Application Research of Q-Type Clustering Model in Financial Data Analysis of Beijing Housing Price

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Abstract. Under the influence of the socio-economic system, financial development and rising house prices are no longer two separate issues. For a specific regional environment, financial development will, to a certain extent, suppress the rising trend of house prices and contribute to the stable development of the regional economy. Based on the connotation of the role of Q-type clustering method, the trend of financial mechanism is determined, and then based on this, the temporal and spatial characteristics of the rising house prices in Beijing are studied. The Q-type clustering algorithm is combined with a threshold effect analysis model, and the practical value of the defined model is verified based on the results of the analysis of known data.

Keywords: Q-type Clustering Method, Financial Development, House Prices in Beijing, Threshold Effect

1 Introduction

Rising house prices have always been a pressing development problem that not only has a serious impact on the country's economic stability, but also has the potential to lower the average quality of life of residents. With the promulgation of the "New National Five" and "National Thirteen" policies to regulate the property market, domestic housing prices have not only failed to decline significantly, but have even risen sharply, with Beijing and other first-tier cities, for example, showing an undoubtedly alarming trend of price increases [1]. While house prices have risen, China's financial markets have developed significantly. According to available information, the development of the financial market has been able to optimise and regulate the credit structure of major banks, which has to a certain extent curbed the intervention of local government organisations in the internal credit environment of banks, and has had a beneficial effect on easing the pressure of rising house prices. In this way, access to development will not only contribute to the country's economic prosperity, but will also give the rising real estate market a good dose of regulation.

In their study, Tian Xinmin and Zhang Zhiqiang pointed out that there is a clear interaction between "financial technology", "economic resources" and "asset increment"[2]. As a fundamental part of economic development, "financial technology" is

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the lifeline for the development of the national economy, whether it is an individual business enterprise or a national organization, the pursuit of profit maximization is inseparable from the continuous development of financial technology; "economic resources" is a term used in the economic field. For the Chinese economic market, the most obvious effect of rising house prices is the accumulation of economic resources; "asset increment" is a state of economic excess, the periodic economic gains brought about by rising house prices can be regarded as fixed asset increment, and the continued accumulation of these assets will have a serious impact on the national. The continued accumulation of these assets has serious implications for the shape of the economy. Then, using the Beijing region as a division, a study is conducted on the relationship between financial development and rising house prices.

2 Theoretical Analysis

2.1 Q-Type Clustering Methods

Clustering methods, also known as cluster analysis methods, are processing methods that classify similar data objects according to abstract ideas. As an important data classification idea, its application aims to ensure the integrity and synchronisation of data objects at the same time. The idea of clustering can be applied in many fields in real life, such as computer science, economics, statistics, etc. However, the criteria for implementing clustering methods vary from field to field, but the results must ensure that all similar data sources are classified into the same data set. Due to the different standards for defining data objects, the clustering criteria used to create different data sets also differ [3-4]. The Q-type clustering method is a special kind of clustering idea that is more suitable for finance-related research. Its application aims at comparing similar economic indicators to determine whether the current economic policies implemented can meet the needs of regional economic development. From the existing research experience, the application scope of the q-type clustering method is limited, but its analysis accuracy is very high, especially for data objects with obvious geographical characteristics such as "house price", the q-type clustering method can maximize the authenticity and accuracy of the analysis results.

Let i denote the economic indicator definition coefficient, u denote the initial value of the time analysis vector, u' denote the maximum value of the vector u, $\hat{p}$ denote the clustering characteristics of the selected economic indicator, q_i denote the clustering value coefficient of the economic indicator, and e_i denote the clustering behaviour term coefficient of the economic indicator. By associating the above physical quantities, the Q-type clustering method expression W_i can be defined as:

$$W_i = \hat{p}\frac{\sum_u^{u'} q_i}{\sum_u^{u'} {e_i}^2} \tag{1}$$

The specific application is as follows:

Because the purpose of the Q-clustering algorithm is to divide the spatial data set $X(X = x_1, x_2, \cdots x_n)$ into k data clusters according to the current situation, and the center of the cluster is $Y = \{y_1, y_2, \cdots y_k\}$. Generally speaking, when considering the clustering algorithm, we need to consider the following three aspects.

(1) Whether there are clustering trends in the data;

(2) If trends are found to exist, how to find these clusters through the algorithm;

(3) Once these clusters are identified, the correctness of the grouping of these clusters is further verified by the algorithm.

The K-means algorithm is described as follows:

1) Assume that there are n nodes, and first select k nodes at random from these n nodes as centres for the initial clustering.

2) then assign other non-clustering centres to similar clustering centres according to their degree of correlation with the clustering centres.

3) calculating the average value of the nodes in each cluster.

4) keep cycling and repeating the above three processes until the standard measurement function starts to converge, and finally each cluster represents one sub-cluster.

The probabilistic model for the Q clustering algorithm is designed as follows: Assume that the spatial samples come from the following conditional probability mixture model:

$$p(x|\Theta) = \Sigma_{j=1,k} P(C_j) p_j(x|\theta_j, C_j) \tag{2}$$

where $\Theta = (\theta_1, \theta_2, \cdots, \theta_k)$ denotes the current number of surrogate parameters, where the parameter vector θ_j is unknown, $p(x|\theta_j, C_j)$ is the molecular weight density, representing the probability density of grouping type j, and the prior probability function $p(C_j)$ is the mixture calculation factor. The following further assumptions are made:

(1) The probability density function of each each group is currently spherically Gaussian distributed $\theta_j = (\mu_j, \Sigma)$, where $\Sigma_1 = \Sigma_2 = \cdots \Sigma_k = \sigma^2 I$, and μ_j and σ^2 are unknown.

(2) Each sample space belongs and is uniquely attributed to a subgroup.

(3) The mixing factors of all subgroups are equal.

Based on the above assumptions, the above probability distribution function can be further simplified as:

$$p(x|\Theta) = max\ \phi(x|\mu_j, \Sigma, C_j) \tag{3}$$

The above functions can then be solved by the maximum likelihood rule, including the Euclidean distance squared term in the minimum equation (3) which gives the K-means error sum-of-squares criterion function.

$$E = \sum_{i=1}^{k} \sum_{p \in C1} |p - m_i|^2 \quad (4)$$

The sum of the error squares of all data node objects within the function, p being the spatial point, representing the data object of the given data, and m_i denoting the mean of the data sub-cluster C. The function ultimately allows the sub-clusters to be compact and independent of each other. By iterating over the above criterion function, the mean of each Gaussian component and the covariance matrix can be derived:

$$\sum = \sigma^2 I, \mu_j = \frac{1}{n_j} \sum x_i \quad (5)$$

$$\sigma^2 = \frac{1}{nd} \sum_{j=1}^{k} \sum_{xj \in Cj} x_i - \mu_j \quad (6)$$

In the formula, n is the grouping which is also the clusters C. The Q -clustering algorithm works better for sub-clusters with spherical class and small difference in size. The Q-clustering algorithm also has good resilience and processing efficiency if the amount of computing data is relatively large.

2.2 Financial Development Trends

Taking Beijing as an example, the development trend of domestic financial policies is explored, as detailed in Table 1.

Table 1. Domestic financial policy trends (Table credit: original)

Stages of economic system development	Types of economic income generating enterprises	Development characteristics
Early Formation	Industrial, heavy industry and other industrial-based production and processing enterprises	High consumption of human and material resources, slow economic growth
Period of rapid development	Industrial-based enterprises predominate, while non-industrial enterprises such as the Internet are beginning to emerge	Still high consumption of human and material resources, but a slight increase in the rate of economic growth
Initial stabilization period	Rapid rise of non-industrial businesses such as the internet, with a declining share of industrial businesses	Controlled consumption of human and material resources and rapid economic growth

The financial policy trends in Beijing shown in Table 1 show that in the early years of the economic system, people focused on building industrial enterprises and most of the economic income was generated by consuming human and physical costs, the concept of financial development was weak at this stage and most people did not have enough financial means to afford additional expenses such as buying a house, so the average house price level in Beijing during this period was relatively low and the growth rate was slow. During this period of rapid development of the economic system, people began to focus on the development of non-industrial businesses such as the internet and continued to pay less attention to traditional industrial businesses. During this period, people gradually realised the importance of financial development policies

and some people began to be able to afford additional financial expenses such as buying a house, so the average level of house prices in the Beijing area continued to rise during this period. During the initial stabilisation period of the economic system, more and more people started to engage in non-industrial businesses such as the internet, more and more people realised that financial development was an effective means of promoting continuous social and economic growth, and the number of people who could afford additional expenses such as buying a house was gradually increasing, so the average house price level in Beijing continued to rise during this period, but due to the macro-control of the state and the government, there were some areas where the house price level began to stabilise after reaching the "ceiling" state.

2.3 Rising House Price Characteristics In Beijing

As the capital of the country, the level of house prices in Beijing not only reflects the basic economic income of its residents, but also to some extent represents the country's ability to develop its financial system. From a macro perspective, the trend of rising house prices in Beijing is generally in line with the trend of "higher and lower increases"[5]. The so-called "high drop" refers to the relatively high base house prices in the region, under the influence of financial development policies, the average value of their house prices in the next period of time does not show a significant upward trend, some special areas of the average value of house prices will also be a small increase, but the overall change is not significant; The term "low rise" refers to the tendency for average house prices to rise significantly in areas with relatively low underlying house prices as a result of financial development policies, and also refers specifically to the rise in house prices in areas with economic development potential, but where the average house price does not reach the nominal limit within a short period of time due to the low level of underlying house prices [6].

From the perspective of Q-type clustering thinking, the rising trend of property prices in Beijing's core urban areas is expected to take the lead in stabilising as the city's finance continues to develop. In terms of regional division criteria, Beijing property prices have a distinctly differentiated character, with prices in central urban areas such as the East and West urban areas, Haidian District and Chaoyang District performing relatively steadily. The performance of the house price market in remote suburban areas such as Miyun District and Yanqing District is relatively weak. For real estate development units, in order to obtain a higher level of economic returns, they should comply with the rules of urban financial development while achieving an accurate differentiation of the level of regional economic development within the city, in order to avoid the emergence of large-scale house price increases on the one hand, and to fundamentally help urban residents solve their housing problems on the other. In addition, Beijing, as a core first-tier city, has an extremely strong demand for housing, but buyers are always faced with a number of choices as the quality differentiation corresponding to different projects in the house price market varies.

3 Model Setup and Data Description

3.1 Q-Type Clustering Method Role Process

In order to study the impact of financial development on the rise of house prices in Beijing, the following aspects should be analysed based on the Q-clustering method.

(1) Regional financial development model: taking house prices in Beijing as an example, this paper analyzes the development form of regional financial mechanism, and combines house price samples with financial samples with the help of Q-type clustering method;

(2) The change law of house prices in Beijing: taking time as the independent variable, this paper analyzes the change trend of house prices in Beijing, and under the action of Q-type clustering method, combines financial samples with house price samples to solve the expression of threshold effect model;

(3) Threshold solution: under the action of Q-type clustering method, the impact of financial development on house prices in Beijing does not always show a continuous upward trend. When the house price level reaches a certain numerical standard, it will begin to decline. This numerical standard is the threshold.

The specific function flow of Q-type clustering method is shown in Figure 1.

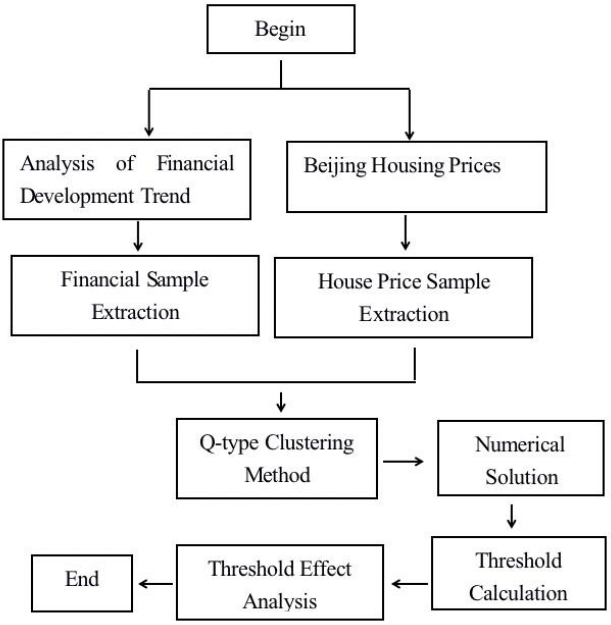

Fig. 1. Function Diagram Of Q-Type Clustering Method (Source of the figure: original)

3.2 Data Modeling

In the light of the above research, the effect of financial development on the rise of house prices in Beijing under the Q-type clustering method is in line with the idea of threshold effect analysis. The threshold effect is a situation where a particular economic parameter reaches a set value and causes a change in the form of development of other economic parameters and a sudden shift to other forms of development, and the threshold value that is the cause of the phenomenon is often referred to as the threshold [7]. In short, under the influence of the principle of the threshold effect, there is necessarily a non-linear relationship between value outcomes and development time, but this linear relationship is characterised by stages, i.e. there is a stage-by-stage developmental character to the mechanism of action of the threshold effect. For generalised economic and financial issues such as house prices, a threshold effect can be considered as a threshold panel model if the subject of the study contains multiple subjects or annual samples.

The most common expressions for extrapolating the threshold effect are as follows:

$$O_{\alpha} = \beta \left[\begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_{\alpha} \end{bmatrix} \right]_{\alpha \geq 1} \tag{7}$$

Where α denotes the maximum value of the threshold factor, e_1, e_2 and e_{α} denote α different analytical arithmetic and R denotes the threshold discriminant. β represents the threshold discrimination coefficient. Because Q-type clustering method has clear requirements for the repeated features of sample data, when solving the threshold effect expression, the analysis amount should be taken several times until its numerical features can meet the practical application requirements of clustering processing.

Under the influence of the Q-type clustering method, the expression of the threshold effect will change, at this time an analytical arithmetic may correspond to more than one analytical result, and with the increase of the total amount of data to be processed, the correspondence between the analytical arithmetic and the analytical result may also change, and the specific correspondence between the two is shown in Equation (3).

$$\begin{cases} s_1 = \delta_1 \cdot \dfrac{\sqrt{\dot{D}}}{e_1} \\ s_2 = \delta_2 \cdot \dfrac{\sqrt{\dot{D}}}{e_2} \\ \vdots \\ s_{\alpha} = \delta_{\alpha} \cdot \dfrac{\sqrt{\dot{D}}}{e_{\alpha}} \end{cases} \tag{8}$$

where s_1, s_2 ... s_{α} denote the results of α different threshold effect analysis, $\dot{D}$ denotes the arithmetic solution eigenvalues under the action of the Q-type clustering method, and δ_1, δ_2 ... δ_{α} denote α different clustering features.

Corresponding the financial development characteristics to the original idea of the Q-type clustering method, it is clear that if the financial development coefficient is used as the independent variable, the faster the rate of development of the regional financial system, the greater the result of the value that the dependent variable indicator may equal, given that the dependent variable indicator is a constant variable coefficient. Conversely, if the rate of development of the regional financial system is constrained, relatively small numerical results may be obtained for the dependent variable indicators, i.e. there is a constant dynamic correspondence between financial development characteristics and the Q-type clustering method. Let A denote the regional financial development covariate (under the Q-type clustering method, this physical quantity is the independent variable by default) and A' denote the result of the dependent variable taking values based on the Q-type clustering method. With the support of equation (3), the numerical correspondence between the coefficient A and the coefficient A' can be expressed as follows:

$$A' = \frac{(\phi-1)^2 \cdot A}{\sqrt[\alpha-1]{s_1+s_2+\cdots+s_\alpha}} \times \frac{f}{|\Delta H|} \tag{9}$$

In the above equation, ϕ denotes the regional financial development vector, the inequality condition for $\phi > 1$ holds constant under the Q-type clustering method, ΔH denotes the amount of unit returns to the regional economy, and f denotes the economic change characteristics.

By applying the calculation principle shown in equation (4) to the threshold effect of the impact of financial development on house price inflation in Beijing, it can be shown that A' can be approximated to be equal to the average value of the amount of house price inflation in Beijing, and the calculation of the A' indicator will vary depending on the urban area chosen for the study. In order to highlight the ability of the threshold indicator in the threshold effect to influence the rising trend of house prices in Beijing, it is stipulated that the calculated value of the A' indicator must be greater than the original A indicator taken in the case that the chain rate of increase of house prices in Beijing is greater than zero.

Equation (5) is an expression for the role of the threshold effect of financial development on house price inflation in Beijing under the effect of the Q-type clustering approach.

$$L_{A'} = \frac{\sum_{\varpi=1}^{+\infty} \lambda \cdot |A'|^{\varpi^2}}{v \cdot (\theta+\sigma)^2} \tag{10}$$

Where λ denotes the discriminant coefficient of the mean amount of house price increase in Beijing based on the Q-type clustering method, ϖ denotes the initial query coefficient of the mean value of house price increase in Beijing, v denotes the growth rate of house price increase in Beijing, θ denotes the temporal disturbance coefficient and σ denotes the spatial disturbance coefficient. Since the form of financial development is influenced by a combination of factors, regional averages are used for the

extraction of coefficient indicators such as Beijing property prices and increase parameters when solving the expression for the threshold effect, which on the one hand can avoid the influence of the characteristic parameter indicators on the solution of the universal law, and on the other hand can derive the universal trend of Beijing's house price increase behaviour, thus making the threshold effect mechanism The ability of the threshold effect mechanism is guaranteed.

The following hypotheses are made regarding the above theoretical basis.

(1) There is a linear relationship between the price level of real estate and financial development indicator in Beijing, so the threshold effect doesn't exist.

(2) Financial development is a threshold variable. Therefore, the same change in financial development leads to different growth in house price when the number of financial indicator belongs to differentiated range.

4 Empirical specification

4.1 Empirical Strategies and Indicators Selected

We examine the two hypotheses using an innovative GMM method developed by Seo and Shin [8], which is exactly the threshold analysis model described above. This model extends the Hansen [9] and Caner and Hansen [10] static panel threshold model and the Kremer et al. [11] panel threshold model by allowing for the transitional variable and other covariates to be endogenous. To estimate the coefficients, they propose a First Difference GMM (FD-GMM) transformation. This algorithm relaxes the exogeneity assumption on regressors and threshold variable and guarantee that the estimators follow a normal distribution asymptotically, which validates the use of Wald test for standard statistical inference on threshold and other parameters. Therefore, we consider the following specification for the house price equation:

$$AHP_{i,t} = \rho AHP_{i,t-1} + \alpha_L FD_{i,t} I(FD_{i,t} \le \gamma) + \alpha_H FD_{i,t} I(FD_{i,t} > \gamma) + \beta X_{i,t} + \upsilon_i + \tau_t + \ell_{i,t} \quad (11)$$

Where $AHP_{i,t}$ and $AHP_{i,t-1}$ are the current and lagged indicator of average house price. $X_{i,t}$ denotes the control variables including GDP per capita and population. $FD_{i,t}$ represents the financial development, which is treated as regime dependent variable as well as transitional variable. $I(\cdot)$ is an indicator of the regime. γ is a hypothetical threshold value. The subscripts L and H are referred to lower and upper regime, respectively. υ_i fixes the effect of district level variation, while τ_t fixes the time effect. $\ell_{i,t}$ shows the random error term. The loans issued by financial intermediation as a share of GDP is a measurement of financial development ($FD_{i,t} = Loans_{i,t} / \mathrm{GDP}_{i,t}$). And the price level of real estates in every region is

measured by the average house price ($¥/m^2$). All statistics are gathered from China Statistical Yearbook over the period from 2001 to 2020 in 16 districts of Beijing , then all these indicators get the Q-type clustering and log transformation.

4.2 Results

In the regression of house price, Equation (11), we regard financial development as not only a regime dependent variable but also a threshold variable. Financial development could be endogenous because of omitted variables and the reverse causality between real estate price and financial liquidity. Therefore, It is necessary to take the endogeneity into account. The novel GMM model could solve that problem perfectly.

Table 2 shows the results for every indicator of financial development using dynamic panel threshold method. For financial loans in second column, the effect of FD is positive and significant in the lower regime, while it becomes less significant in the upper regime. If the financial development indicator increases by 1%, the average house price should grow by 10.3% in the lower regime correspondingly, comparing with only 5.4% in the upper one. However, the locomotive effects of these control variables are much lower. 1% growth of population and GDP per capita results in 2.8% and 1.9% increase in average house price respectively. The lagged average house price could only explain about 0.7% rise of current house price. In addition, the estimated threshold value of financial loans rate is 42% and the linearity test indicates an overall significant nonlinear relationship. Also, the over-identification test (J-test) shows no over-identification problems.

Table 2. Dynamic Panel Threshold Analysis: Average house price regression. (Table credit: original)

Dependent variable: $\text{Ln.AHP}_{i,t}$	$FD_{i,t}$
Thresholds($\hat{\gamma}$)	0.42**
	(0.17)
Financial development	
$\hat{\beta}_L\left(FD \le \gamma\right)$	0.130***
	(0.032)
$\hat{\beta}_H\left(FD > \gamma\right)$	0.054*
	(0.029)
$\text{Ln.AHP}_{i,t-1}$	0.007*
	(0.004)
Ln.GDP/capita	0.019***
	(0.007)
Ln.population	0.028**
	(0.013)
Obs	320
Districts	16
Linearity test(p-value)	0.001
m_2	0.191
J(p-value)	0.547

Note: The null of linearity test is H0: $\hat{\beta}_L = \hat{\beta}_H$. m2 tests for lack of second order serial correlation in the residuals. The moment restrictions are not valid and the GMM estimator will be inconsistent If this test rejects the null hypothesis. The J test is a specification test which means that if it rejects, either the orthogonality conditions, or other assumptions, or both are false. Robust standard errors in the parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In summary, it can be concluded that financial development under the Q-type clustering method does bring about a threshold effect on the upward trend of house prices in Beijing. When financial development indicator does not reach the threshold value, the average house price in the region will continue to rise dramatically; while when financial development indicator reaches or has exceeded the threshold value, the average house price in the region will not rise as fast as it used to be in the lower regime, i.e. the hypothesis (2) is confirmed.

5 Conclusion

This paper has empirically tested the hypothesis that the higher financial development level leads to the lower house price growth rate, using a panel of 16 districts in Beijing over 2001–2020. Under the influence of the socio-economic system, financial development and rising house prices are no longer two separate issues. The influence relationship between financial development and the rising trend of house prices in Beijing under the effect of Q-type clustering method is:

(1) The threshold effect brought about by financial development has a strong real-time regulatory effect in restraining the rising trend of house prices in Beijing. In order to maintain the stability of the regional economic development, the implementation of financial policies should focus on stimulating public consumption when the price level is low, so that the social and economic motivation can be enhanced; when the price level is high, the implementation of financial policies should focus on maintaining the balance of public consumption and avoiding an unreasonable layout of the social and economic system.

(2) The ability of financial policy to regulate the rising behaviour of house prices in Beijing is a two-way street, maintaining the stability of the market-based economy and enabling the basic economic needs of residents to be met, while also dispatching available social and economic resources and enabling the constraining power of financial policy to be guaranteed.

For house prices in Beijing, the threshold effect brought about by the financial development system can not completely stabilize. In different periods of economic development or for different economic entities, their demand for financial policies is also different. Therefore, in the process of realizing the comprehensive construction of the economic system, we should not only pay attention to the development period of financial policies, but also consider the residents' demand for basic economy, Finally, combined with the influence relationship between the two, cluster analysis is carried out, and the financial and economic development strategy most in line with the actual application needs is summarized.

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