Analysis of the Impacts of Urban Public Transport on the Housing Price in Hangzhou, China

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Abstract. With the rapid increase of urban population, housing demand is gradually increasing, and traffic congestion is becoming more and more serious. People are increasingly concerned about the relationship between housing and public transportation. Hence, studying the impact of public transport on housing prices will be conducive to promoting the coordinated development of urban public transport and urban social economy. Taking Hangzhou, China as a case city, this study selected 477 residential districts and their surrounding comprehensive public transport characteristics to construct the hedonic price model, and further quantitatively analyses the impact of urban public transport on housing prices. The empirical results showed that most of the public transport characteristics produce significant premium capacity to the housing market. The ranking of the premium capacity from high to low is the distance between the community to the subway station, the speed of nearby roads, and the number of public bicycle stations. In addition, a few public transport characteristics, such as the number of bus and water bus stops, have no significant impact on housing prices. This research can serve as a theoretical basis for government departments to carry out urban planning and real estate enterprises to make decisions.

1. Introduction
In China, urban population had reached 793 million by the end of 2016, and 57.34% of the population were urban dwellers. There were 156 large cities with populations over 1 million, including 13 cities with a population of more than 10 million. The effect of urban population agglomeration is very obvious, which also leads to the traffic congestion. The increase in urban population will also lead to the occurrence of "urban diseases", such as scarcity of urban land resources and housing shortage. Importantly these problems have a direct impact on the normal life of residents. The status of urban public transport is one of the important factors affecting the price of urban real estate. Scientifically and quantitatively analyzing the impact of urban public transport on housing prices is of great practical significance for the government to improve the construction of the transport system and real estate enterprises to make development decisions. Therefore, this study takes Hangzhou as an example, uses housing market data to build a characteristic price model, and quantitatively analyzes the impact of urban public transport on housing prices.

2. Literature Review
Since the 1950s, some scholars have found that public transport has an important impact on people's choice of residential communities. Tiebout (1956) studied the supply of local public goods, and he proposed that people show their preference for public goods through the choice of residential communities under the premise of sufficient population flow and symmetrical supply and demand...
information of local public goods. Among them, urban public transport has the attribute of public goods and belongs to a part of them. Muth (1969) indicated that the location of urban houses would be affected by both transport costs and housing prices. Yiu and Wong (2005) found that the housing market effectively capitalized the traffic accessibility into the housing prices when they analyzed the impact of the construction of subsea tunnel in the west of Hong Kong on the housing prices. Glascock et al. (2011) believed that transport accessibility is an important factor for residents to consider in the process of purchasing houses, and that people will invest the time saved due to convenient transport into the real estate price in the form of capital. Lankila et al. (2015) believed that spatial distance has an important impact on the availability of public goods (services), which is reflected in the significant impact of accessibility on housing prices. Jin and Zhuo (2016) studied the influence of supply intensity and level of public goods on housing prices in 35 large and medium-sized cities across the country, and found that public goods have a significant impact on housing prices, among which road traffic and education resources have a greater impact on housing premium capacity.

Although literature in this field is well established, the relationship between urban public transport and housing prices remains very confusing. Generally speaking, the accessibility of transport facilities has a significant positive impact on housing prices, because it makes it easier for residents to go to work or shop. Voith (1993) analyzed the relationship between the rapid rail transit system and housing prices in Boston and Philadelphia, and found that the price of houses near public transport facilities in Boston was significantly higher by 6.7%, while in Philadelphia it was 7.5 to 8% higher. Benjamin and Sirmans (1996) studied the impact of the Washington subway system on housing prices and found that for every 0.1 miles away from subway stations, the corresponding property rents fell by 2.4% to 2.6%. Zhang (2005) took Shanghai Metro Line 1 as the research object and found that the housing price along the line is negatively correlated with the distance of the station. The farther the station is from the city center, the greater it affects the surrounding housing prices. Nie et al. (2010) took Shenzhen Metro Phase 1 as the research object and concluded that the average price of residential houses within 700 meters around the subway station rose by 19.5%. Adjacent public transport stations may also have a negative impact on housing prices, mainly due to noise pollution, crowded people, poor environment, and unsafe conditions. Bowes and Ihlanfeldt (2001) indicated that activities such as crime and retail in the vicinity of subway stations had a negative impact on housing prices, which depended on the distance of the real estate from the urban area and the income level of the tenant. Glascock et al. (2011) found that the proximity of bus stations had a negative impact on housing prices in Hong Kong, mainly due to negative external factors such as noise pollution caused by buses; also, the prices of houses near ferries in the New Territories are actually lower, mainly due to the relatively weak infrastructure in the region.

Most prior studies concentrated on single aspects such as rail transit. They did not comprehensively incorporate urban public transport characteristics into the research system, and take into account the impact of new public transport characteristics such as water bus, public bicycle and so on. Therefore, this study used the hedonic price model to quantitatively measure the characteristics of comprehensive urban public transport in Hangzhou.

3. Data and Model

3.1. Study Area and Data Sources

This study focuses on the main urban area of Hangzhou, including six administrative areas: Shangcheng, Xiacheng, Jianggan, Gongshu, Xihu, and Binjiang. The data on housing price comes from the relevant information of second-hand houses on the "Transparent house sales network" (http://www.tmsf.com/). In February 2017, a total of 59516 housing sources were obtained, and the average price at the residential area level was calculated as the dependent variable. Combined with the data on independent variables, after removing the abnormal and incomplete data, there are 477 samples in the end.

Relevant data on the number and distance of public transport facilities are based on the survey of Hangzhou traffic travel conducted by Hangzhou Traffic Planning and Design Institute in November 2016. The data on road speed is from the monthly statistics of Hangzhou Transportation Bureau. Non-
traffic characteristic variables are obtained through interview on spot and field survey by the project team. Table 1 shows the description, quantization, and expected sign of these variables.

### 3.2. Model Selection and Testing

**1. Model Selection**

In this study, we used the hedonic price model and OLS to estimate the model. After comparison, the logarithm function were selected to establish the hedonic price model. The logarithm form of housing price are the dependent variable. The continuous variables such as distance, number of stations, density and housing age are logarithm form, while the virtual variable and grade variable are linear form. The specific functions are as follows:

$$
\ln P = \alpha_0 + \sum \alpha_i \ln Z_i + \sum \alpha_j Z_j + \varepsilon
$$

In the formula, $P$ is the house price; $Z_i$ is the continuous characteristic variable; $Z_j$ is the discontinuous characteristic variable; $\alpha_0, \alpha_i, \alpha_j$ are the coefficients to be estimated; $\varepsilon$ is the error term.

**2. Model Testing**

The multiple correlation coefficient of logarithmic function model is 0.825; the coefficient of determination is 0.681; the adjusted $R^2$ is 0.666; the significance test value of variance analysis of regression equation is 0.000; the significance level of $T$ test of most regression coefficients is less than 0.1; the minimum value of $VIF$ is 1.562 and the maximum value is 6.908, which all are less than 10. The majority of observations of the dependent variable predicted value and the residual scatter plot fall randomly within a range of ±2 vertically and the residual distribution is approximately normal. In conclusion, the logarithmic function model has a good fitting effect and can be used for subsequent empirical analysis.

| Variable                          | Variable Definition and Quantization                                                                 | Expected Sign |
|-----------------------------------|------------------------------------------------------------------------------------------------------|---------------|
| Distance to Wulin CBD             | Straight-line distance between the community center and the coast of Wulin CBD (km)                  | -             |
| Distance to West Lake             | Straight-line distance between the community center and the coast of West Lake (km)                  | -             |
| Distance to Qianjiang CBD         | Straight-line distance between the community center and the coast of Qianjiang CBD (km)              | -             |
| Road speed                        | The average speed of 1,000 meters of roads around the community (km h$^{-1}$)                        | -             |
| Distance to subway station        | Straight-line distance between the community center and the nearest subway station (km)             | -             |
| Number of bus stops               | The number of bus stops within 100m around the community                                            | +             |
| Number of public bicycle stations | The number of public bicycle station within 100m around the community (outside the closed area line of the community) | +             |
| Number of water bus stops         | The number of water bus stops within 500m around the community                                      | +             |
| Population density                | The number of population per km$^2$ of the block                                                     | -             |
| Post density                      | The number of jobs per km$^2$ of the block                                                           | +             |
| Motor vehicle density             | Ownership of motor vehicles per km$^2$ of the block                                                  |               |
| Education supporting              | A school within 1000 m of the community is each scored as 1, with a total of 4                       | +             |
| Sports facilities                 | The overall evaluation of sports facilities in the community is divided into 5 levels$^a$          | +             |
| Living supporting                 | The living supporting in the community is divided into 5 levels$^a$                                | +             |
| Natural environment               | The natural environment quality outside the community is divided into 5 levels$^a$                  | +             |
Housing age | The age of the building (year, transaction years minus actual built years) | -
Administrative areas | 1 if the community is in an administrative area; 0 otherwise | ?

Note: *The 5 levels are very good, good, common, poor, quite poor, scored as 1-5, respectively.

4. Results and Discussion

(1) Significance Analysis

The regression results from the hedonic price model are shown in Table 2. Among the traffic variables, the significance levels of the number of bus stops, the number of water bus stops, and the motor vehicle density variables were more than 10%, which were not included in the model. The remaining eight traffic characteristic variables all have a significant impact on housing prices.

| B | Standard Error | Beta | T | Sig |
|---|---|---|---|---|
|(Constant) | 10.925 | 0.450 | 24.258 | 0.000 |
| Ln (Distance to Wulin CBD) | -0.064 | 0.028 | -0.180 | -2.305 | 0.022 |
| Ln (Distance to West Lake) | -0.149 | 0.025 | -0.367 | -6.049 | 0.000 |
| Ln (Distance to Qianjiang CBD) | -0.116 | 0.026 | -0.261 | -4.501 | 0.000 |
| Ln (Road speed) | -0.093 | 0.047 | -0.067 | -1.981 | 0.048 |
| Ln (Distance to subway station) | -0.026 | 0.015 | -0.090 | -1.680 | 0.094 |
| Ln (Number of bus stops) | 0.019 | 0.016 | 0.035 | 1.228 | 0.220 |
| Ln (Number of public bicycle stations) | -0.021 | 0.010 | -0.058 | -1.986 | 0.048 |
| Ln (Number of water bus stops) | -0.024 | 0.019 | -0.042 | -1.293 | 0.197 |
| Ln (Population density) | -0.047 | 0.010 | -0.166 | -4.705 | 0.000 |
| Ln (Post density) | 0.014 | 0.007 | 0.064 | 1.989 | 0.047 |
| Ln (Motor vehicle density) | 0.076 | 0.056 | 0.243 | 1.362 | 0.174 |
| Education supporting | 0.054 | 0.007 | 0.269 | 7.448 | 0.000 |
| Sports facilities | 0.031 | 0.007 | 0.163 | 4.728 | 0.000 |
| Living supporting | 0.029 | 0.008 | 0.152 | 3.708 | 0.000 |
| Natural environment | 0.025 | 0.010 | 0.079 | 2.506 | 0.013 |
| Housing age | -0.155 | 0.025 | -0.249 | -6.226 | 0.000 |
| Jianggan | -0.119 | 0.045 | -0.155 | -2.629 | 0.009 |
| Gongshu | -0.074 | 0.058 | -0.113 | -1.281 | 0.201 |
| Xihu | 0.098 | 0.042 | 0.182 | 2.318 | 0.021 |
| Xiangcheng | -0.287 | 0.109 | -0.485 | -2.637 | 0.009 |
| Shangcheng | -0.202 | 0.104 | -0.323 | -1.934 | 0.054 |

The number of bus stops did not enter the model, which is mainly related to the high ownership rate of private cars of Hangzhou residents (more than 60%), and people's dependence on bus travel is not strong. In addition, there are many bus stops around the community, which are easy to generate noise, exhaust and other environmental pollution, and also bring about congestion and high crime rate. These negative factors offset the advantages of traffic convenience, which is basically consistent with the previous research conclusions of Bowes, Ihlanfeldt (2001), Glascock, et al. (2011). Water bus is a unique public transport vehicle in Hangzhou, with slow speed, few shifts and weak carrying capacity compared with other means of transport. It cannot become a common means of transportation for residents to commute, so its impact is not significant.

(2) Influence Analysis

It can be seen from table 2 and table 3 that the symbols of the eight traffic variables entering the model are consistent with the expectation except for the number of public bicycle stations.
regression coefficient of public bicycle station is contrary to the expectation, which may be related to the planning of Hangzhou municipal government. Public bicycle stations are constructed in order to solve the problems of difficult driving, parking, and inconvenience of public transportation in the old community, and they have specifically increased the deployment density in the old community. At the same time, it is greatly affected by weather, and can only be used as a supplementary way of urban public transport connection.

The linear distance of the West Lake, Qianjiang CBD and Wulin CBD is inversely proportional to housing prices, indicating that the farther away from the center, the lower the housing price. The subway has a significant positive impact on housing prices, which shows that people have a great demand for subway with large capacity and high speed. The farther the subway station is, the less convenient it is for people to take the subway. For every 1 km increase in the distance between the community and the adjacent subway station, the average price of standard housing will decrease by 1672.54 yuan / m². A large number of traffic and pedestrians lead to the slow speed of the road, indicating the high prosperity of the area. Therefore, the price of residential areas with slow traffic speed is higher. For every 1 km / h increase in the average speed of roads within 1000m around the community, the average price of standard residential buildings decreased by 91.827 yuan / m².

Table 3. Elastic coefficient and marginal price of traffic characteristics

| Variable                      | Regression coefficient | Elastic coefficient (%) | Marginal price(yuan/m²) |
|-------------------------------|------------------------|-------------------------|-------------------------|
| Ln (Distance to Wulin CBD)    | -0.064                 | -0.064                  | -426.250                |
| Ln (Distance to West Lake)    | -0.149                 | -0.149                  | -1106.410               |
| Ln (Distance to Qianjiang CBD)| -0.116                 | -0.116                  | -463.480                |
| Ln (Road speed)               | -0.093                 | -0.093                  | -91.830                 |
| Ln (Distance to subway station)| -0.026                | -0.021                  | -1672.540               |

5. Conclusions
This study took Hangzhou as a case city, collected data on 59,516 apartments in 477 communities, established a hedonic price model, and quantitatively analyzed the impact of urban public transport on housing prices. The main empirical research conclusions are as follows: (1) In general, traffic characteristics have a significant positive impact on housing prices. (2) From the perspective of standardized regression coefficient (Beta), the impact of traffic characteristic variables on housing prices from high to low are: distance to West Lake, distance to Qianjiang CBD, distance to Wulin CBD, population density, distance to subway station, road speed, post density, number of public bicycle stations. In addition, the number of bus stops, the number of water bus stops and the density of motor vehicles have little influence on people. (3) From the above results, it can be seen that the distance between the community and the subway station has the greatest impact on the housing prices, which shows that people have the greatest demand for subway with large capacity and high speed.

This study can also provide theoretical basis for government departments to make urban planning and real estate companies to make decisions. The following suggestions are put forward: (1) The government should vigorously develop urban public transport, especially urban rail transit. It can be seen from the research that people have a strong dependence on urban public transport, especially rail transit. When planning residential land, we can strengthen the comprehensive development of land supply around the subway station, improve the efficiency of land use, and form good economic and social benefits of urban rail transit. (2) The real estate developers fully consider the premium capacity of public transport characteristics in the development planning. When choosing land, real estate developers should pay more attention to the construction projects in the areas near the well-planned road and rail transit stations, which will help to obtain higher profits from the market premium in the sales process.
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