Study on the Influence of Metro on the Housing Price Around the Line--A Case Study of Luoyang Metro Line 2

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Abstract. This paper takes Luoyang Metro Line 2 as an example to study the impact of the metro line on the surrounding house prices. Combining with the hedonic price model, the paper uses the linear model and the semi-logarithmic model to analyze the impact of the metro line on the surrounding house price. The results show that the surrounding house price of the metro is affected by many characteristics. The value-added benefit of the subway is the most obvious in the range of 2000 meters around the subway station, and the subway station is beneficial to the value-added of the surrounding land. At the same time, neighborhood characteristics, other location characteristics and architectural features also have a certain impact on housing prices. Finally, combined with these effects, the government and real estate developers put forward some suggestions to promote the better implementation of urban planning around the subway.

1. Preface

With the rapid development of Chinese economy, the urban population is increasing day by day. Traffic congestion, environmental pollution and other issues are becoming increasingly serious. Because of its advantages of safety, speed and environmental protection, subway has become an important tool to alleviate urban traffic problems. Metro, as a very advantageous means of transportation, has a strong radiation effect. Along the subway, a large number of living, commercial, office and other facilities gathered, thus enhancing the development of the land around the subway station. The impact of the subway on the surrounding house prices has become a hot topic at home and abroad. Subway increases the convenience of people’s life and travel, improves the location conditions, and promotes the development of surrounding commercial economy. But different cities have great differences in development level, geographical location and so on, the impact of the subway on the surrounding housing prices cannot be generalized. Luoyang subway is currently in its infancy, and the quantitative analysis of the impact of Luoyang subway on the surrounding housing prices has a certain research significance.

2. Project Introduction

The master plan of Luoyang Metro consists of four main lines, which were formally submitted to the National Development and Reform Commission in February 2016 and approved for approval in August of the same year. As a result, Luoyang City became the second metro city in Henan Province and the first non-provincial capital city in the central and western regions of China to have a metro. In December 2016, the trial construction of Luoyang Longmen Station of Luoyang Line 2 began. In December 2017, a ceremony was held at Luoyang Station to mark the start of the construction of Line 2. According to the master plan, Luoyang Metro Line 2 has 19 stations. The first phase of the project, which starts at
Jingsan Station and ends at Longmen Avenue Station, is about 18.3 kilometers long, with 15 stations and an investment of 14.03 billion yuan. The first phase is expected to be completed and put into operation in the first half of 2022. The second subway line is the main traffic route connecting the north and south of the main urban area of Luoyang City, which will greatly shorten the transit time of the north and south traffic after the completion of the project.

3. Model Selection and Variable Explanation

3.1. Model Selection

From the domestic and foreign literature, we can see that there are three main theories about rail transit and housing price, including demand function model, transportation cost model and hedonic price model. Demand function model focuses on the relationship between supply and demand to determine the impact of supply and demand is more complex and changeable, and the traffic cost model is mainly based on the traffic cost as a reference, although it is simple and easy to implement, but the credibility and persuasion is low. Hedonic price model refers to the utility or satisfaction of a product or service. This kind of utility or satisfaction is not entirely brought about by the product itself, but it is determined by the characteristic attributes it contains. From this theory, it can be seen that the price of goods or services can be composed of the unit price of the corresponding attributes, which is called characteristic price. The difference of housing price is caused by the characteristic attribute of the house, different characteristic attribute price determines different housing price. Because of the contribution effect and satisfaction degree of the specific characteristic attribute, the housing price is different. Hedonic price model is an applied method of econometrics. There are three functional models in the application research of real estate price. Hedonic price model is an application method of econometrics. There are three main forms of application research in real estate price, namely linear form, logarithmic form and semi-logarithmic form.

Linear form: \[ P = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon \]

Logarithmic form: \[ \ln P = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \cdots + \beta_n \ln X_n \]

Semi-logarithmic form: \[ \ln P = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n \]

In the above three formulas, \( P \) is the price per square meter of housing and \( X \) is all the characteristic attributes of housing; \( \beta_0 \) is a constant that represents the sum of all other feature attributes; \( \beta_1 \sim \beta_n \) is the eigenvalue of the eigenvariable and \( \epsilon \) is a random error term. Three different forms of expression have different application scenarios, and model formulas should be selected according to specific data characteristics and availability. Many of the independent variables selected in this paper are dummy variables with values of 0 and 1, which cannot be logarithmically processed. Therefore, linear model and semi-logarithmic model are selected for model fitting. From the domestic and foreign references, the neighborhood characteristics, location characteristics and building characteristics of housing are the main characteristics of the study of housing price influencing factors, this paper selects 17 independent variables to build a hedonic price model.

3.2. Variable explanation

3.2.1. Dependent variable. Housing price is the dependent variable of the model, and the transaction price of housing in China is not the public data content. The data used in this paper are obtained from the network. In order to ensure the rigor and applicability of the data, the housing price needs to be normalized, such as putting forward the factors of rising prices and so on.

3.2.2. Location characteristic variable. The location characteristic of the house refers to the location characteristic of the house in the ground. Because of the specific distance from the house to the subway station, this paper takes the distance as the variable to assign the value. If there is a subway station within
a certain distance, the value is 1, otherwise it is 0. For example, M0 means that the distance between the building and the subway station is 1 within 500 meters, otherwise 0; M1 means that the distance between the real estate and the subway station is 1 within 500-1000 meters, otherwise it is 0; M2 means that the distance between the real estate and the subway station is 1 within 1000-2000 meters, otherwise it is 0; M3 means that the distance between the real estate and the subway station is 1 within 2000-3000 meters, otherwise it is 0. The distance to CBD (M4) and the number of bus routes within 500 meters (M5) are also important location characteristics.

3.2.3. Neighborhood characteristic variable. Neighborhood matching is an important variable affecting housing price. In this paper, the neighborhood characteristic variables are the greening rate (N1), the number of schools within 500 meters (N2), the number of hospitals (N3) and the property cost (N4).

3.2.4. Architectural characteristic variable. The building characteristics of residential buildings include building area (A1), orientation (A2), plot ratio (A3), decoration degree (A4), average age of residents (A5), building types (A6), conversion floor (A7).

3.3. Data Source and Description Statistics
In this study, 52 ordinary residential buildings within 4000 meters of Luoyang Metro Line 2 are collected, and the construction ages range from 1 to 25 years. The number of units selected for each project varies from 1 to 10, and the total number of samples collected is 457. The unit price varies from 5067 to 22979 yuan/m², the area varies from 33m² to 216m², and the floor is from 1 to 21 floors. The data of this study come from the sales department of each building and the sales center of second-hand housing.

4. Data analysis
4.1. Model operation result
4.1.1. Initial Model Operation Results
On the basis of the linear model and semi-logarithmic model proposed above, SPSS 25.0 is used to fit the regression model of the data, and the fitting results of the linear model and semi-logarithmic model are obtained. The fitting results of the initial linear model are shown in Table 3. The adjusted R² of the model is 0.699, and the independent variable can explain 69.9% of the variation of the dependent variable. The fitting degree of the model is good. The F statistic is 63.362 and the corresponding significance Sig. Value is 0.000, that is, the model passed the F test, and the overall linear relationship between dependent and independent variables is established. From the regression coefficient, the dependent variables Price are M0, M1, M4, N1, N3, N4, A1, A3, A4. M2 has no significant effect on Price, but it is not excluded because of its economic significance. The histogram, normal P-P diagram and scatter diagram of the initial linear model are shown in Figure 1. The results show that the normalized residual increases when the house price is more than 18000 yuan/m². In order to ensure the applicability of the model, a sample with the house price more than 18000 yuan/m² is needed.

The fitting results of the initial semi-logarithmic model are as shown in Table 4. The adjusted R² of the initial semi-logarithmic model is 0.749, and the explanatory power of the independent variable to the dependent variable is 74.9%. The fitting degree is good. The F statistic is 80.896 and the corresponding significance Sig. Value is 0.000. The surface model passes the F test. From the regression coefficient, the dependent variables LNPrice are M0, M4, N1, N3, N4, A1, A3, A4, A6.
Table 1. Initial linear model fitting results

|                | Unstandardized Coefficients | Standardized Coefficients | t     | Sig.  |
|----------------|-----------------------------|---------------------------|-------|-------|
| (Constant)     | 7721.676                    | 950.364                   | 8.125 | .000  |
| M0             | 1253.179                    | 494.165                   | 2.536 | .012  |
| M1             | 916.101                     | 466.040                   | 1.966 | .050  |
| M2             | -42.131                     | 441.315                   | -0.095| .924  |
| M3             | -543.746                    | 530.933                   | -1.024| .306  |
| M4             | -606.281                    | 31.066                    | -19.51| .000  |
| M5             | 28.961                      | 15.224                    | 1.902 | .058  |
| N1             | 80.487                      | 11.326                    | 7.106 | .000  |
| N2             | 2.634                       | 40.345                    | 0.065 | .948  |
| N3             | 172.087                     | 53.302                    | 3.229 | .001  |
| N4             | 2073.759                    | 343.026                   | 6.045 | .000  |
| A1             | 7.973                       | 2.302                     | 3.464 | .001  |
| A2             | 260.392                     | 143.260                   | 1.818 | .070  |
| A3             | -183.859                    | 69.268                    | -2.654| .008  |
| A4             | 362.210                     | 103.681                   | 3.494 | .001  |
| A5             | -419.448                    | 635.527                   | -0.660| .509  |
| A6             | 491.131                     | 412.639                   | 1.190 | .235  |
| A7             | 94.270                      | 316.342                   | .298  | .766  |

R^2          | 0.710                      |
Adjusted R^2 | 0.699                      |
F             | 63.362                     |
Sig.         | 0.000                      |

Dependent Variable: Price

Figure 1. Initial linear model histogram, normal P-P graph, scatter plot
Table 2. Initial semi-log model fitting results

|                | Unstandardized Coefficients | Standardized Coefficients |
|----------------|-----------------------------|---------------------------|
|                | B   | Std. Error | Beta | t  | Sig. |
| (Constant)     | 8.993 | 950.364 | 8.125 | .000 |
| M0             | .082 | 494.165 | .170 | 2.536 | .012 |
| M1             | .044 | 466.040 | .135 | 1.966 | .050 |
| M2             | -.011 | 441.315 | -.006 | -.095 | .924 |
| M3             | -.057 | 530.933 | -.043 | -1.024 | .306 |
| M4             | -.053 | 31.066 | -.561 | -19.51 | .000 |
| M5             | .002 | 15.522 | .069 | 1.902 | .058 |
| N1             | .005 | 11.326 | .230 | 7.106 | .000 |
| N2             | .001 | 40.345 | .002 | .065 | .948 |
| N3             | .008 | 53.302 | .123 | 3.229 | .001 |
| N4             | .144 | 343.026 | .227 | 6.045 | .000 |
| A1             | .001 | 2.302 | .102 | 3.464 | .001 |
| A2             | .012 | 143.260 | .048 | 1.818 | .070 |
| A3             | -.016 | 69.268 | -.083 | -2.654 | .008 |
| A4             | .027 | 103.681 | .098 | 3.494 | .001 |
| A5             | -.021 | 316.342 | -.058 | -.660 | .509 |
| A6             | .065 | 316.342 | .054 | 1.190 | .235 |
| A7             | .006 | 316.342 | .008 | .298 | .766 |
| R²             | 0.758 |
| Adjusted R²    | 0.749 |
| F              | 80.896 |
| Sig.           | 0.000 |

Dependent Variable: LNPrice

4.1.2. Operation result of the improved model

Excluding the sample whose house price is more than 18000 yuan/m², the linear model and semi-logarithmic model are fitted again, and the improved linear model fitting result and the improved semi-logarithmic model fitting result are obtained, as shown in Table 3 and Table 4, respectively. Therefore, we can get the hedonic price model of Luoyang Metro Line 2 to the surrounding house prices:

- Linear model:
  \[ \text{Price} = 7758.611 + 971.895M_0 + 569.475M_1 + 148.936M_2 - 420.126M_3 - 504.164M_4 + 9.529M_5 + 54.008N_1 + 70.539N_2 + 98.255N_3 + 863.118N_4 + 2.702A_1 + 35.222A_2 - 211.569A_3 + 254.833A_4 - 217.189A_5 + 951.242A_6 + 86.174A_7 \]

- Semi-logarithmic form:
  \[ \text{LN Price} = 8.994 + 0.006M_0 + 0.024M_1 - 0.001M_2 - 0.048M_4 + 0.001M_5 + 0.004N_1 + 0.005N_2 - 0.004N_3 + 0.078N_4 + 0.001A_1 + 0.001A_2 - 0.018A_3 + 0.021A_4 - 0.020A_5 + 0.144A_6 + 0.007A_7 \]
### Table 3. Improved linear model fitting results

|                | Unstandardized Coefficients | Standardized Coefficients | t     | Sig.  |
|----------------|-----------------------------|---------------------------|-------|-------|
|                | B   | Std. Error | Beta |       |       |
| (Constant)     | 7758.611 | 950.364 | | 8.125 | .000  |
| M0             | 971.895 | 494.165 | .170 | 2.536 | .012  |
| M1             | 569.475 | 466.040 | .135 | 1.966 | .050  |
| M2             | 148.936 | 441.315 | -.006 | -.095 | .924  |
| M3             | -420.126 | 530.933 | -.043 | -1.024 | .306  |
| M4             | -504.164 | 31.066 | -.561 | -19.51 | .000  |
| M5             | 9.529 | 15.224 | .069 | 1.902 | .058  |
| N1             | 54.008 | 11.326 | .230 | 7.106 | .000  |
| N2             | 70.539 | 40.345 | .002 | .065 | .948  |
| N3             | 98.255 | 53.302 | .123 | 3.229 | .001  |
| N4             | 863.118 | 343.026 | .227 | 6.045 | .000  |
| A1             | 2.702 | 2.302 | .102 | 3.464 | .001  |
| A2             | 35.222 | 143.260 | .048 | 1.818 | .070  |
| A3             | -211.569 | 69.268 | -.083 | -2.654 | .008  |
| A4             | 254.833 | 103.681 | .098 | 3.494 | .001  |
| A5             | -217.189 | 635.527 | -.058 | -2.660 | .009  |
| A6             | 951.242 | 412.639 | .054 | 1.190 | .235  |
| A7             | 86.174 | 316.342 | .008 | .298 | .766  |
| R²             | 0.714 |       |       |       |       |

Adjusted R²: 0.702

F: 60.996

Sig. 0.000

Dependent Variable: Price

### Table 4. Improved post-logarithmic model fitting results

|                | Unstandardized Coefficients | Standardized Coefficients | t     | Sig.  |
|----------------|-----------------------------|---------------------------|-------|-------|
|                | B   | Std. Error | Beta |       |       |
| (Constant)     | 8.994 | .066 | | 135.578 | .000  |
| M0             | .066 | .034 | .121 | 1.923 | .055  |
| M1             | .024 | .032 | .047 | .733 | .464  |
| M2             | -.001 | .030 | -.002 | -.033 | .973  |
| M3             | -.051 | .037 | -.056 | -1.387 | .166  |
| M4             | -.048 | .002 | -.598 | -21.500 | .000  |
| M5             | .001 | .011 | .018 | .500 | .617  |
| N1             | .004 | .001 | .154 | 4.989 | .000  |
| N2             | .005 | .003 | .061 | 1.924 | .055  |
| N3             | .004 | .004 | .042 | 1.136 | .257  |
| N4             | .078 | .025 | .116 | 3.136 | .002  |
| A1             | .000 | .000 | .043 | 1.498 | .135  |
| A2             | .001 | .010 | .002 | .076 | .939  |
| A3             | -.018 | .005 | -.116 | -3.800 | .000  |
| A4             | .021 | .007 | .078 | 2.884 | .004  |
| A5             | -.020 | .155 | -.035 | -.129 | .897  |
| A6             | .144 | .030 | .224 | 4.854 | .000  |
| A7             | .007 | .023 | .008 | .310 | .757  |
| R²             | 0.741 | | | | |
Adjusted $R^2$ 0.730
F 70.037
Sig. 0.000
Dependent Variable: LNPrice

4.2. Result analysis
In terms of statistics and econometrics, the adjusted $R^2$ of the improved linear model and the semi-logarithmic model are 0.702 and 0.730 respectively, and the explanatory power of each independent variable to the dependent variable is 70.2% and 73% respectively, which indicates that the model has a good fit. The F statistics of the improved linear model and semi-logarithmic model are 60.996 and 70.037, respectively, and the corresponding Sig values are 0.000, which indicates that the model is significant as a whole. The results of collinearity diagnosis show that the variance expansion factor of each variable is between 1 and 4, which indicates that there is no multicollinearity in the model.

From the economic significance test, we can see that the closer to the subway station, the greater the coefficient, which indicates the greater the impact on housing prices from the coefficients of M0, M1, M2, M3. The subway station provides great convenience for residents to travel and promotes the rise of housing prices, which also proves the impact of the subway on housing prices. The coefficient of variable M4 is negative, indicating that the further away from CBD, the lower the house price. The coefficients of M5, N1, N2, N3, N4 are positive. Schools, transportation, hospitals and so on belong to the supporting facilities of the house. The more perfect the facilities are, the higher the house price is, which accords with the economic significance. A1-A7 belongs to the characteristic variable of the building, and the coefficients of A3 and A5 are negative, which indicates that the floor area ratio and the age of the house have a negative influence on the house price, that is, the larger the floor area ratio is, the lower the house price is. The older the house, the lower the price. The coefficients of A1, A2, A4, A6 and A7 are all positive, indicating that the area, orientation, decoration degree, category and floor of the house can make the house price increase.

5. Conclusions and recommendations
The influence radius of Luoyang Metro Line 2 on the price of surrounding residential buildings is 2000 meters, showing a significant linear relationship with housing prices, that is, the closer to the subway station, the greater the impact on the value-added housing prices, thus proving the external value-added benefits of the metro. This conclusion has brought certain enlightenment to the government, real estate developers and other businesses.

In land planning, government departments should fully consider the value-added benefits of MTR stations and make rational planning and division of surrounding land. At the same time, developers in the subway peripheral land investment and development should also be combined with the value-added benefits of the subway, reasonable pricing. Metro is an important part of urban traffic, and plays a great role in alleviating the pressure of urban traffic. Therefore, the planning of metro should take the solution of urban traffic problems as the primary purpose, consider its external value-added benefits comprehensively, and match with urban planning.

5.1. Deficiencies in research
Theoretically, when the hedonic price model is applied, the more sample data, the more reliable the result is. However, the data collected in this paper are static data, so the research tends to static research, and the dynamic research is insufficient. At the same time, Luoyang Metro Line 2 is in the construction stage, has not been put into use, so we can only study the impact of the metro on housing prices from the planning and construction stage.

References
[1] He Yazhen. Study on the Influence of Qingdao Metro Line M2 on Surrounding Housing Price by Using Hedonic Price Model [D]. Ocean University of China. 2015.5
[2] Deng Xiaoyuan. Analysis of the influence of housing characteristics on second-hand housing prices in different regions of Beijing [J]. Business Information. 2019. 2 (1): 34-36
[3] Du Qinjun, Wang Weixiu. Analysis of the influence of urban subway construction on housing prices along the line [J]. Land and Resources Science and Technology Management. 2019. 8 (5): 48-51
[4] Han Yongchao, Chen Chun, Shen Wujing. Impact of Chongqing Rail Transit on Housing Prices along Rail Line 3 Based on Hedonic Price Model [J]. Price M, 2017.1 (4): 29-32
[5] Ye Qi. Study on Hedonic Price Model of Residential Buildings Around Subway Stations [D]. Capital University of Economics and Trade. 2018.5