Quantitative study on factors affecting the price of residential real estate multiple linear regression model

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Abstract. To study the impact of the “zero threshold” household entry policy on the fluctuation of residential commodity housing prices in Jinan, this paper uses the average sales price data of residential commodity housing in Jinan from 2006 to 2018, selects 6 relevant indicators including the total population at the end of the year, and constructs a multiple linear regression model. The model uses Eviews7.2 software, innovatively implies variables such as equivalent sound level, performs stepwise regression analysis, weighted correction regression model correction, and performs statistical tests such as heteroscedasticity and sequence correlation. The results show that the local general public budget expenditure and the average equivalent sound level of roads and environment have a positive impact on prices, while the local general public budget revenue and the total population at the end of the year have a negative impact on prices.

1. Introduction

On June 1, 2020, the "Jinan City Public Security Bureau implemented the implementation rules for the comprehensive opening of restrictions on settlement" was fully implemented. Jinan, the capital of Shandong Province, achieved a "zero threshold" for settlement, and it will attract a large number of people to gather in Jinan in the future. After the new population is settled in Jinan, production activities such as entrepreneurship and employment will continue to increase local fiscal revenue, and will also encourage local governments to increase fiscal expenditures, solve the new households’ demand for residential commercial housing, and improve and optimize the living and business environment. Improve the quality of living.

There are many factors that affect the fluctuation of residential real estate prices. Foreign scholars mainly study the five perspectives of supply and demand factors, government policies, consumer (individual) factors, residential characteristics, and spillover effects through regression models and heterogeneous expectations models (Xia Enjun, 2018) [1]. In the United States, Holly, Pesaran and Yamagata research found that every 1% increase in household income can drive house prices up by 1% (Eddie Chi-Man Hui, Xin-Rui Wang, Sheng-Hua Jia, 2016) [2]. In Germany, Maennig and Dust research found that population decline will lower housing prices, but population growth has no effect on housing prices (Eleonora Granziera, Sharon Kozicki, 2015) [3]. In Spain, studies by Gonzalez and Ortega have shown that immigration inflows contributed about 52% of the country’s house price rise in 1998-2008 and 37% of the increase in new housing (Anupam Nanda, Jia-Huey Yeh, 2014) [4].

Domestic scholars have tried to conduct research from six aspects such as residents' income, social output, construction cost of commercial housing, and supply and demand (Li Yonggang, Wu Xiaozhou, 2016) [5] (Zhou Liangjin, Xia Enjun, Wei Xing, 2019) [6]. In Shanghai, for the dynamic characteristics...
of real estate prices, an empirical study of real estate price prediction methods based on Elman neural network (Hu Xiaolong, Gao Zhenhua, Ma Guanghong, 2008) [7]; support vector machine based on principal component analysis can also be used Shanghai house price prediction (Shen Ruina et al., 2013) [8]; In Wenzhou, the total area and total sales are converted into price indicators, and the gray system is used to construct the model to predict prices (Guo Peijun, Mao Haizhou, 2009)[9 ]; In Beijing, research on house price prediction based on the Markov chain (Gu Xiujuan et al., 2012) [10]; Granger causality test and VAR model can also be used to analyze the interaction between real estate development investment and inflation Research on the impact of relationship on housing prices (Zhang Hong, Yang Fei, 2012) [11]; in Taiyuan, combining wavelet analysis theory with ARMA model to predict urban housing prices (Hou Puguang, 2014) [12] ; In Xinjiang, through the establishment of a gray Markov prediction model, it has continuously predicted the trend of high prices of commercial housing (Han Xuejuan, 2019) [13].

The above research fully shows that in different countries and different urban real estate markets, the same or different prediction models and explanatory variables have significant differences in the significance of the price of residential commercial housing. The results reflect that the scope of application of various models is limited by the regional characteristics of the real estate market. In order to better study the impact of Jinan’s household registration system reform and population influx on the fluctuation of residential real estate prices in Jinan, this paper selects a widely used multiple regression model for prediction. The final result can provide a theoretical reference for the Jinan municipal government to stabilize real estate prices, formulate and promulgate relevant real estate regulation and control policies, and can also satisfy real estate development enterprises to formulate residential commodity housing prices and provide a basis for decision-making. It can also be used to evaluate the price trend for consumers to purchase residential commercial housing.

2. Research design

2.1. Data sources
In this study, from the "Jinan City Statistical Yearbook", the factors affecting the price fluctuations of residential housing in Jinan from 2006 to 2018 were selected. In order to ensure the availability of data, the average value of road traffic equivalent sound level and environmental noise equivalent sound level is calculated.

Table 1. Statistical Table of Influencing Factors of Residential Commercial Housing Prices in Jinan City from 2006 to 2018.

| Years | Average sales price of residential commercial houses (yuan/square meter) | Local general public budget revenue (100 million yuan) | Local general public budget expenditure (100 million yuan) | Total population at the end of the year (ten thousand people) | Road traffic equivalent sound level dB(A) | Environmental noise equivalent sound level dB(A) |
|-------|-------------------------------------------------|---------------------------------------------------|---------------------------------------------------|-------------------------------------------------|----------------------------------------|---------------------------------------------|
| 2006  | 3318.9                                          | 128.44                                            | 146.98                                            | 603.35                                          | 68.6                                   | 53.9                                        |
| 2007  | 3719.62                                         | 157.02                                            | 179.98                                            | 604.85                                          | 69.6                                   | 53.2                                        |
| 2008  | 4155                                            | 186.02                                            | 221.32                                            | 603.99                                          | 69.8                                   | 53.0                                        |
| 2009  | 4790                                            | 210.19                                            | 259.92                                            | 603.27                                          | 69.3                                   | 54.1                                        |
| 2010  | 6100                                            | 266.13                                            | 336.8                                             | 604.08                                          | 69.7                                   | 54.1                                        |
| 2011  | 6663.89                                         | 325.42                                            | 396.88                                            | 606.64                                          | 69.5                                   | 53.8                                        |
| 2012  | 6650.56                                         | 380.82                                            | 465.67                                            | 609.21                                          | 69.1                                   | 52.3                                        |
| 2013  | 7013                                            | 482.07                                            | 519.32                                            | 613.25                                          | 69.3                                   | 52.6                                        |
| 2014  | 7158                                            | 543.13                                            | 571.41                                            | 621.61                                          | 69.7                                   | 54.2                                        |
| 2015  | 7527                                            | 614.32                                            | 658.18                                            | 625.73                                          | 70                                     | 53.6                                        |
| 2016  | 8405                                            | 641.22                                            | 741.26                                            | 632.83                                          | 67                                     | 53.1                                        |
| 2017  | 9712                                            | 677.21                                            | 834.06                                            | 643.62                                          | 70.6                                   | 53.7                                        |
| 2018  | 12161.45                                        | 752.82                                            | 1018.25                                           | 655.9                                           | 69.7                                   | 53.3                                        |
2.2. Variable selection
In this study, the number of population changes was selected as the main explanatory variable. At the same time, based on the innovation of research methods, local fiscal revenue, local fiscal expenditure, and equivalent sound levels that have a significant impact on life and production are selected as explanatory variables, and a multiple regression evaluation model of residential commercial housing prices is constructed to evaluate the prices of residential commercial housing in Jinan. Fluctuations.

Model design
Let \( Y_i \) be the average sales price of residential commercial housing, \( X_{1i} \) be the local general public budget revenue, \( X_{2i} \) be the local general public budget expenditure, \( X_{3i} \) be the total population at the end of the year, \( X_{4i} \) It is the equivalent sound level of road traffic dB(A), \( X_{5i} \) is the equivalent sound level of ambient noise dB(A), \( \beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5 \) are the parameters, and \( \mu_i \) is the random disturbance term. Establish an initial multiple regression model:

\[
Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \mu_i \tag{1}
\]

Because this model does not perform parameter estimation and model testing, there is the possibility of explanatory variable adjustment, so equation (1) is called the initial model.

3. Measurement inspection and result analysis

3.1. Equation (1) Model estimation results and analysis

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| C        | 24584.86    | 9814.382   | 2.504983    | 0.0407|
| \( X_{1i} \) | -11.04197  | 1.688746   | -6.538562   | 0.0003|
| \( X_{2i} \) | 21.96590   | 1.907174   | 11.51751    | 0.0000|
| \( X_{3i} \) | -66.58567  | 14.38314   | -4.629424   | 0.0024|
| \( X_{4i} \) | 92.14355   | 76.30293   | 1.207602    | 0.2664|
| \( X_{5i} \) | 200.0181   | 113.0037   | 1.770014    | 0.1200|

It can be seen from the estimation results in Table 2 that local general public budget revenue, local general public budget expenditure and year-end total population Jinan City residential commercial housing price fluctuations have a significant impact, and the equivalent sound level of road traffic and the equivalent noise level of environmental noise have an impact. The impact of price fluctuations of residential commercial housing in the city is not significant. Based on the actual situation, this result may be caused by multicollinearity between variables. Therefore, continue to use stepwise regression analysis to test the possible multicollinearity between explanatory variables, and according to the economic significance of each explanatory variable, the relevant Variables, such as removal and replacement.

3.2. Stepwise regression analysis
The initial model (1) test results fully show that the equivalent sound level of road traffic and the equivalent sound level of environmental noise have no significant effect on the price fluctuation of residential commercial housing in Jinan. Considering that both variables are related to the equivalent noise level of noise, there may be multi-collinearity. Therefore, the method of one-by-one elimination is adopted to establish the model (2) and perform quadratic regression.

\[
Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \mu_i \tag{2}
\]

Using the same method as model (1), the output of the secondary estimation in Table 3 is obtained:
Table 3. Equation (2) model estimation output.

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| C        | 29208.42    | 10647.10   | 2.743322    | 0.0253|
| $X_{1i}$ | -10.62167   | 1.881702   | -5.644713   | 0.0005|
| $X_{2i}$ | 21.16890    | 2.085733   | 10.14938    | 0.0000|
| $X_{3i}$ | -60.06032   | 15.64662   | -3.838549   | 0.0050|
| $X_{4i}$ | 124.6358    | 83.35226   | 1.495290    | 0.1732|

It can be seen from the estimation results in Table 3 that after removing the explanatory variable of equivalent noise level of environmental noise, the local general public budget revenue, local general public budget expenditure and the total population at the end of the year still have significant effects on the price fluctuations of residential commercial housing in Jinan. However, the effect of the equivalent sound level of road traffic on the price fluctuation of residential commercial housing in Jinan is still not significant. Therefore, it is necessary to eliminate the equivalent sound level of road traffic and adopt further modification of the model.

3.3. The revised model

Comprehensively considering the results of quadratic regression, the actual economic significance of each explanatory variable, the equivalent sound level of road traffic and the equivalent sound level of environmental noise have a certain impact on the price fluctuation of residential commercial housing in Jinan City, and cannot be eliminated by a simple method of eliminating variables Processing, in order to further analyze the effect of equivalent sound level on the price of residential commercial housing in Jinan, this paper uses a simple arithmetic average method to calculate the equivalent sound level of road traffic and the equivalent sound level of environmental noise to obtain the average equivalent of road and environmental noise. The sound level is used as the explanatory variables $X_{6i}$ and $\beta_6$ as the parameters, and the correlation test is performed between each explanatory variable. As shown in Table 4:

Table 4. Statistical table of correlation test between explanatory variables.

| Introduced explanatory variables | R2    | p-value of t statistic | P-value of F statistic | significant |
|----------------------------------|-------|------------------------|------------------------|-------------|
| $X_{1i}$                         | 0.8693| 0.00                   | 0.00                   | Y           |
| $X_{1i}, X_{2i}$                 | 0.9761| 0.01,0.00              | 0.00                   | Y           |
| $X_{1i}, X_{2i}, X_{3i}$         | 0.9889| 0.00,0.00,0.01         | 0.00                   | Y           |
| $X_{1i}, X_{2i}, X_{3i}, X_{6i}$ | 0.9927| 0.00,0.00,0.04         | 0.00                   | Y           |

To sum up, establish a revised regression model:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_6 X_{6i} + \mu_i$$

(3)

Using the same method as the models (1) and (2), the estimated output results in Table 5 are obtained:

Table 5. Equation (3) model estimation output.

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| C        | 24539.33    | 9509.956   | 2.580383    | 0.0326|
| $X_{1i}$ | -10.84131   | 1.613667   | -6.718434   | 0.0001|
| $X_{2i}$ | 21.65207    | 1.798496   | 12.03898    | 0.0000|
| $X_{3i}$ | -64.51095   | 13.65100   | -4.725730   | 0.0015|
| $X_{6i}$ | 259.2042    | 107.5570   | 2.409923    | 0.0425|

From the estimation results in Table 5, it can be seen that the combined road and environment average equivalent sound level, local general public budget revenue, local general public budget expenditure and
total population at the end of the year have a significant impact on the price fluctuations of residential commercial housing in Jinan. Therefore, the regression result of the model is obtained:

\[ Y_i = 24539.33 - 10.84131X_{1i} + 21.65207X_{2i} - 64.51095X_{3i} + 259.2042X_{6i} \]  \hspace{1cm} (4)

The analysis results show that the average sales price of residential commercial housing has a negative correlation with the local general public budget revenue and the total population at the end of the year, and has a positive correlation with the local general public budget expenditure and the average equivalent sound level of roads and environment, which is the same as the proportional relationship in the model. The economic significance is in line with the theory, indicating that the modified model has a good degree of fitting, the constant items and the t-test values of each explanatory variable are all passed, and there is no multiple collinearity.

3.4. Model checking

3.4.1. Goodness-of-fit test. Calculated using Eviews7.2, the coefficient of determination \( R^2 = 0.995177 \) and the coefficient of adjustment \( \bar{R}^2 = 0.992766 \), indicating that the sample regression equation fits the sample observations well, and the explanatory variables affect the price of residential commercial housing in Jinan. The interpretation ability is 99.27\%, and it can be judged that the modified model fits well.

3.4.2. Overall significance test. The following hypotheses and alternative hypotheses are proposed: \( H_0: \beta_0=\beta_1=\beta_2=\ldots=\beta_k=0 \), \( H_1: \beta_j \) is not all 0. Have obtained \( F=412.7018 \), given \( \alpha=0.1 \), the table look-up degrees of freedom \( k-1=4 \) and \( n-k=8 \) are: \( F_{\alpha}(4,8)=2.806 \), because \( F>F_{\alpha}(4,8) \), it fully shows At a significance level of 0.1, the model rejects the null hypothesis that the population is not significant. Therefore, the model is significant overall.

3.4.3. Overall significance test. The comparison between the Fitted curve and the Actual curve fully shows that the multivariate linear model of the factors affecting the price of residential commercial housing in Jinan has a good effect.

4. Results and discussion

This article uses a multiple regression model and uses the data of "Jinan Statistical Yearbook" to make a step-by-step regression analysis of the factors that affect the price fluctuations of residential commercial housing in Jinan, and corrects the average equivalent sound level of the road and the environment to successfully build a regression of residential commercial housing price fluctuations. The study found that the increase in local general public budget revenue and the total population at the end of the year can effectively stabilize and reduce prices, while the increase in local general public budget expenditure and the average equivalent sound level of roads and environment is conducive to economic construction, to the improvement of the living quality, to the promotion of the real estate prices.
The enlightenments of this article for the research on the price fluctuation of residential commercial housing in Jinan are as follows:

First, we should always adhere to the "houses are used to live, not used to speculate" policy, while developing the economy and improving the priority of the provincial capital city, adhere to the real estate purchase restriction policy and real estate tax policy unshakable, it is recommended to pilot real estate tax. The reform of the fee system, by increasing the household holding cost of residential commercial housing, speeding up and increasing the supply of residential land, to achieve an increase in local general public budget revenue, with effectively controlling the rapid rise in residential commercial housing prices.

Second, while achieving a “zero threshold” for settlement and attracting a large number of talent inflows, it is also necessary to solve the problem of potential population retention and achieve a positive increase in population net inflows in order to better reduce the price of residential commercial housing. Third, reducing the use of local general public budget expenditures in areas with higher prices can increase expenditures on infrastructure construction such as subways and construction of new districts, etc., to narrow the gap in commodity housing prices in different regions, and to control the rapid rise in prices as a whole.

Fourth, through industrial upgrading and the conversion of old and new kinetic energy, reduce the impact of roads and environmental equivalent sound levels on residents' lives, scientifically guide the movement of population, moderately reduce the purchase demand for residential commercial housing in the core area population, and effectively control and stabilize real estate prices.

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