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Analysis of price fluctuation and its main influencing factors in urban housing market based on multiple linear regression modeling

Xiaohui Zhang[1,*]
[1] School of Mathematics and Statistic, Zhengzhou Normal University, Zhengzhou, Henan, 450044, China
Corresponding authors: (e-mail: zzsyzxh2006@163.com).

Abstract Urban housing prices are influenced by a variety of dynamic factors that work together in the real estate market. This study examines the key factors affecting price fluctuations in the urban housing market, focusing on analyzing housing price changes in Hangzhou. The effects of real estate enterprise factors, consumer demand, government policies, economic factors and housing characteristics on price volatility are investigated through a multiple linear regression model using a sample of 7,843 transaction data from six districts of Hangzhou's main urban area. The results show that enterprise factors (β=0.275, p=0.001), consumer factors (β=0.073, p=0.000) and government policies (β=0.055, p=0.000) are the important factors affecting house prices. The adjusted R^2 of the regression model is 0.695, which indicates that the selected variables have strong explanatory power for house price fluctuations. The model provides a valuable reference for real estate developers and government policy makers to help them better predict market trends and formulate appropriate strategies. The study shows that the strategies of real estate developers and consumer demand have a direct impact on house price fluctuations, while the government's regulatory policies and economic environment also play an important role in the market.

Index Terms housing prices, multiple linear regression, firm factors, consumer demand, government policies, economic factors

I. Introduction

The real estate industry is a pillar industry of a country, and the healthy development of this industry has an inescapable role in the overall development of a country's economy [1]. The degree of development of the real estate industry depends on the level of development of the economy of a region or a country, which in turn affects the level of economic development of the region, and it is mutually reinforcing and constraining with macroeconomic development [2]. The immovability of real estate and the territoriality of real estate consumption make the development of real estate industry has obvious regional characteristics. The regional characteristics of real estate will have a greater externality on the development of a regional economy, which affects the economic activities of the region through the output, investment, consumption and price of real estate [3], [4]. At the same time, the level of economic development of a region, natural resource endowment, etc. will determine the supply and demand of real estate in the region [5]. Therefore, the development and fluctuation of the real estate industry are influenced by many factors, which makes the development and fluctuation of the real estate industry have distinctive regional characteristics. The residential market is a market in which consumers, developers, financial institutions, the government and many other decision-making bodies participate, and its price fluctuations are not only affected by many macro factors such as the macroeconomic situation and industrial policies, but also by region-specific factors such as land supply and credit policies, which makes the fluctuations of residential prices complex and variable [6]-[8]. Therefore, the study of the fluctuation law of residential market price is of reference value in guiding the choice of consumers' purchase timing, developers and the design of regulatory policies [9].

At present, domestic and foreign scholars usually draw on the models and methods used to study the volatility of asset returns in financial markets to characterize the volatility of residential market prices. For example, Trung, N. D identified 24 factors affecting the price volatility of urban residential land, which can be categorized into eight categories and are significantly affected by the new crown epidemic [10]. Zhang, Y et al. investigated the impact of information disclosure on real estate market efficiency and found that an increase in the amount of disclosure reduces the magnitude of price volatility and decreases the likelihood of a real estate bubble by 57.4%, suggesting that greater transparency is needed to stabilize the housing market [11]. Alkali, M et al. found that different types of real estate have different volatility ranges, where negative information has a significant impact on the price volatility

of urban real estate homes, and pointed out policy implications for market regulation [12]. Jin, C et al. explored pricing patterns in the U.S. residential real estate market and found that fundamentals and irrational consumer sentiments, during periods of real estate volatility, and their aftermath, had a significant impact on pricing patterns [13]. Balli, H. O et al. used the EGARCH model to study the price volatility of residential property in New Zealand and found that macroeconomic fundamentals and tourism have a significant impact on house price volatility, and there are differences in the sensitivity of different regions [14]. In summary, price volatility in urban housing markets is influenced by a variety of factors.

Urban housing markets are complex and dynamic systems that are influenced by a wide range of social, economic and policy factors. Understanding the main factors affecting housing price volatility is crucial for developers, consumers and policymakers. In recent years, with the acceleration of urbanization, factors such as supply and demand in the housing market, government regulatory measures, and the macroeconomic environment have gradually increased their impact on price volatility. Many studies at home and abroad have shown that the investment decisions of real estate development enterprises, the purchasing power of consumers, and the policy measures of the government are the key factors determining the fluctuation of housing prices. However, real estate markets in different cities are affected by these factors to different degrees, especially for a rapidly developing city like Hangzhou, where price fluctuations in the housing market are particularly complex. Therefore, this study focuses on Hangzhou and deeply analyzes the main factors affecting the price fluctuation of its housing market, and quantitatively evaluates the degree of influence of each factor by means of a multiple linear regression model. The study modeled real transaction data from six districts of Hangzhou's main urban area through multiple linear regression analysis. The sample size of the data is 7843 items, of which the training set is 4642 items and the test set is 3201 items. The study considers five aspects, namely business factors, consumer factors, government policies, economic factors and housing characteristics, to explore the impact of these factors on the fluctuation of house prices. The data are divided using stratified sampling to ensure that the data from different regions are evenly distributed to improve the accuracy of the model. During the regression analysis, stepwise regression is used to ensure that the model can effectively extract important variables and exclude irrelevant variables. In addition, a series of diagnostic tests such as multiple covariance test and residual analysis were conducted to ensure the robustness of the model. Through these analytical methods, this study reveals the quantitative impact of various factors on house price fluctuations, providing theoretical support for policy adjustment and real estate decision-making.

II. Factors affecting price volatility in urban housing markets

II. A. Enterprise factors

Real estate development enterprises in the real estate market plays a dual role of producer and seller, the ultimate goal of its production and sales behavior is to maximize profits, real estate development enterprises in the various stages of real estate development will make different decisions, these decisions determine the future development and profitability of the enterprise. The price of real estate is composed of the production cost of real estate and the enterprise's expected profit, and its price setting will affect the enterprise's profit.

From the macro perspective of the market as a whole, factors such as the number of real estate development enterprises, the amount of investment, the area of new construction, the area of construction and the area of completion will all affect the supply of real estate and thus cause the price of real estate to varying degrees.

II. B. Consumer factors

People are the main body of the economy and society, each person in modern society can not exist as an isolated individual, need to exchange with others to obtain living materials, in the process of exchange produced producers and consumers, the two respectively as the real estate market suppliers and demanders, the status of equal importance, the two sides have formed an inseparable relationship.

From the macro perspective of the market as a whole, the number of consumers is also an objective factor that affects the price of housing, for example, a large number of rural laborers going to the city to work, rural families choosing to rent or buy houses in the city in order to give their children a better education, and outsiders coming to the local real estate market to buy a house, etc. will make the number of consumers in the local real estate market increase, thus raising the demand.

II. C. Governmental factors

The government is also an important player in the real estate market, providing land elements, formulating real estate-related policies, and monitoring the overall operation of the real estate market. By formulating land policies, the government can regulate real estate prices from the source. When prices are too high, increasing the supply of

land can reduce the cost of land acquisition by real estate enterprises, thus appropriately lowering prices. In addition, the government also often uses monetary policy to regulate the market, if the government adopts loose monetary policy, it will create a loose economic environment for the market by increasing the money supply or lowering the interest rate by two means, the real estate enterprise financing costs and the reduction of consumer personal housing loan costs so that both sides of the respective demand increase, which real estate enterprises increase the investment demand, the increase in consumer consumption demand, market size is further expanded. Real estate companies increased investment demand and consumers increased consumer demand, further expanding the market size.

II. D.Economic factors

In the macroeconomic environment, inflation and real estate prices have a close relationship, the overall rise in prices will bring about an increase in real estate prices. In addition, the overall rise in prices will offset the interest on residents' deposits, housing and real estate assets have a certain value-added capacity, in order to offset the losses brought about by inflation, consumers will reduce their holdings of monetary assets and turn to holdings of real estate assets, thus increasing demand for real estate and prompting the rise in housing prices. In the long run, a superior and stable macroeconomic environment will lead to the development of industrialization and urbanization, and the expansion of industrialization and urbanization will directly lead to the gathering of the working population, and the gathering of the working population will lead to the expansion of the demand for housing and the rise in housing prices.

II. E.Housing Characterization Factors

Commodity prices can not be separated from the impact of the characteristics of the commodity itself, for real estate commodities, the location of the house, house type, orientation, exterior design, decorative style and other factors will have a certain impact on the price of housing. There are real estate location attributes are also important factors affecting the price of housing, such as in the city center of the busy area of real estate on the consumers and investors have great attraction, in the location of the real estate can not only provide consumers with convenient living conditions, but also has a greater potential for appreciation, consumers and investors have a strong demand for real estate in the area, the price of housing naturally can not be lowered.

III. Data preparation and modeling

III. A. Data preparation

In the model construction process, the dataset is generally divided into a training set and a test set, the training set is used to construct the model and train the model, and the test set is used to test the model performance. The division of the data set is not only for the integrity of the model construction process, but also to prevent the phenomenon of overfitting that leads to a decline in the overall performance of the model. In machine learning, the dataset is usually divided into training set and test set in the ratio of 3:1.

The data in this study comes from the real transaction data of the six districts of the main city of Hangzhou, in order to ensure the accuracy of the final model, the data segmentation results should be uniformly distributed in the six districts of the main city of Hangzhou, and finally, the author divided the original dataset according to the way of stratified sampling in the administrative districts to obtain a total of 7,843 samples, with 4,642 for the training set and 3,201 for the test set.

III. B. Multiple linear regression modeling

III. B. 1) Introduction to multiple linear regression

Regression analysis is a predictive modeling technique that refers to a method of statistical analysis that determines interdependent quantitative relationships between two or more variables [15]. The method often uses the basic principles of data statistics to mathematically process a large amount of statistical data and determine the correlation between the dependent variable and certain independent variables, to establish a regression equation with good correlation, and to generalize it for use in predicting the change of the dependent variable in the future analytical method. According to the number of variables involved, it is categorized into univariate regression and multiple regression, and since the factors affecting housing prices are obviously diverse, this study adopts the form of multiple linear regression.

III. B. 2) Modeling

Multiple linear regression is one of the most widely used analytical methods in statistics to study the dependence between a dependent variable and multiple independent variables, by refining the important information hidden in

the data, and then summarize the inner law of the data, and can analyze the degree and manner of the influence of the explanatory variables on the dependent variable [16].

The general form of the multiple log-linear regression model is:

$$y = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_i x_i + \varepsilon \tag{1}$$

where y is the explanatory variable (dependent variable); $b_1, b_2, ..., b_i$ are unknown parameters (regression coefficients), b_0 is the regression constant; $x_1, x_2, ...x_i$ are explanatory variables (independent variables); and ε is the random error term.

For this study, suppose we end up with n sets of data $\{(x_{i1}, y_i), (x_{i2}, y_i), ..., (x_{ip}, y_i)\}, (i = 1, 2, ..., n)$, then the multiple linear regression model can be expressed as:

$$\begin{cases} y_1 = b_0 + b_1 x_{11} + b_2 x_{12} + \cdots + b_p x_{1p} + \varepsilon_1 \\ y_2 = b_0 + b_1 x_{21} + b_2 x_{22} + \cdots + b_p x_{2p} + \varepsilon_2 \\ \vdots \\ y_n = b_0 + b_1 x_{n1} + b_2 x_{n2} + \cdots + b_p x_{np} + \varepsilon_n d \end{cases} \tag{2}$$

It can also be expressed in matrix form as follows:

$$\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix} = \begin{pmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1p} \\ 1 & x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & x_{n1} & x_{n2} & \cdots & x_{np} \end{pmatrix} \cdot \begin{pmatrix} b_0 \\ b_1 \\ \vdots \\ b_n \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix} \tag{3}$$

III. B. 3) Model testing

For the multiple linear regression model it is also necessary to perform R -test, F -test and T -test.

(1) R test

R is here called the coefficient of complex correlation or full correlation coefficient, and the formula for the complex correlation R is:

$$R = \sqrt{1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{n} (y_i - \bar{y}_i)^2}} \tag{4}$$

The complex correlation coefficient R indicates how well the set of influences $x_1 \sim x_m$ is correlated with Y. The closer the R value is to 1, the better the effect of utilizing multiple linear regression.

(2) F test

The F test is used to test whether the whole regression coefficient is meaningful. The constructive statistic F is:

$$F = \frac{n - m - 1}{m} g \frac{R^2}{1 - R^2} \tag{5}$$

F obeys the F distribution with the first degree of freedom m and the second degree of freedom $n - m - 1$, and given the significant level A, checking the table of F distribution yields $F_A(m, n - m - 1)$. If $F > F_A(m, n - m - 1)$, it is considered that this set of regression coefficients is meaningful, and can be predicted using the established multiple linear regression prediction model; otherwise, it is considered that this set of regression coefficients is meaningless, and the established multiple regression model is not valid.

(3) T test

It is used to test whether each regression coefficient is meaningful or not. Construct the statistic T.

$$T_j = \frac{b_j}{\sqrt{c_j g \sigma}} \tag{6}$$

where c_{ii} is the j th element of the main diagonal of the matrix $(X'X)^{-1}$, and T_j obeys a distribution with $n-m-1$ degrees of freedom When given a significance level A, if:

$$|T| = t\frac{a}{2}(n-m-1) \tag{7}$$

Then x_i is considered to have a significant effect on γ, otherwise it is considered to have no effect, and the corresponding non-influential factor should be removed.

IV. Empirical results and analysis

IV. A. Parameter estimation and hypothesis testing of the model

IV. A. 1) Goodness-of-fit test for regression equations

According to the principle of stepwise regression method, the final model of this paper is the sixth model. The analysis of variance for the residential price model was obtained at the 5% significance level, as shown in Table 1.

By analyzing the results of the data in Table 1, it can be seen that: the coefficient of determination of the semi-logarithmic model, R^2, is 0.711, the adjusted R^2 is 0.695, and the coefficient of complex correlation, R, is 0.847. Since the three coefficients mentioned above are all greater than 0.7, then it means that the overall fit of the model is high, and that more parts of the explanatory variables can be explained, and vice versa, fewer parts of the variables fail to be explained. It is concluded that there is a strong linear relationship between the independent and dependent variables.

Table 1: Model summary

Model	R	R^2	Adjus R^2	Standard estimation error	Change statistics					
					R^2 change	F change	df1	df2	Sig.F change	Durbin-Watson
1	0.782[a]	0.606	0.602	0.14348	0.611	222.012	1	145	0.000	1.972
2	0.811[b]	0.647	0.460	0.13252	0.047	17.154	1	144	0.000	
3	0.825[c]	0.677	0.673	0.12174	0.033	15.158	1	143	0.002	
4	0.837[d]	0.692	0.684	0.12089	0.019	8.002	1	141	0.007	
5	0.847[e]	0.711	0.695	0.11857	0.022	10.037	1	140	0.005	

a. Predictor variables: (constant), business factors.

b. Predictor variables: (constant), business factors, consumer factors.

c. Predictor variable: (constant), business factors, consumer factors, government factors.

d. Predictor variables: (constant), business factors, consumer factors, government factors, economic factors.

e. Predictor Variables: (Constant), Business Factors, Consumer Factors, Government Factors, Economic Factors, Housing Characteristics Factors.

f. Dependent Variable: Housing Price

IV. A. 2) Significance test of regression equation

The regression analysis is shown in Table 2. The probability p-value of the significance test of the regression equation of residential prices in HCM City is 0.000, when the significance level α is 0.05, the probability p-value of this regression equation is smaller than the significance level α, which indicates that the regression equation is highly significant, and at the same time it can be concluded that the linear relationship between the characteristics of the residential houses that enter the equation and the dependent variable ($\ln P$) can be be established.

Table 2: Analysis of variance

Model		Sum of squares	df	Mean square	F	Sig.
5	Regression	5.213	5	0.757	63.274	0.001[f]
	Residual error	1.862	141	0.016		
	Total	7.087	147			

e. Predictor Variables:(Constant), Firm Factors, Consumer Factors, Government Factors, Economic Factors, Housing Characteristics Factors.

g. Dependent variable: housing prices

IV. A. 3) Significance test of regression coefficients

In the fifth model, the t-test values of the regression coefficients of all variables are less than 5%, as shown in Table 3. When the t-test values of the regression coefficients of the variables are all less than 5%, it indicates that the corresponding partial regression coefficients in this regression equation are significant. And the test of significance level is analyzed to show that the fit of semi-logarithmic model to the sample data is statistically significant and the regression equation is valid.

Table 3: Coefficient

Model		Nonnormalized coefficient		Standard coefficient trial	t	Sig.	Common linear statistics	
		B	Standard error				Tolerance	VIF
5	Constants	8.784	0.052		179.254	0.001		
	Enterprise factor	0.275	0.025	0.611	12.273	0.001	0.792	1.314
	Consumer factor	0.073	0.022	0.167	4.215	0.000	0.802	1.119
	Government factor	0.055	0.015	0.192	4.573	0.000	0.857	1.114
	Economic factor	0.049	0.012	0.203	4.483	0.001	0.733	1.428
	Housing characteristics	0.064	0.006	0.105	3.174	0.021	0.909	1.103

a. Dependent variable: housing prices

IV. A. 4) Multiple covariance test

Two important indicators of multicollinearity for model variables are: tolerance and variance inflation factor (VIF). In general, the variance inflation factor and tolerance is an inverse relationship, and its value range is greater than or equal to 1. Therefore, when the variance inflation factor takes the value of the minimum value of 1, the multicollinearity between variables is the weakest, that is to say, the smaller the value indicates that the multicollinearity between the explanatory variables is very weak; while when the tolerance takes a value of more than 0.1, it can be assumed that there is a weaker multicollinearity between the independent variable and the rest of the independent variables.

In the model analysis established in this section, the variance inflation factor of each variable analyzed and studied is close to 1 and the tolerance degree is greater than 0.1, which can be seen from the above description: the multicollinearity between the explanatory variables is very weak, the linear correlation does not exist, and it will not have an effect on the establishment of the regression equation.

The multicollinearity test is shown in Table 4. From the perspective of variance ratio, the third characteristic root can only explain 95% of the variance of the consumer factor, the fifth characteristic root can only explain 75% of the variance of the economic factor, the second characteristic root can explain 49% of the variance of the enterprise factor, and can explain 24% of the variance of the housing characteristic factor, which account for a relatively small proportion, and similarly the rest of the characteristics of the root can explain the variance of the variables account for a very small proportion, and therefore it can be learned that: there is no multicollinearity between the variables. Therefore, it can be learned that: multicollinearity between variables does not exist. From the analysis of the condition index, only the sixth condition index is greater than 10, and all of them are less than 10, which further indicates that there is no multicollinearity among the variables.

Table 4: Multiple linear test

Model	Dimension	Eigenvalue	Conditional index	Variance ratio					
				Constants	Enterprise factor	Consumer factor	Government factor	Economic factor	Housing characteristics
5	1	6.138	1.000	0.00	0.02	0.02	0.01	0.01	0.01
	2	0.351	3.239	0.00	0.51	0.01	0.012	0.26	0.01
	3	0.392	3.454	0.00	0.06	0.93	0.04	0.04	0.01
	4	0.311	4.271	0.01	0.28	0.05	0.03	0.22	0.24
	5	0.203	5.673	0.00	0.01	0.00	0.15	0.01	0.31
	6	0.045	10.833	0.94	0.19	0.01	0.08	0.07	0.41

a. Dependent variable: housing prices

IV. B. Regression model testing

IV. B. 1) Residual normality tests

If the regression model developed fits the data well, then the residuals should conform to a normal distribution. There are many different ways to perform residual normality tests, which can be performed by plotting histograms of standardized residuals, normal probability distributions, etc. to examine whether the residuals obey a normal distribution.

If the residuals are closer to the normal distribution, then the more the histogram of regression standardized residuals conforms to the normal distribution, and the more the points of the normal probability distribution plot are evenly distributed around the straight line. Specifically, as shown in Figures 1 and 2, it shows that the distribution of the residuals of the regression model we established basically conforms to the normal distribution and is meaningful.

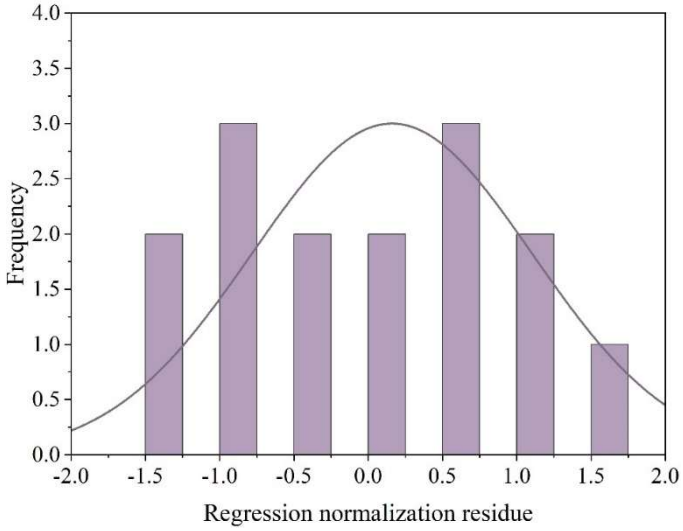

Figure 1: Residual difference analysis histogram

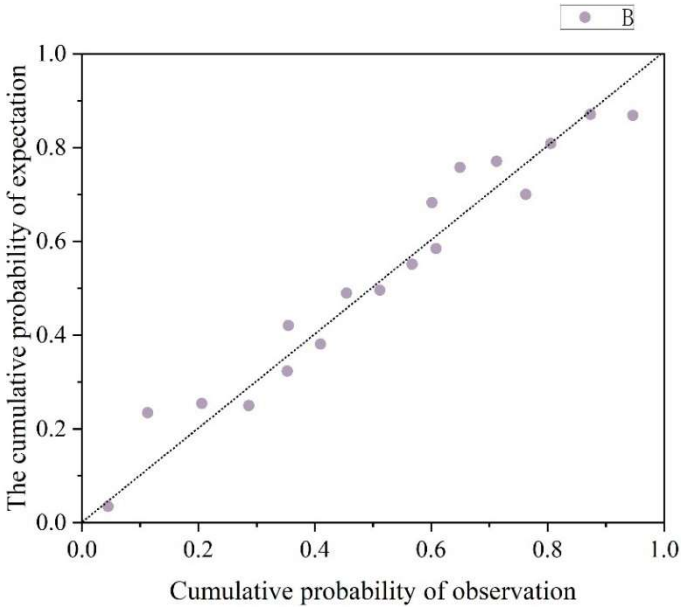

Figure 2: Normal probability profile

IV. B. 2) Heteroscedasticity test

If the random error term introduced in the modeling has heteroskedasticity, then the standardized residual plot will exhibit an asymptotic or decreasing shape as shown in Figure 3. The standardized residual plot of the optimal model is obtained from the figure, the points basically fall in the band interval of (2, +2) and the standard deviation of the

regression does not change with the increase of the expected value and is completely randomly distributed in the band, thus obtaining that the optimal model is well fitted to the data of the sampled sample.

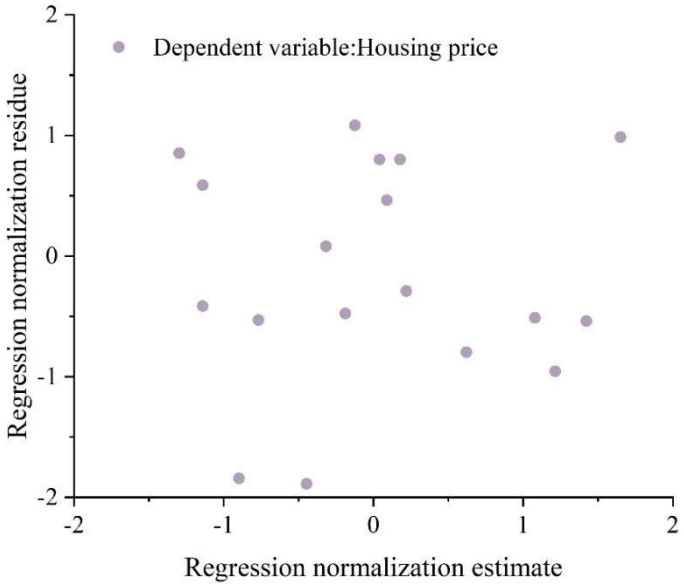

Figure 3: Heterovariance diagram

IV. B. 3) Strong point of influence test

Strongly influenced points can affect the effectiveness of linear regression, so we must pay attention to the detection of these points. However, in the regression process, selecting the standard deviation to set the outliers, the result does not show the outliers. By drawing the difference between the cookie distance and the leverage value is shown in Table 5. The strong influence points can be detected by this scatter plot. And it can be seen from the graph that 2017 is an outlier. In order to stimulate the economy, the state introduced a series of measures, including many preferential policies in the real estate market, such as the loosening of the capital of commercial housing development, preferential interest rates for loans, low-cost housing and affordable housing reduction policies, and so on. Make housing prices and sales soared, realize the magnificent reversal from the trough to the peak. Can be seen, the government factors urban housing market price occupies a fairly important position.

Table 5: Cook distance and leverage value difference

Year	Value
2008	0.3901
2009	0.2011
2010	0.5842
2011	0.5887
2012	0.1762
2013	0.0000
2014	0.0000
2015	0.1853
2016	0.1771
2017	1.8642
2018	0.1825
2019	0.3759
2020	0.1633

IV. C. Analysis of the economic significance of the model

From the regression equation obtained, it is known that two factors, consumer factor and economic factor, are the key factors influencing the prices in the housing market during the period 2008-2020.The trend of increase in the prices of urban housing during the period 2008-2020 is shown in Table 6. It can be seen that the consumer economy has steadily increased during the 13-year period from 2008 to 2020. The economic and social development of a

region can be seen from the changes in the consumer economy. The urban consumer economy is an inevitable consequence of modernization and can contribute to the expansion of market size as well as accelerate the progress of industry to feed the modernization of agriculture.

Table 6: The growth trend of consumers and economic factors in 2008-2020

Year	Consumer economy	Economy policy
2008	4.63504	34.34389
2009	17.51825	36.1086
2010	30.40146	35.02262
2011	42.40876	38.59729
2012	55.58394	40
2013	66.75182	41.08597
2014	80.18248	41.40271
2015	91.05839	43.21267
2016	104.23358	43.52941
2017	117.11679	46.0181
2018	127.9927	49.95475
2019	141.45985	52.39819
2020	153.46715	53.84615

V. Conclusion

The results of the analysis of Hangzhou housing market show that enterprise factors, consumer factors and government policies are the key factors determining the fluctuation of house prices. Through the regression analysis of the multiple linear regression model, corporate factors (β=0.275, p=0.001) have the greatest influence on house price fluctuations, while consumer demand (β=0.073, p=0.000) and government policies (β=0.055, p=0.000) also have a significant influence. The adjusted R^2 value of the model is 0.695, indicating that the selected influences can explain most of the price fluctuations. Specifically, the investment decisions of real estate developers directly affect the supply side, while the purchasing power of consumers determines the changes in the demand side, and government policies have a significant impact on market prices by regulating land supply and interest rates. The study also shows that economic factors and housing characteristics have a relatively small impact on house prices, but they can also exert some pressure on the market during certain specific periods. Overall, policymakers should pay attention to changes in business behavior and consumer demand, and adopt flexible regulatory measures to cope with fluctuations in the housing market. Real estate developers, on the other hand, should adjust their development strategies according to market demand and policy directions to ensure the return on investment of their projects.

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