_{t+s}, b_{t+s+1}; s \geq 0\}$ to maximize profits. Therefore, we can establish Lagrange's equation according to the above conditions.

$$\mathcal{R} = \sum_{S=0}^{\infty}(1+r)^{-s}\{F(k_{t+s}, n_{t+s}) - w_{t+s}n_{t+s} - k_{t+s+1} + (1-\delta)k_{t+s} + b_{t+s+1} - (1+r)b_{t+s}]\} \quad (20)$$

And we can get its first-order conditions:

$$F_{n,t+s} - w_t = 0 \quad (21)$$
$$F_{k,t+s} - (\delta + r) = 0 \quad (22)$$

According to the most common optimization conditions mentioned above, the marginal product of labor is the actual wage, that is, the marginal production of labor is $F_{n,t+1} = w_t$. The further analysis shows that the demand for labor originates from the capital stock. When we give a certain capital stock and a specific level of technology, the increase in real wages will increase the demand for labor.

Similarly, the demand for capital we receive is $F_{k,t+1}^{-1}(\delta + r)$. The total investment equation can be further obtained:

$$i_t = F_{k,t+1}^{-1}(\delta + r) - (1-\delta)k_t \quad (23)$$

We assume that there is no lag in the adjustment of investment, that is, there is no additional hidden costs. Therefore, an increase in interest rates will reduce investment, and an increase in the marginal product of capital will increase the optimal capital stock and investment. In the short run, the firm's optimal decision is to make the net marginal product of capital equal to the financing cost by choosing the appropriate capital stock, which is the opportunity cost of holding the bond. In long-run equilibrium, residents choose to save until the yield is reduced to the resident's time preference θ. In this case, $F_{k,t+1} = \delta + r$ is established.

Relatively speaking, the first-order condition of debt b_t is 0, that is to say, no matter what the value of b_t is, its result is valid. Consequently, any value of the debt is consistent with the goal of maximizing profit. Therefore, when financing the new investment, the manufacturer can take both the form of debt and the profit (that is, undistributed profit).

2.3. Financial Market

Next, we establish a general equilibrium state by linking family departments and enterprise departments, and integrate the above constraints, so as to determine the final analysis framework.

First, we introduce the identity of the national income so that consumption (family) and production (enterprise) are united together. Among them, C_t represents the total consumption of residents, that is, the summary of general consumption and real estate consumption.

$$y_t = C_i + i_t = F(k_t, n_t) \tag{24}$$

By the integration of residents' budget constraints and the capital accumulation equation, we can get that:

$$x_t = F(k_t, n_t) - w_t n_t - \Delta k_{t+1} - \delta k_t + \Delta a_{t+1} - r_t a_t \tag{25}$$

Similarly, we can get the profit equation of the manufacturer:

$$\pi_t = F(k_t, n_t) - w_t n_t - \Delta k_{t+1} - \delta k_t + \Delta b_{t+1} - r_t b_t \tag{26}$$

Further,$x_t - \pi_t = \Delta(a_{t+1} - b_{t+1})$- r$(a_t - b_t)$ can be obtained.

Since we assume that the financial assets of resident are the firm's liabilities, the bond market is in equilibrium when $a_t = b_t = a_{t+1} = b_{t+1}$ is reached, at which time, $x_t = \pi_t$.

2.4. Labor market

The family's consumption of real estate depends mainly on its income effect. In order to simplify the model, assuming that the household does not have variable income, it is composed of its fixed income. The output of the city is mainly composed of capital endowment (considering land elements only) and family labor. The form that satisfies the Cobb-Douglas function with constant returns to scale is as follows:

$$y_t = Ak_t^{\varepsilon} n_t^{1-\varepsilon} \tag{27}$$

From the first-order condition of formula (25), we can get the equation of motion of income per capita (formula (26)) and land transfer per capita (formula (27)):

$$w_{n,t} = A(1-\varepsilon)(\frac{k_t}{n_t})^{\varepsilon} \tag{28}$$

$$y_{n,t} = A\varepsilon(\frac{n_t}{k_t})^{1-\varepsilon} \tag{29}$$

Combining formula (26) and (27), we can get:

$$(\frac{A\varepsilon}{y_{n,t}})^{\frac{1}{1-\varepsilon}} = (\frac{w_t}{A(1-\varepsilon)})^{\frac{1}{\varepsilon}} \tag{30}$$

Excessively high land lease payments will led to the rising in house prices, while a high transfer cost per capita will have a crowding-out effect on per capita income. If the gap between household income and the city house prices is very large, the assets of the family will flow to the low price city. If the expected macroeconomic recession, wages and salaries are lower than the optimistic economic state, that is, $\frac{w_t}{A(1-\varepsilon)}$ is lower than the original value, $y_{n,t}$ is higher than the original value. The model in this paper assumes that the income budget of household is mainly used for general consumption and household consumption, and its budget constraint is: $p_t^h h_t + c_t \leq m$. The decline in household income will reduce m, and except for meeting the general consumption, the consumption of real estate will be reduced.

A sluggish market economy (rising unemployment rate) may result in a decrease in household income. However, a steady or declining anticipated income will curb the growth of real estate consumption; similarly, when the market is booming (per capita GDP growth), real estate consumption is rising. In other words, the development of the market economy is positively related to the consumption of real estate. When the market economy reaches a certain stage, the consumption of real estate tends to be steady. So, we can get the second and third hypotheses of the model:

Hypothesis 2: The unemployment rate has a negative impact on real estate consumption

Hypothesis 3: Per capita GDP has a positive impact on real estate consumption.

3. Data and methodology

3.1. Data

The core variables involved in this analysis are LTSALE, lAPRICE, and LPGDP, which measure real estate sales, house price level and individual income respectively. In addition, on the basis of the study of the core variables, we take into account other factors in the robustness test: 1. In recent years, China has accelerated its urbanization process, which has the same cumulative effect with the rise of China's housing market. Therefore, this paper added the urbanization index (UR) for verification; 2. In view of special national conditions in China, the government's fiscal expenditure is a major factor driving the growth of economy, and the overall volatility in housing market is also closely linked with the policy. Therefore, in analyzing the real estate market, we must control the government consumption index (LG); 3. We considered the unemployment rate (UE) in order to measure the economic stability; 4. The import and export index (LEX) is used to measure the degree of external dependence of the region; 5. Considering the endogenous problem brought by GDP, we will use coal consumption as a tool variable of GDP to ensure the robustness of the result. In this paper, except for the unemployment rate (UE) and urbanization (UR), all the variables that measure the economic indicators take the natural logarithm in order to reduce the phenomenon of heteroscedasticity as much as possible and transform the non-linear relationship of the variables into a linear relationship. The description of all the variables and the representative symbols are shown in Table 1.

Table 1. *Mnemonic and Variable Definition*

Mnemonic and Variable Definition	mnemoic	defination
economic preformance	LPGDP	LPGDP=ln(GDP per capita)
average price of local house	lAPRICE	lAPRICE=ln(average price of local house)
Commodity housing sales	LTSALE	ltsale=ln(Commodity housing sales)
unemploment rate	UE	The ratio of unemployment of labor population
imports and exports	LEX	lex=ln(ex)
the consumption of local government	LG	lg=ln(the consumption of local government)
Industrialization	UR	ur=2 &3 industry output value proportion
the consumption of coal	LCOAL	lcoal=ln(the consumption of coal)

The data used in this paper are derived from the national statistical yearbook of China, the Guotai'an database and the EPS database. The data are derived from 31 provincial administrative units in China. Because of the serious loss of data in Tibet, the sample of Tibet is abandoned, that is, the observed individual is 30 provincial administrative units. The data of core variables TSALE, PGDP and PRICE collected in this paper are relatively long-term data, with a total of 17 data (from 1999 to 2015). In order to ensure data integrity, we can take into account the "Notice on Further Deepening the Reform of Urban Housing System and Accelerating Housing Construction" in July 3, 1998 promulgated by the State Council, which officially opened a new round of real estate reform. In order to explore the basic impact of real estate consumption in recent years, it is necessary for us to start the analysis from the beginning of the real estate marketization process. Therefore, we use the PVAR model as the main part of the paper to analyze the interaction GDP per capita, house prices and the consumption. The data used in the analysis ranged from 1999 to 2015 and contained 510 samples. The statistics of the variables were described as part A of table 3.2.

In order to ensure the robustness of the results, we add control variables to ensure that there is no omission variables which will cause bias to the result. However, because the data collected for the control variables have only been available since 2004, we can only create 12 panel data of the balance panel. The number of samples obtained is 12*30=360. Although the time limit of the analysis data is not consistent, it can still be analyzed, which is mainly based on the following two reasons:

One of them, in August 12, 2003, the No. 18 document was drafted by the Ministry of construction of "notice on promoting the sustained and healthy development of the real estate market". This document defines real estate as "the pillar industry of the national economy," and this position means that there will be a directional change in the allocation of resources from a real economy centered at manufacturing to a virtual economy featuring real estate. Since 2004, China officially opened the golden decade of real estate (2004-2013). We verified the data again from 2004 to 2015 and compared it with the data from 1999 to 2015 to ensure the consistency of the results.

Secondly, from the initial stage of the rapid development of real estate, from 2004, we use dynamic panel econometric analysis to better capture the dynamic characteristics of the real estate industry and the impact of other economic indicators on it.

In order to ensure the credibility of the conclusion, we adopt different models and measurement methods in the analysis of the fifth part, so as to ensure the robustness of the final conclusion. The statistical description of the variables involved in the robustness test section is shown in part B of Table 2.

Table 2. *Variables descriptive statistics*

Variable		Mean	Std. Dev.	Min	Max	Observations
part A:Variable descriptive statistics in pvar						
PGDP	overall	26329.81	21572.1	2475.304	107960.1	N =510
	between		13767.83	10856.89	65248.19	n = 30
	within		16785.73	-13010.14	78973.61	T =17
TSALE	overall	9708124	1.31E+07	32445	9.97E+07	N =510
	between		8092491	536061.3	3.39E+07	n =30
	within		1.04E+07	-1.94E+07	7.55E+07	T =17
APRICE	overall	3862.882	3077.002	820	22633	N =510
	between		2162.204	2464.529	11532.24	n =30
	within		2222.561	-2905.353	14963.65	T = 17
part B:variables statistic describe in spatial panel						
PGDP	overall	4698.114	3269.869	1378	22633	N =360
	between		2702.609	2936.417	14146.33	n =30
	within		1900.461	-4205.219	13367.36	T =12
APRICE	overall	33230.71	21777.95	4215	107960	N =360
	between		16646.14	14148.25	76593.5	n =30
	within		14341.39	-4997.708	71412.29	T =12
TSALE	overall	1.32E+07	1.42E+07	118396	9.97E+07	N =360
	between		1.09E+07	736264.9	4.54E+07	n =30
	within		9307081	-2.23E+07	6.75E+07	T =12
UE	overall	3.597639	0.672498	1.21	6.5	N =360
	between		0.585581	1.5375	4.323333	n =30
	within		0.3462	2.346806	5.907639	T =12
G	overall	1886.71	1590.692	107.11	9796.25	N =360
	between		1297.873	285.19	5568.544	n =30
	within		947.3328	-1595.694	6114.416	T =12
UR	overall	88.33046	6.059474	63.107	99.5628	N =360
	between		5.797925	71.83161	99.25896	n =30
	within		2.032563	79.60584	93.41555	T =12

In the following econometric analysis, we apply panel vector autoregressive model, panel Granger principle and different kinds of spatial econometric models to explain the theoretical model results obtained above. In view of the limited space, so here is a brief description of the basic principles of different measurement models.

3.2. Panel unit root

The stability of the unit root test result is related to the accuracy of the subsequent empirical research. Therefore, the effective unit root test is the basis of empirical research. In this paper, two unit root test methods proposed by Pesaran are used to test. Because the two methods are basically the same way to construct statistics, so here is the introduction of a wider range of IPS heterogeneous panel data test method. The basic model constructed by the IPS method is expressed as follows:

$$\Delta y_{it} = \rho_i y_{i,t-1} + \sum_{L=1}^{pi} \beta_{iL} \Delta y_{i,t-L} + z'_{it} \gamma_i + \epsilon_{it}, i = 1,2,\dots,N \text{ ; t=1,2…,T}$$

In which, z_{it} indicates intercept or time trend term,γ_i is a coefficient vector, ϵ_{it} satisfies the independent normal distribution.

The null hypotheses: H_0: ρ_i=1, established for all i;

The alternative hypotheses: H_1:ρ_i<1, established for at least one i.

The statistic of IPS test can be defined as:

$$\mathrm{t-bar} = \frac{1}{N}\sum_{i=1}^{N} t_i$$

In which,t_i is a single t statistic of the original hypothesis H_0 : ρ_i=1 under the model test. Therefore, the IPS test uses the unit root test performed by the mean $\mathrm{t-bar}$ of each cross-sectional element DF_i statistic. And, under the conditions of the finite mean and the variance: $E(DF_i) = \mu, Var(DF_I) = \sigma^2$. By the central limit theorem, it can be obtained that:

$$\sqrt{N}(DF - \mu) \Rightarrow N(0,1)$$

Therefore, the statistic can be compared with the critical value to determine the final result.

3.3. PVAR model GMM estimation

Vector autoregressive model (VAR) has been widely used in time series analysis, but often requires time series data has a longer time span. The panel data often has the characteristics of "large intercept, short time sequence". Therefore, if VAR is applied to panel data, the following problems are inevitable: first of all, the general panel timing is short, and the traditional estimation methods cannot be directly applied to the Panel VAR. The second is that the panel data model contains many individuals and so the heterogeneity between sections must be taken into account. This is often overlooked in VAR for timing analysis. However, with the development of the dynamic panel data model, these two types of problems have been solved to some extent.

Since the data collected in this model is the provincial balance panel data for 1999-2015, GMM can be used to estimate the balance panel. Suppose $y_{it} = [pgdp_{it}, tsale_{it}, aprice_{it}]'$ is a 3*1-dimensional variable, and the number of endogenous variables is 3; i represents the i-th province, and the value is 1 ~ 30 (the surveyed individual is 30 provincial-level administrative units); t represents the year of the sample, and the range is from 1 to 17 (the time span used in this section is from 1999 to 2015); Then we can set the m-th equation of PVAR (q) model as:

$$y_{it}^{m} = x'_{it} b^{m} + \eta_{i}^{m} + \gamma_{t}^{m} + \mu_{it}^{m}$$

In which, $x_{\mathrm{it}} = [y'_{\mathrm{it}-1}, y'_{\mathrm{it}-2}, \cdots y'_{\mathrm{it}-\mathrm{q}}]'$ represents (3•q) *1-dimensional variable, which contains lags for all endogenous variables.b^{m} represents the coefficient vector,$\eta_i^m$and γ_t^mrepresent the individual effects and time effects respectively.; μ_{it}^{m} is the interference item, which needs to meet the following conditions:

$$\mathrm{E}(\mu_{it}^{m} \mid \eta_{i}^{m}, \eta_{i}^{m}, x'_{it}) = 0$$

Since the model contains not only the individual effectη_i^m, but also the explanatory variable x_{it} contains the lagged term of the explained variable. Therefore, we first remove the time effect by using the "in-group mean difference method" and further remove the fixed effect by the "forward mean-difference method". Finally, the GMM can be used to obtain the consistent estimator of b^{m}.

3.4. Panel granger causality test

This paper uses the method of panel Granger causality test used by Dumitrescu & Hurlin (2012), so a brief explanation of its principle is given here. The Granger causality in the traditional sense is to consider the lag time of a certain variable to forecast the current variables of other related variables. The traditional Granger causality test only applies to time series samples and cannot be used to test panel data. Dumitrescu & Hurlin (2012) further expand on the original basis, making Granger causality test applicable to panel data. The variable PGDP, for example, can set its basic model is expressed as follows:

$$pgdp_{\mathrm{it}} = \alpha_{\mathrm{i}} + \sum_{p=1}^{P} \beta_{ip} pgdp_{\mathrm{i,t-p}} + \sum_{p=1}^{P} \gamma_{ip} tsale_{\mathrm{i,t-p}} + \sum_{p=1}^{P} \kappa_{ip} aprice_{\mathrm{i,t-p}} + \varepsilon_{i,t}$$

It is worth noting that the variables that use this model must be stationary sequences and the data is a balance panel.

The original test hypothesis is consistent with the general Granger. Assuming that we analyze the Granger causality relationship between sales and per capita gdp, then the null hypothesis:

$$H_0 : \gamma_{i1} = \gamma_{i2} = \cdots = \gamma_{ip} = 0, \quad \forall \mathrm{i} = 1,2,\cdots,\mathrm{n}$$

Alternative hypothesis:

$$H_1 : \gamma_{i1} = \gamma_{i2} = \cdots = \gamma_{ip} = 0, \quad \forall \mathrm{i} = 1,2,\cdots,\mathrm{m}$$
$$\gamma_{i1} \neq \gamma_{i2} \neq \cdots \neq \gamma_{ip} \neq 0, \quad \forall \mathrm{i} = \mathrm{m}+1,\cdots,\mathrm{n}$$

In which, m<n.

Relatively speaking, the alternative hypothesis is more relaxed, just to meet that some individual parameters can be different from 0

Based on the above assumptions, we can construct the following statistics: First, regression is performed based on all the samples n to obtain the statistic W_i from q linear hypotheses $\gamma_{i1} = \gamma_{i2} = \cdots = \gamma_{ip} = 0$, and finally the average value is obtained. Then we can get the mean Wald statistic of n samples:

$$\bar{w} = \frac{1}{n}\sum_{i=1}^{n} W_i$$

Among them, W_i is the Wald statistic adjusted for individual i after normalization in period t. The results of DH indicate that by using Monte Carlo simulations, the resulting $\bar{w}$ statistics are well-behaved and can be used to detect panel models.

If further based on the statistics of W_i is independent and identically distributed at the sample level, the statistic $\bar{Z}$ follows the standard normal distribution when the intertemporal number t >> n and t, n are close to ∞:

$$\bar{Z} = \sqrt{\frac{n}{2p}} * (\bar{w} - p) \xrightarrow{d} \mathrm{N}\ (0,1)$$

Therefore, the result of the final test is based on the value of the statistics. If $\bar{Z}$ relative greater than the corresponding standard threshold, then we can reject the null hypothesis, which proves the existence of Granger causality. Although the sample size and duration are small, DH also shows that based on the Monte Carlo model, the test results also show better finite sample properties.

3.5. Spatial panel model

In general, the spatial panel model is divided into Spatial Durbin Model, Spatial Autoregressive Model, Spatial Autocorrelation Model and Spatial Error Model. Because different models have their own characteristics and advantages, the empirical analysis of this paper will take into account the effect of different models, and the subsequent dynamic spatial panel will use the space Dubbin model. So in a general static panel, we based on SAR, SAC, SEM and GSPRE four models for analysis. In view of the length of space, a generalized spatial panel model is set up, and the above three models can be set by strengthening their different assumptions.

The generalized space panel model can be set as:

$$y_{it} = \tau y_{i,t-1} + \rho w'_i y_t + d'_i X_i \delta + \mu_i + \gamma_i + \varepsilon_{it}$$
$$\varepsilon_{it} = \lambda m'_i \varepsilon_i + v_{it}$$

In which, w'_i is the i-th row of the spatial weight matrix W.$w'_i y_t = \sum_{j=1}^{n} w'_{ij} y_{jt}$, w_{ij} represents the (i, j) element of the spatial weight matrix W; $\rho w'_i y_t$ is the space lag item; y is an explained variable that represents the sale of real estate in this model; X represents the matrix of the explanatory variable (LPGDP, LAPRICE, UE, LEX, LG, UR, LCOAL). The explanatory variable μ_i, is introduced in the model of construction, which represents the individual effect of province i, γ_i is the time effect of province i, d'_i is the i-th row of the corresponding spatial weight matrix, m'_i is the i-th row of the space weight matrix of the perturbation term.

All of the three measurement models we use can be obtained on the basis of these conditions. The Spatial Autoregressive Model (SAR) is defined if $\lambda = 0$ and $\delta = 0$, and the Spatial Autocorrelation Model (SAC) if $\tau = 0$ and $\delta = 0$; if $\tau = \rho = 0$ and $\delta = 0$, which is the Spatial Error Model (SEM).

In addition, we also use the general spatial random effects model for analysis (the GSPRE model). According to description of the model analysis of Bclotti, Hughes, Mortari (2017), the model is set as follows:

$$y_t = X_t \beta + \mu + v_t$$
$$v_t = \lambda M v_t + \epsilon_t$$

$$\mu = \phi W\mu + \eta$$

By comparing the estimation results of the above models, we can further verify the corollary of the theoretical model in this paper.

4. Empirical analysis

4.1. Panel VAR

Due to the vast territory of China and the disparity between different provinces, and the rapid fluctuations in the real estate market in China in recent decades, the development of real estate in different regions is also different. Therefore, this section uses Inessa Love (2006) to measure the degree of marketization analysis method, the use of indicators of the median will be divided into high-priced provinces and low-cost housing provinces. The median calculation method is: First of all, calculate the median price of commodity houses in various regions, and the median of the panel data is re-obtained between the different provinces. Then set it as a cut-off point, the province is higher than the sample median high housing prices, otherwise is the low-cost provinces. Therefore, the content of this section is to make a comparative analysis of the high price area, low price area and the overall sample respectively. Therefore, the unit root test also needs to separately test the different divided sample groups.

4.1.1. Panel root test

In order to ensure the stability of empirical data, we classify the core variables (LPGDP, ltsale, lAPRICE) according to the previous classification criteria and perform unit root tests separately. Therefore, we examined the existence of unit root in LPGDP (overall sample), LPGDP_l (low-price region sample) and LPGDP_h (high-price region sample) separately. The same classification method is used for the rest of the two indexes, which are not described here. In addition, the unit root test must be carried out for other variables to ensure that all the variables are stationary, so the list is unified here.

In this paper, the individual ADF based tests method of Pesaran (2003, 2007) is used to identify whether there is a unit root process in the data, the statistics are constructed using the average value of the T value obtained by testing single cross-sectional DF or ADF statistics. The original assumption is that the sequences corresponding to all sections in the panel are all non-stationary, that is, the I(1) process. The advantage of Pesaran's method is that it takes into account the heterogeneity of the cross-section of the panel data and its correlation. The results of the calculation are as shown by Table 3.

Among them, t-bar represents the average of 30 samples for ADF identification respectively. cv10, cv5 and cv1 are the critical values at 10%, 5% and 1% respectively. Z[t-bar] is the normalized t-bar statistic. From the analysis of the results, we can see from table 5.1 that all the variables (except the p value of LPGDP and LPGDP_l is 0.069 and 0.061, which is significant at 10% significance level) are significant at 5% significance level. To ensure the stability of the sequence, we use other calculation methods to further verify the results.

Table 3. *Individual ADF based tests*

variable	t-bar	cv10	cv5	cv1	Z[t-bar]	P-value	length
LPGDP	-2.017	-2.07	-2.15	-2.32	-1.485	0.069	2
LPGDP_h	-4.162	-2.67	-2.78	-3.01	-7.29	0.000	3
LPGDP_l	-2.157	-2.14	-2.26	-2.47	-1.544	0.061	2
LTSALE	-2.098	-2.07	-2.15	-2.32	-1.923	0.027	1
LTSALE_h	-2.561	-2.14	-2.26	-2.47	-3.08	0.001	0
LTSALE_l	-2.358	-2.14	-2.26	-2.47	-2.309	0.010	1
lAPRICE	-2.153	-2.07	-2.15	-2.32	-2.215	0.013	0
lAPRICE_h	-2.292	-2.14	-2.26	-2.47	-2.056	0.020	0
lAPRICE_l	-2.546	-2.14	-2.26	-2.47	-3.022	0.001	1
LUE	-2.133	-2.07	-2.17	-2.34	-2.055	0.020	2
LEX	-2.106	-2.07	-2.17	-2.34	-1.92	0.027	0
LG	-4.542	-2.07	-2.17	-2.34	-14.052	0.000	2
LUR	-2.24	-2.07	-2.17	-2.34	-2.589	0.005	2
LCOAL	-5.055	-2.07	-2.17	-2.34	-16.603	0.000	2

In order to verify the robustness of the sequences, we further adopted the method of testing the heterogeneous panel unit root (IPS test) by Im, Pesaran & Shin (2003). The advantage of this method is that not only the heterogeneity of the cross section but also the sequence related problem of the interference term are considered. The construction method of the statistics is similar to that of Pesaran, which is obtained by averaging the t values after performing an ADF test on a single section. Therefore, the null hypothesis is that the sequences corresponding to all the sections in the panel are non-stationary, that is, the I(1) process. As the premise of its use is required to balance the data panel, and the data just meet the requirements, so we can apply this method for unit root identification, the test results shown in Table 4.

It can be seen from the p-value that all the variables reject the null hypothesis at a significant level of 5%, so the sequence can be considered as stable.

Table 4. *Panel-root test using IPS*

variable	t-bar	cv10	cv5	cv1	W[t-bar]	P-value	length
LPGDP	-2.591	-1.69	-1.73	-1.82	-6.338	0.000	3
LPGDP_h	-2.62	-1.82	-1.91	-2.08	-4.59	0.000	3
LPGDP_l	-2.563	-1.82	-1.91	-2.08	-4.373	0.000	3
ltsale	-2.003	-1.69	-1.73	-1.82	-3.171	0.001	3
ltasle_h	-2.089	-1.82	-1.91	-2.08	-2.571	0.005	3
ltasle_l	-1.916	-1.82	-1.91	-2.08	-1.913	0.028	3
lAPRICE	-2.05	-1.69	-1.73	-1.82	-3.463	0.000	2
lAPRICE_h	-2.13	-1.82	-1.91	-2.08	-2.763	0.003	2
lAPRICE_l	-1.954	-1.82	-1.91	-2.08	-2.069	0.019	2
lue	-2.451	-2.33	-2.38	-2.48	-2.354	0.009	3
lex	-1.769	-1.69	-1.74	-1.83	-2.014	0.022	2
lg	-1.965	-1.69	-1.74	-1.83	-2.572	0.005	0
lur	-2.068	-1.69	-1.74	-1.83	-3.078	0.001	1
lcoal	-2.54	-1.69	-1.74	-1.83	-5.847	0.000	0

4.1.2. Panel VAR

Through the unit root test, all the variables are verified to be stationary sequence, so it can be further analyzed. Before using the PVAR model, we first estimate the lag order of the panel model. In accordance with the method of time series, we can also determine the best delay order by three information criteria, AIC, BIC, and HQIC. From the results of Table 5, we can see that in the total sample model, the best lag order is lagging 2 orders. In the sample group with high housing price, the optimal lag order is also lagging behind the 2 orders, while in sample group with low housing prices, the optimal lag order is lagging four orders. Considering that the overall period of the sample is too short and the sample size is small, if the lag order is too large, the degree of freedom of sample loss will be more serious, which will affect the final analysis result. Therefore, this paper uses lagged three orders to analyze the low sample population.

Table 5. *Selection order criteria for panel VAR*

panel A: for all the sample			
lag	AIC	BIC	HQIC
1	-5.45352	-4.54948	-5.0972
2	-5.71147*	-4.67255*	-5.30084*
3	-5.60612	-4.41627	-5.13446
4	-5.69792	-4.33779	-5.15711
panel B: for the sample which is the high-house price			
lag	AIC	BIC	HQIC
1	-5.36153	-4.54167	-5.03063
2	-5.77394*	-4.76981*	-5.36801*
3	-5.39034	-4.18185	-4.90104
4	-5.55038	-4.11355	-4.9678
panel C: for the sample which is the low-house price			
lag	AIC	BIC	HQIC
1	-5.0264	-4.20654	-4.6955
2	-1.35908	-0.35495	-0.953148
3	-4.95404	-3.74554	-4.46473
4	-5.7114*	-4.27457*	-5.12883*
5	-5.48386	-3.78971	-4.79614

Notes: *Indicates the corresponding optimal lag order

4.1.3. The results of PVAR model

In this paper, the GMM method is used to estimate the PVAR model. The results are as shown by table4.3. From the sample population, the sample size (195) of the low-price model analysis is roughly the same as the sample number of the high-price population (210), indicating that it is more appropriate to use the median to classify without large errors. It can be seen from the comparative results of the model that the consumption of lagged two periods in the low-price housing group has a negative impact on the current per capita GDP while the high-priced part has a significant positive impact on the current per capita GDP. From the actual situation in China, low-cost areas are generally less developed regions, the negative impact of simple real estate sales is relatively greater, and the incubation period longer; In the developed regions (Model 2), their industries are relatively perfect and the economic structure is relatively complete. The positive impact on the sales of real estate is even more pronounced. At the national level, it is also positively affected.

Through the analysis of real estate consumption, we can see that in the model of high housing price, lagged per capita GDP has a more significant impact on the consumption. However, it is noteworthy that in model two and model three, the lag two periods per capita GDP will have a significant negative impact on real estate consumption. Combined with the realities, we think the rapid economic growth will increase residents' enthusiasm for property investment in the short term, while the enthusiasm will be relatively cooled in the long run, resulting in a wait-and-see situation. In addition, lagged sales will have a positive impact on current sales, which is in line with the real situation in China. People will be optimistic about the sales level based on the previous period, which will increase the purchasing desire of the current period. This is also in line with the estimation made in the model.

Through the analysis of commercial housing prices, no matter from which model, the previous period for the current price of house prices will have a significant positive impact, indicating that housing prices have the tendency of overlay in the short-term. However, the effect of GDP per capita lagging behind the two periods on housing prices is different in different regions. Our explanation to this situation is that: the economic growth of less developed areas will enhance people's purchasing power for real estate, leading to a significant increase in housing prices. In the economically developed areas, the lagged economic growth will promote the rise of housing prices (not significant), but for a long time, as housing prices rise to a certain level, it will further cool the market, causing people to wait and see, so that housing prices will be slightly reduced.

To sum up, the effect of consumption in high housing price sample and low housing sample on GDP is not significant, but from the whole country, it has a significant positive role. Conversely, the impact of GDP on sales in model 1 and model 3 is not significant, but it has a significant positive impact on model two (high housing price). This shows that real estate consumption and GDP do have the same trend, which proves the conclusion of hypothesis 3. In addition, although there is no significant relationship between high-price-sample and low-price-sample from part B and part C of Table 6. At the national level, there is a positive impact of mutual promotion of house consumption and house price changes, which shows that it is in line with our assumption of Hypothesis 1 from the country as a whole.

Table 6. *Panel Vector Auto-Regression: System-GMM Results*

	Model 1 Low pirce		Model 2 High price		Model 3 Total sample	
PART A :LPGDP						
L.LPGDP	1.693***	-2.68	0.863***	-4.88	0.963***	-5.51
L.LTSALE	-0.039	(-0.26)	0.052	-1.46	0.116***	-3.8
L.lAPRICE	0.246	-0.69	0.036	-0.32	-0.106	(-1.47)
L2.LPGDP	-0.194	(-1.05)	-0.149	(-1.23)	-0.213**	(-2.22)
L2.LTSALE	-0.130**	(-1.99)	0.055***	-2.85	0.036*	-1.8
L2.lAPRICE	-0.109	(-0.62)	-0.044	(-0.66)	-0.043	(-0.77)
L3.LPGDP	-0.258	(-0.92)				
L3.LTSALE	-0.003	(-0.04)				
L3.lAPRICE	-0.05	(-0.32)				
PART B:LTSALE						
L.LPGDP	-0.97	(-0.33)	2.025***	-2.73	1.154	-1.56
L.LTSALE	1.258**	-1.98	0.728***	-3.69	0.829***	-5.77
L.lAPRICE	-0.764	(-0.50)	-0.86	(-1.54)	-0.793***	(-2.70)
L2.LPGDP	0.212	-0.38	-1.898***	(-3.66)	-1.199***	(-3.14)
L2.LTSALE	0.141	-0.44	0.181	-1.64	0.193**	-2.02
L2.lAPRICE	0.995	-1.52	0.731***	-2.67	0.542***	-2.86
L3.LPGDP	-0.421	(-0.34)				
L3.LTSALE	0.221	-0.6				
L3.lAPRICE	-0.527	(-0.77)				
PART C:lAPRICE						
L.LPGDP	0.091	-0.14	0.406	-1.36	-0.171	(-0.59)
L.LTSALE	-0.019	(-0.13)	0.045	-0.61	0.102**	-2.05
L.lAPRICE	0.858***	-2.66	0.804***	-3.89	0.664***	-5.65
L2.LPGDP	0.414***	-2.65	-0.440**	(-2.08)	-0.023	(-0.14)
L2.LTSALE	-0.006	(-0.09)	0.027	-0.66	0.088**	-2.4
L2.lAPRICE	0.214	-1.2	0.025	-0.27	0.02	-0.27
L3.LPGDP	-0.349	(-1.27)				
L3.LTSALE	-0.017	(-0.20)				
L3.lAPRICE	-0.218	(-1.34)				
N	195		210		420	
AIC	-4.492		-5.345		-5.711	
BIC	-2.529		-3.624		-4.673	
HQIC	-3.697		-4.649		-5.301	

Notes: t statistics in parentheses;* p<0.1, ** p<0.05, *** p<0.01

4.1.4. Impulse response analysis

Since the impulse response function can measure the dynamic change of a sequence after being subjected to a unit random disturbance, it can make up for the deficiencies in economic explanatory power due to too many VAR model parameters. Therefore, we further plot the impulse response impulse with a 5% confidence interval, which is seated by a Monte Carlo simulation of 1000. Therefore, we can get the final analysis results (as shown in Figure 1, Figure 2, Figure 3).

Because we mainly measure the interaction relationship between the level of real estate consumption and the per capita GDP, the analysis of other variables is omitted here. As can be seen from Figure 1, The GDP per capita has the biggest impact on the first phase of the housing sales, and then gradually presents a trend of attenuation; Although real estate consumption has a positive impact on per capita GDP, its significant level is insufficient; As can be seen from Figure 2, in the areas with high housing prices, the impact of per capita GDP on housing sales is gradually increasing. But after the third stage, it began to stabilize, until the sixth phase still did not show a trend of attenuation; The impact of housing sales on per capita GDP also showed a stable positive impact, indicating that in the more economically developed regions, the two showed a mutually reinforcing trend; In view of the national level reflected in Figure three, it is basically consistent with the impact of the economically developed areas; It can be seen that in the whole country, real estate consumption and economic growth showed a synchronized trend, which shows that the growth momentum of China's economy has been inextricably linked with real estate consumption in recent years.

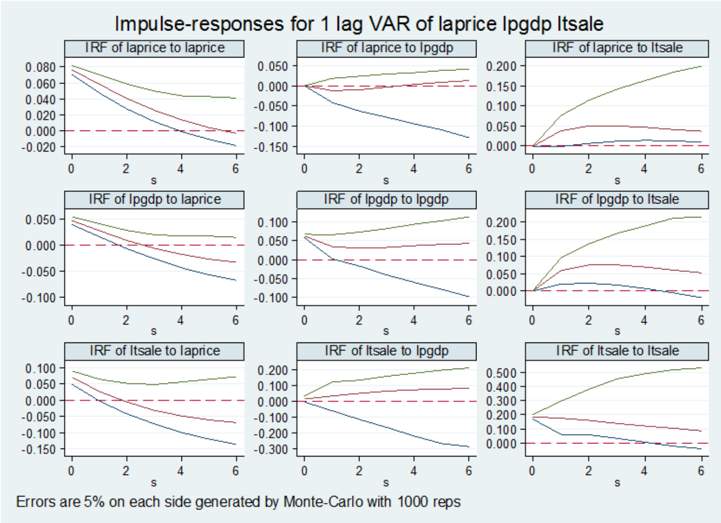

Figure1: *Model 1*

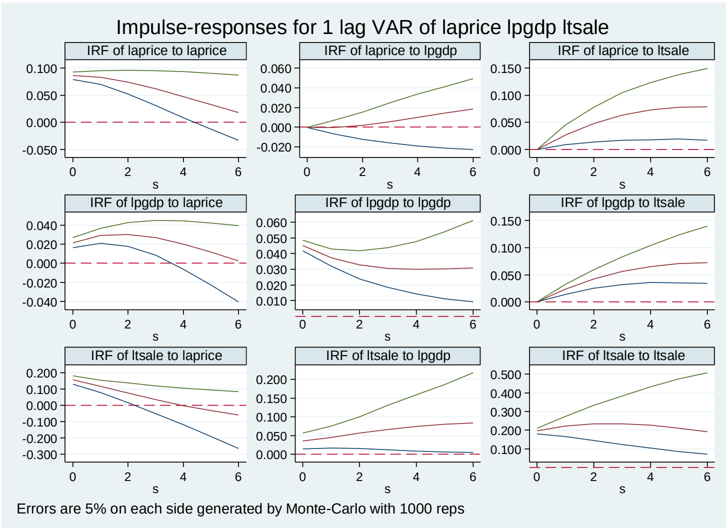

Figure1: *Model 2*

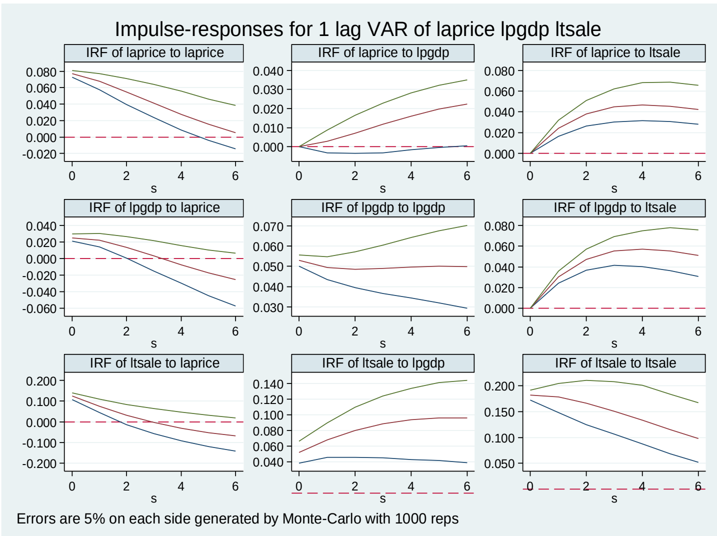

Figure1: *Model 3*

From the above analysis of model one (low-price area), we can draw the following conclusions: Housing prices have a significant role in promoting consumption, and the impact of the first phase to achieve maximum effect, and then slowly at 0; The sales situation for the price in the short term has a positive impact, which later attributable to the negative impact with significant situation in not high. Therefore, we think there is a positive relationship between real estate prices and consumption in the short run, which is in line with the conclusion of Hypothesis 1; GDP has a significant positive impact on real estate consumption. Consumption has a positive impact on economic growth, its effect is insignificant. Therefore, we believe that economic growth has a significant one-way impact on consumption. Similarly, we analyze the model two (high housing price area), and house prices have a significant positive impact on sales, while sales impact on house prices is significant in first, second periods, which indicates that there is a positive interaction in the short term, thus verifying our hypothesis1; However, there is a significant positive interaction impact between economic growth and sales, which proves that the hypothesis 2 theory is established in the high house price region; For model three, we can still get the same conclusion from the model two from the impulse response graph, which is not explained here.

4.1.5. Panel granger test

Because Grange causality test can be used to measure whether all the lag phases of the panel affect the current value of other variables, it has important reference for analyzing economic problems. This paper first uses WALD test to detect the causal relationship between variables on the basis of the pvar model. The results are shown in Table 7, and the null assumption is that there is no causal relationship between variables. From the p values, we can see that except that the granger causality exists from LPGDP to lAPRICE at 10% significance level, the remaining variables rejected the null hypothesis at a significant level of 5%, indicating that there was a significant granger causality relationship among all three variables.

Table 7. *Granger causality Wald tests for Panel VAR*

Equation	Excluded	chi2	df	Prob > chi2
h_lAPRICE	h_LPGDP	4.744	2	0.093
h_lAPRICE	h_ltsale	7.1653	2	0.028
h_lAPRICE	ALL	35.95	4	0.000
h_LPGDP	h_lAPRICE	11.979	2	0.003
h_LPGDP	h_ltsale	14.489	2	0.001
h_LPGDP	ALL	34.227	4	0.000
h_ltsale	h_lAPRICE	9.0599	2	0.011
h_ltsale	h_LPGDP	23.66	2	0.000
h_ltsale	ALL	53.699	4	0.000

In addition, Dumitrescu & Hurlin (2012) is used to test the robustness of the result further. Its null hypothesis is consistent with the null hypothesis of wald test, that is, none of the Granger-causes exists. From the statistical results, except for the Granger causality relationship between sales and price, there is a significant causal relationship among the remaining variables.

Table 8. *Dumitrescu & Hurlin Granger non-causality test results*

	W-bar	Z-bar	Z-bar tilde
LPGDP to ltsale	13.669	49.0668(0.0000)	35.4397(0.0000)
LPGDP to lAPRICE	4.1418	12.1682(0.000)	8.4008(0.0000)
ltsale to LPGDP	2.6155	6.2567(0.0000)	4.0688(0.0000)
ltsale to lAPRICE	1.2289	0.8865(0.3753)	0.1336 (0.8937)
lAPRICE to LPGDP	7.471	25.0623(0.000)	17.8494(0.000)
lAPRICE to ltsale	6.5723	21.5813(0.000)	15.2985(0.000)

According to the above Granger test results, we can conclude that there is a two-way Granger-cause between per capita GDP and real estate consumption; There is a two-way Granger-cause between GDP per capita and the price level; House prices have a one-way Granger-cause for real estate consumption.

Therefore, Hypotheses 1 and 3 are verified.

4.2. Robustness test

4.2.1. Spatial panel analysis

In part 4, we use the pvar model to analyze. Since only three variables are involved, it will inevitably lead to errors and affect the accuracy of the results. Therefore, we further consider the spillover effect of the space between different inter-provincial regions. In this chapter, the method of spatial measurement is used to increase the control variables in order to enhance the credibility of the previous results. Since the added variable has been described in detail in Part 3, it will not be elaborated here.

Using space econometric analysis, we must first establish a space weight matrix. Based on the spatial distance between regions, this paper establishes a "spatial weighting matrix" according to the distribution of geographical location. The spatial data of n different areas are recorded as $\{x_i\}_{i=1}^{n}$, the subscript i indicates the i-th province,w_{ij} is the weight distance between province i and province j. So the final weight matrix can be expressed as follows:

$$W = \begin{bmatrix} w_{11} & \cdots & w_{11} \\ \vdots & & \vdots \\ w_{11} & \cdots & w_{11} \end{bmatrix}$$

In which, the main diagonal elements are 0, that is, $w_{11} = \cdots = w_{nn} = 0$, which means that the distance between the same area is 0. Therefore, the spatial weight matrix W is a symmetric matrix. We use the general method of calculating the adjacent measurement, that is, if the area i and j have a common border, then w_{ij} takes 1, otherwise takes 0. Taking into account the data used, we use the method of vehicle contiguity to measure the matrix.

In addition, before using spatial econometric analysis, you must consider whether the data is space-dependent. If it does not exist, we can use standard methods of measurement. If it is available, the space measurement methods can be used. The general measurement of spatial dependence is using the moran'I index, with the value of Moran'I between -1 and 1. Moran 'I greater than 0 represents positive autocorrelation, that is, high value is adjacent to high value, low value is adjacent to low value; less than 0 indicates negative autocorrelation, that is, high value is adjacent to low value. If Moran 'I is close to 0, the spatial distribution is random, and there is no spatial autocorrelation. To make it easier to understand, we measure the Moran 'I index from 2004 to 2015 according to the price index, and draw the polyline trend chart, as is shown in Figure 1. All the measured indexes are more than 0.247, so there is a significant spatial autocorrelation. In addition, in order to better understand the specific spatial dependence of provinces and municipalities, we draw the moran'I index quintile hotspot map of China according to the 2015 Moran'I indicator.

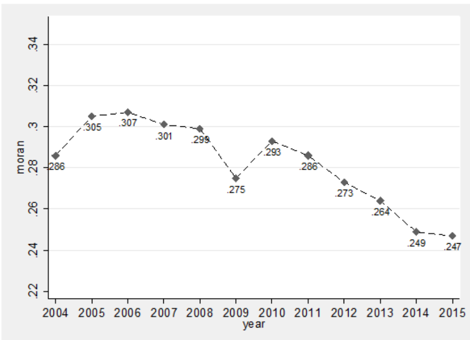

Figure 2. *Moran trend map*

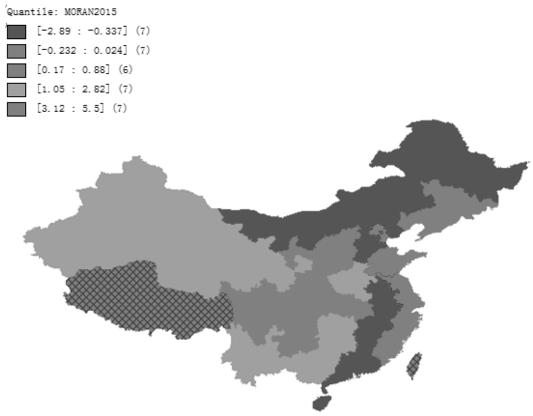

Figure 3. *2015 house price Moran index bitmap*
Notes: As Tibet, Taiwan did not include the analysis of this paper, it is shaded here.

4.2.2. Stability analysis

In order to ensure the robustness of the results, we first use mixed OLSs, Spatial Autoregressive Model (SAR), Spatial autocorrelation model (SAC), Spatial error model (SEM) and the spatial random effects model (GSPRE) to analyze. In the analysis of SAR and SEM, we consider the influence of fixed effect and random effect separately, and consider the effect of time (individual) and the superposition effect of the two on the result in SEM model. The results of empirical analysis are shown in Table 9.

Table 9 uses real estate consumption as the dependent variable for empirical analysis. Through the analysis of the results, it is found that except for the mixed OLS model, the fitting degree of the other models is relatively poor, which is generally distributed in the range of 0.4 to 0.6. However, the significance level of the core variables (LPGDP, LAPRICE) is good. From the analysis of LPGDP, all the eight models had a positive significant effect (significant level at 1%), indicating that per capita income would have a positive propelling effect on real estate purchase, in line with our earlier hypothesis 3. In addition, from the analysis of LAPRICE, we can see that except the model one, the remaining space measurement models have positive significant results, which also verify our previous PVAR model and our theoretical explanation for the specific situation. Due to the high prices rising year by year, it will enhance people's expectations: house prices will continue to rise. So as to urge residents to upgrade their purchasing desire, which can verify Hypothesis 1; when further examining the impact of unemployment on housing consumption, the results obtained do not well validate our hypothesis 2. Although the fourth to the eighth models gets negative results, which are consistent with our hypothesis, the overall level is insignificant, while the only significant is the positive effect in model one.

We consider that this result may be due to the correlation between the explanatory variable LPGDP and the disturbance term, resulting in the endogenous problem of the model, so we introduce coal consumption as a tool variable of per capita GDP. Combined with China's special national conditions, we consider the use of coal energy consumption as a tool variable of per capita GDP, and then test the validity of the conclusion. The use of coal is mainly based on the following reasons: firstly, after the reform and opening up, China is able to develop rapidly, relying largely on low resource conditions and demographic dividends. Secondly, as a major energy consumer, China's major energy resource is coal, which is closely related to the production and life of the residents; Thirdly, the correlation degree of coal resources and housing prices, real estate sales is not high. In view of the above three points, we think it is feasible to use coal energy consumption as a tool variable.

In order to ensure the comparison of the results, we use the model used above. Keeping the other variables unchanged, only use coal consumption instead of per capita GDP variables. In the model one, we use the two-stage least square method to regression. While in the space panel model, the per capita GDP variables are replaced directly to test the robustness of the model.

From the Table 10, we can conclude that the spatial panel model still obtain good estimation results after we eliminate endogenous problems. Compared with before, the fitting level is enhanced. Besides the model one was not significant, the impact of coal consumption on real estate sales at a significant level of 1%. It shows that although the use of coal consumption as a substitute for GDP, the results are still consistent with the original empirical results, indicating that the use of tool variables is more reasonable. In addition, we can also see the price still has a significant positive impact, and the overall level is better. Finally, in view of the unemployment rate, although the results obtained from the statistics are not significant, there are still six models from the eight models that show negative impact. Therefore, on the whole, the second hypothesis is verified in a certain extent. In addition, the index of other explanatory variables is more significant as a whole, which also shows that the spatial panel model set is more reasonable.

From Table 11, the ability to explain hypothesis 2 is not sufficient. On the one hand, it is due to the influence of tool variable coal on the model. On the other hand, we think that the impact of exogenous shocks on the results is not taken into account. The most intense shocks came from the financial crisis of 2008 years. Therefore, we consider the use of dummy variables to characterize the impact of this shock on the result. We can set the value to 0 before 2008 and 1 in 2008 and beyond, add the interaction of virtual variables and the per capita GDP in the model, and make re-regression on the formula to get Table 11. From the results obtained, all the models are significant results except that virtual items are automatically omitted in the regression of model seven, while the interaction item has a negative effect on all models, which shows that it is correct that we set up the virtual variables in the model. For the unemployment rate, all the spatial empirical models have significant negative effects except that the model one is positive correlation. This strongly confirms the conclusions we put forward in hypothesis 2, and the final empirical results are well confirmed by hypothesis 1 and hypothesis 3.

Although we have shown the accuracy of the hypothesis from a different perspective in the previous part, the spatial models in our analysis only consider the static characteristics between data, that is, variables are only affected by the same period, while macroeconomic problems are characterized by dynamic fluctuations. From the previous PVAR model, we can also see that the current sales not only affected by the significant impact of pre-sales, but also by the impact of other variables. Therefore, considering static characteristics alone cannot fully reflect the overall situation of economic variables. In order to reflect the dynamic characteristics of the economy, this paper further uses the Space Durbin model to analyze. The reasons can be shown as follows: firstly, in the static panel, the Durbin model is not considered, so it needs to be considered here; Secondly, the fluctuation of housing prices has the effect of regional spillovers and the interaction between neighboring provinces. Thirdly, the Durbin model measures the impact of the relationship between regions and meets the overall analysis of the characteristics. Based on the above three considerations, this paper uses the method of Han-Philips (2010) to establish a linear dynamic panel model for regression analysis of house prices.

In order to ensure the consistency of the results, the random effects model and the dynamic effects model are used for analysis. The empirical results are shown in Table 12. In which, w1x_LPGDP represents the first-order space lag variable of the logarithm of per capita GDP(AR(1) LPGDP spatial lag). From the results, the conclusions obtained by the two models are consistent and the degree of fitting is further optimized. As we have assumed, the lagged first order of real estate consumption has a good significant effect. However, the relationship between unemployment rate and property consumption we have explored can only be verified in the fixed-effects model, but the results are not significant. In addition, the estimated coefficients of the first-order spatial lag of GDP, price, government expenditure and other indicators of variables also have a significant effect. While getting the results, GLOBAL Moran MI test was further used to test whether the variables have spatial autocorrelation, LM Lag test was used to test whether there was spatial autocorrelation of lagged dependent variables as well as using LM SAC test to test whether the whole system has spatial autocorrelation. From the test results, we all reject the null hypothesis at a significant level of 1%, which shows that the data has a spatial effect once again, and the model setting is more reasonable. More importantly, the main variables we analyzed LPGDP and LSALE still have a significant positive impact. Therefore, the robustness of Hypothesis 1, 3 is verified in this model, but unfortunately Hypothesis 2 is not validated.

Table 9. *Results of spatial auto regression*

	ols	sar_fe	sar_re	sem_fe	sem_re	sac_fe_~d	sac_fe_~h	gspre
LPGDP	1.092***	0.496***	0.433***	0.830***	0.758***	0.934***	0.600***	0.727***
	-10.92	-4.4	-3.7	-7.02	-6.21	-7.42	-4.16	-5.87
LAPRICE	-0.112	0.766***	0.666***	1.188***	1.081***	1.325***	1.307***	1.059***
	(-1.16)	-6.61	-5.49	-10.67	-9.19	-10.32	-8.94	-8.98
UE	0.241***	0.008	0.007	-0.012	-0.014	-0.014	-0.025	-0.018
	-5.57	-0.18	-0.17	(-0.30)	(-0.34)	(-0.37)	(-0.64)	(-0.43)
LG	0.987***	-0.339***	-0.170*	-0.323***	-0.160*	-0.283***	-0.231***	-0.115
	-26.3	(-3.82)	(-1.75)	(-3.70)	(-1.67)	(-3.25)	(-2.61)	(-1.16)
UR	-0.009*	0.049***	0.049***	0.014	0.013	0	0.018*	0.016*
	(-1.66)	-5.34	-5.32	-1.54	-1.48	-0.01	-1.69	-1.78
_cons	0.717		-3.551***		-1.502*			2.457
	-1.3		(-4.82)		(-1.81)			-0.46
Spatial								
rho		0.379***	0.367***			-0.160*	0.073	
		-8.57	-8.17			(-1.87)	-0.56	
lambda				0.530***	0.533***	0.655***	0.08	0.528***
				-10.29	-9.89	-9.23	-0.51	-9.69
phi								1.038***
Variance								
sigma2_e		0.041***	0.046***	0.039***	0.042***	0.039***	0.038***	
		-13.31	-12.59	-13.06	-12.38	-12.9	-14.61	
lgt_theta			-2.536***					
			(-15.45)					
ln_phi					2.825***			
					-9.23			
sigma_mu								0.810***
								-6.49
sigma_e								0.207***
								-24.54
N	360	360	360	360	360	360	360	360
r2	0.866	0.406	0.489	0.44	0.519	0.463	0.491	0.539

Notes: t statistics in parentheses， * p<0.1, ** p<0.05, *** p<0.01

Table 10. *Results of Spatial Auto Regression with IV*

	xiv	sar_fe	sar_re	sem_fe	sem_re	sac_fe_~d	sac_fe_~h	gspre
LPGDP	-0.176							
	(-0.75)							
LAPRICE	0.857***	0.995***	0.664***	1.394***	1.274***	0.395***	0.858***	1.239***
	-4.58	-7.15	-6.1	-12.84	-12.21	-4.13	-5.31	-12.38
UE	0.012	-0.011	-0.001	-0.016	-0.028	0.019	-0.002	-0.03
	-0.2	(-0.27)	(-0.03)	(-0.37)	(-0.64)	-0.54	(-0.06)	(-0.69)
LG	0.862***	-0.205**	-0.095	-0.113	0.01	-0.196***	-0.177**	0.039
	-16.13	(-2.43)	(-1.12)	(-1.30)	-0.11	(-2.85)	(-2.14)	-0.45
UR	-0.008	0.034***	0.045***	0.022**	0.017*	0.049***	0.040***	0.016*
	(-1.03)	-3.72	-5.09	-2.34	-1.81	-6.09	-4.17	-1.76
LCOAL		0.356***	0.441***	0.350***	0.372***	0.336***	0.353***	0.397***
		-5.02	-6.7	-4.33	-5.08	-5.67	-5.24	-5.55
_cons	2.927***		-4.788***		-2.029**			-2.061**
	-3.68		(-6.41)		(-2.24)			(-2.26)
Spatial								
rho		0.087	0.409***			0.670***	0.262**	
		-1.34	-9.85			-14.02	-2.16	
lambda				0.463***	0.472***	-0.602***	-0.249	0.469***
				-8.2	-8.13	(-5.25)	(-1.60)	-8.11
phi								0.565***
								-3.42
Variance								
sigma2_e		0.034***	0.043***	0.043***	0.047***	0.034***	0.036***	
		-13.39	-12.64	-13.13	-12.52	-11.97	-13.45	
lgt_theta			-2.337***					
			(-14.75)					
ln_phi					2.290***			
					-7.74			
sigma_mu								0.554***
								-6.69
sigma_e								0.216***
								-24.97
N	360	360	360	360	360	360	360	360
r2		0.544	0.582	0.61	0.66	0.481	0.552	0.67

Notes: t statistics in parentheses,* p<0.1, ** p<0.05, *** p<0.01

Table 11. *Results of spatial auto regression with policy dummy variables*

	ols	sar_fe	sar_re	sem_fe	sem_re	sac_fe_~h	gspre
LPGDP	1.737***	1.215***	1.184***	1.484***	1.440***	1.172***	1.421***
	-13.35	-9.34	-8.8	-11.85	-11.18	-9.42	-10.91
LAPRICE	-0.201**	0.412***	0.309***	0.812***	0.707***	0.705***	0.698***
	(-2.04)	-3.59	-2.58	-7.17	-5.95	-5.37	-5.89
UE	0.235***	-0.067*	-0.066	-0.100***	-0.101***	-0.099***	-0.104***
	-5.79	(-1.67)	(-1.60)	(-2.74)	(-2.69)	(-2.98)	(-2.75)
LG	1.004***	-0.154*	0.013	-0.115	0.04	-0.135*	0.079
	-28.37	(-1.85)	-0.14	(-1.44)	-0.45	(-1.82)	-0.88
UR	-0.012**	0.033***	0.033***	-0.008	-0.008	-0.007	-0.006
	(-2.12)	-3.91	-3.91	(-0.97)	(-0.93)	(-0.77)	(-0.70)
dum	6.319***	3.980***	4.193***	5.285***	5.548***	0	5.528***
	-7.12	-8.82	-8.85	-9.47	-9.52	.	-9.5
lp_dum	-0.786***	-0.500***	-0.527***	-0.650***	-0.683***	-0.647***	-0.683***
	(-7.15)	(-8.96)	(-8.99)	(-9.70)	(-9.74)	(-9.93)	(-9.74)
_cons	-3.343***		-4.953***		-2.417***		0.885
	(-4.22)		(-6.65)		(-2.67)		-0.19
Spatial							
rho		0.341***	0.327***			-0.374***	
		-8.18	-7.69			(-3.90)	
lambda				0.576***	0.579***	0.584***	0.571***
				-11.2	-10.78	-7.2	-10.54
phi							1.038***
							-30.74
Variance							
sigma2_e		0.034***	0.038***	0.030***	0.033***	0.027***	
		-13.34	-12.6	-12.95	-12.27	-12.52	
lgt_theta			-2.505***				
			(-15.03)				
ln_phi					2.782***		
					-9.02		
sigma_mu							0.694***
							-6.44
sigma_e							0.182***
							-24.31
N	360	360	360	360	360	360	360
r2	0.883	0.517	0.601	0.546	0.624	0.089	0.642

Notes: t statistics in parentheses,* p<0.1, ** p<0.05, *** p<0.01

Table 12. *Spatial panel linear dynamic regression: Durbin models*

	SDM_re	SDM_fe
Lsale	Coef.	Coef.
L1.lsale	0.735***	0.915***
	6.77	7.19
LPGDP	0.846***	1.020***
	5.25	6.57
LAPRICE	0.603**	0.369*
	3.15	1.65
UE	0.041	-0.074
	0.71	-1.28
LG	0.318***	-0.230*
	3.55	-1.84
LUR	2.573***	1.55
	2.81	1.10
w1x_LPGDP	0.332***	0.322***
	5.27	5.61
w1x_LAPRICE	-0.276***	-0.294***
	-4.25	-3.56
w1x_UE	0.038	0.003
	1.18	0.08
w1x_LG	0.074*	0.046
	1.70	0.72
w1x_LUR	-0.101	1.342**
	-1.06	2.59
_cons	8.465***	-8.990***
	3.37	-2.97
R^2	0.805	0.543
N	330	330
diagnosis		
GLOBAL Moran MI	0.981***	0.979***
LM Lag (Robust)	317.535***	22.217***
LM SAC (LMLag+LMErr_R)	960.997***	662.135***

Notes: t statistics in parentheses,* p<0.1, ** p<0.05, *** p<0.01

5. Conclusion

To analyze the impact on housing sales in China, an optimal dynamic general equilibrium model is setup including unemployment. The empirical results indicate housing sales is positively correlated with the economic growth and is positively correlated with housing prices. Our spatial panel econometric empirical results suggest that housing prices and economic growth have increased housing sales in China. However, since house is considered as a special commodity in China, and unemployment show negative impacts on housing sales.

Future research avenues include development of the continues variable optimal dynamic stochastic general equilibrium of the nexus among housing prices, geography (Monkkonen *et al.,* 2012), job status (Zabel, 2012), home ownership (Li, 2017) and financial development (Tang & Coulson, 2017). This model would require an in-depth analysis of dynamic optimization of housing prices along with specially developed non-linear energy consumption function in China (Wang, 2011). In addition, a similar empirical framework could be extended by using a spatial difference-in-difference panel econometric model (Shih *et al.,* 2014). This model would require an in-depth analysis of the institutional effect of regional energy policy on housing prices and housing sales (Chen *et al.,* 2011). Finally, natural experiment coverage could be conducted to examine the nexus among energy consumption, housing prices and housing sale after and prior to national energy policy between the control regional group and treatment regional group (Du & Peiser, 2014). This strategy would enable researchers to investigate whether or not housing prices and housing sales are altered when energy intensity is improved (Chow & Niu, 2015).

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