Research Paper

Spatio-temporal effects of urban rail transport on residential prices around stations

A case study of Harbin Line 1

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Abstract

With the vigorous development of rail transit in China, the impact of urban rail transit on the price of land along its routes has attracted widespread attention, including the price of residential houses, office buildings, and commercial buildings. Exploring its spatio-temporal effects helps to predict the impact of new rail transit in the future as well as to help the government formulate reasonable house price regulation and urban land use policies. This paper measures the spillover effect of Harbin rail transit, taking Harbin Line 1 as an example, and explores the spatial and temporal effects of urban rail transit on residential prices within 2 km of the station by comparing the 2013, 2018, and 2024 year periods from the pre-construction period to the completion of the operation of the urban rail transit. The results show that the prices along the urban rail transit lines are affected by a combination of factors such as location, neighbourhood and architecture, among which, the urban rail transit has a significant value-added effect on the prices of the residences along the lines.The price of each industry shows different degrees of decreasing with the increase of the distance from the railway transport. Rail transit has significant market segmentation effects on the prices of businesses along the line, and the radius of influence of the central city market is larger than that of the non-central city market. Urban rail transport has a positive impact on the prices of businesses along the route during both the initial operational and construction periods, with the construction period having a significantly higher impact on residential prices than the initial operational period.

Keywords

Railway stations, Residential property price, Spatio-temporal effect , Harbin

1. Introduction

Since the State Council issued the Guiding Opinions on Priority Development of Public Transport in Cities, public transport has gradually taken a leading position in urban transport and become a strategic focus of urban transport. As China's urbanisation construction process continues to accelerate, the city's infrastructure facilities are becoming more and more perfect, and the transport system has ushered in new challenges. On the one hand, urban rail transit system can greatly reduce traffic pressure, on the other hand, it can also improve the space utilisation rate, optimise the space layout, and play a vital role in promoting the process of environmentally friendly and conservation-oriented cities(Li X 2022). ‘Land preparation along rail transit lines, public transport oriented integrated development, and last kilometre construction have become the key tasks of many cities during the 14th Five-Year Plan period. The last kilometre construction has become one of the priorities of many cities during the ‘14th Five-Year Plan’ period(Huang Cuncun,Wang Xiaowen and Li Linna 2021).

Taking Harbin's residential market in 2024 as a reference, there is a disparity in the value of properties adjacent to metro lines, with prices in some areas exceeding 40,000 yuan per square metre while in others they are as low as 0.1 million yuan per square metre, and there are even high-grade residential areas where the average price is 40 times that of low-grade residential areas. There is an inevitable logic behind such differences in property prices, but excessive price differences may lead to the misuse of metro resources and problems such as unbalanced urban development, monopolisation of educational resources and social stratification(Teng Li, Zhong Chujie and Cai Di 2022) . In the face of limited urban construction funds and spatial resources, there is an urgent need for in-depth analyses of the metro's impact on residential prices, and for research into how to effectively regulate premiums in order to enhance the social and economic benefits of urban metros(Zheng Siqi,et al.2014).

2. Research Case and Methodology

2.1. Case Study

Harbin is a prefecture-level city under the jurisdiction of Heilongjiang Province, the capital of the province, a sub-provincial city, a megacity, the core city of the Harbin-Changchun urban agglomeration, an important central city in Northeast China and an important manufacturing base of the country, as determined by the State Council. Harbin Metro Line 1 is the first metro line to be built and operated in Harbin, Heilongjiang Province, China, and the first alpine-resistant metro line in China, which was opened on 26 September 2013 for operation. The line is roughly north-south direction, starting from Harbin East Station in the north, through the Daowai District, Nangang District, Xiangfang District, Pingfang District and other areas, and ending in the south of Xinjiang Street Station, 23 stations along the line, the line length of 26.27 kilometres. The line was started in September 2008, in 2013 opened for operation. Based on the metro construction, it is studied every five years starting from 2013.

The impact of urban rail transport on residential prices is generally limited to a certain range. Relevant studies show that the impact of rail transport on residential prices is weak when the distance from the station is more than 2 km(Qu Shijin et al 2018). Therefore, taking into account domestic and international experience, the study scope is defined as the area within a 2 km radius of the stations along Harbin Metro Line 1. Taking Harbin Metro Line 1 as an example, the study explores the spatial and temporal effects of urban rail transit on residential prices within 2 km of the stations from the pre-construction to the completion of the operation process (Bao Shanju, Lu Lin 2018).

2.2. Research methodology

Characteristic Price Model, is argued that property consists of a number of unique attributes and that the value of property depends on the overall utility derived from these attributes(Zhou Xinxin et al. 2020). By analysing the price composition of property commodities and revealing the value embedded in each attribute, the attribute factors in property price fluctuations are disentangled while maintaining the property attributes unchanged, so that the impact of attribute changes can be excluded one by one from the overall price changes, and ultimately, the price changes can be purely driven by the relationship between supply and demand. Common types of property value models include linear, logarithmic and semi-logarithmic(HURST N B, WEST S E. 2014). After repeated trials, the best-performing semi-logarithmic attribute value model is adopted in this study to explore the impact of urban metro on residential prices in time and space(Forouhar A.2016).

2.3. Data sources

Through data crawling, we obtained 16,077 POI points in the Golder map of Harbin city and 16,077 sample data related to the residences in Harbin city from 2013 to 2024. According to the date of

residential information published on the website as the basis of time division, the residential houses are divided into 3 periods, i.e. the early operation period, the construction period, and the maturity period. The data is mainly obtained from the China Residential Price Quotation Platform, supplemented by real estate websites such as Anjuke, Chain Home and Housing World. Residential prices are all per square metre. The geographic location information of POI landmarks such as residences, hospitals, parks, schools, etc. is captured from Gaode map to build a spatial database(as shown in the figure1 to3).

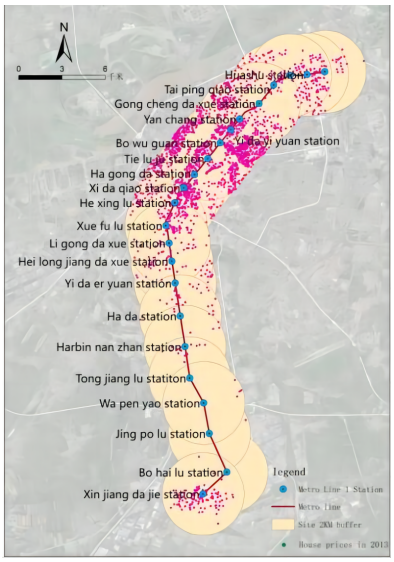

Figure 1. Price of dwellings within the 2km buffer zone of rail stations, 2013. Source: Author's own drawing.

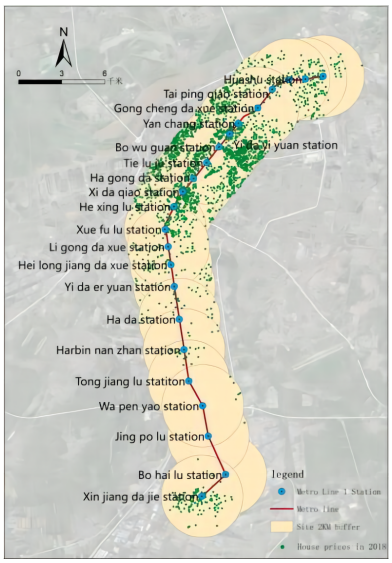

Figure 2. Price of dwellings within the 2km buffer zone of rail stations, 2018. Source: Author's own drawing.

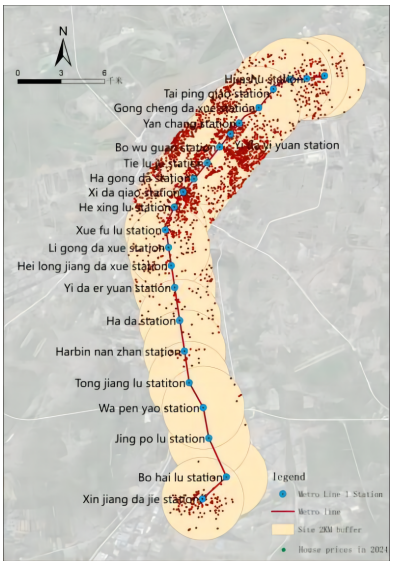

Figure 3. Price of dwellings within the 2km buffer zone of rail stations, 2024. Source: Author's own drawing.

Explore the value-added model of the residential market around rail transit stations. In-depth analysis of the impact of geographic location, architectural attributes, environmental construction and other factors on residential prices, and combining these factors with actual transaction prices, comparing the overall level of the study area, and dividing price levels (LIANG X J et al. 2018). To study how different indicator factors act on the premium effect of the residential market around the rail transit stations and their influence (as shown in the table1).

Table 1 Selection and assignment methods for housing price influencing variables Source: Literature Integration

Category indicators		Unit	Method of assignment of indicators
Dependent variable	*Y*	Yuan/m2	2 km around the rail transit station The average price of each residential quarter within the scope
Location traffic	*X1*	m	Straight-line distance from residential quarter to nearest rail transit station
	X2	m	Distance from residential quarter to CBD (take the nearest residential quarter to Harbin International Financial City CBD, Haxi Railway Station CBD and Hadong New District CBD)
	X3	Strip	Number of bus lines within 500m around residential quarters
Architectural features	*X4*	Actual value assignment	Floor area ratio of residential quarters
	X5	a	House construction time (difference between the opening year of residential subdivisions and 2024)

	X6	Actual value assignment	Greening rate of residential quarters
	X7	Dummy variable	1 km around residential quarter If there are primary schools in it, it is 1, and if there are no primary schools, it is 0.
	X8	Dummy variable	1 km around residential quarter If there are secondary schools within it, it is 1, if there are no secondary schools, it is 0
	X9	Dummy variable	1 km around residential quarter If there are high schools in it, it will be 1, if there are no high schools in it, it will be 0
Environment	*X10*	Dummy variable	1 km around residential quarter If there are hospitals in it, it is 1, if there are no hospitals in it, it is 0
Construction	*X11*	Dummy variable	1 km around residential quarter If there is a shopping mall inside, it is 1, if there is no shopping mall inside, it is 0
	X12	Dummy variable	1 km around residential quarter If there is a park inside, it is 1, if there is no park inside, it is 0
	X13	Dummy variable	1 km around residential quarter If there is a stadium inside, it is 1, if there is no stadium, it is 0
	X14	Dummy variable	1 km around residential quarter If there is a museum inside, it is 1, if there is no museum, it is 0

3. Analysis of results

3.1. Spatial distribution pattern of residential prices

Through the ArcGIS 10.8 version of the software to draw the Harbin underground line 1 around the distribution of residential market prices, observation of the image can be found, residential prices in the construction of rail transit at different stages of the geographic north-south axis presents an ‘inverted U’ distribution characteristics, that is, the centre of the region prices are higher, the two sides of the lower, especially the southern region of the lowest prices. The southern region has the lowest price. In order to explore the spatial distribution characteristics of residential prices near urban rail transit stations, we calculated the average residential prices of each station and drew a line chart of residential prices according to the order of stations from north to south(as shown in the figure4).

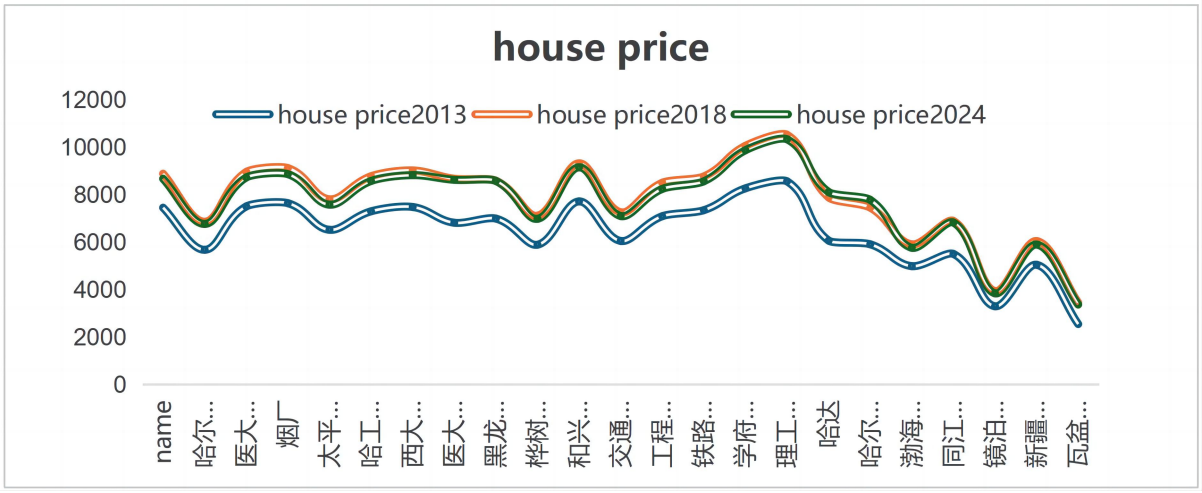

Figure 4 Trends in average housel prices around the site, 2013, 2018 and 2024

Source: Author's own drawing.

Along Harbin Metro Line 1, the spatial distribution of residential prices exhibits a single-centre characteristic, with the highest price point located at the Polytechnic University station in the city centre

zone. From this centre outwards, residential prices gradually decrease as the distance from the central business district increases(as shown in the figure5 to 7).

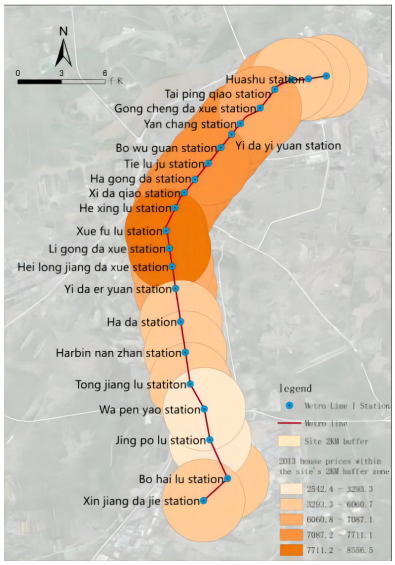

Figure 5. Average price of dwellings within the 2km buffer zone of rail stations, 2013. Source: Author's own drawing.

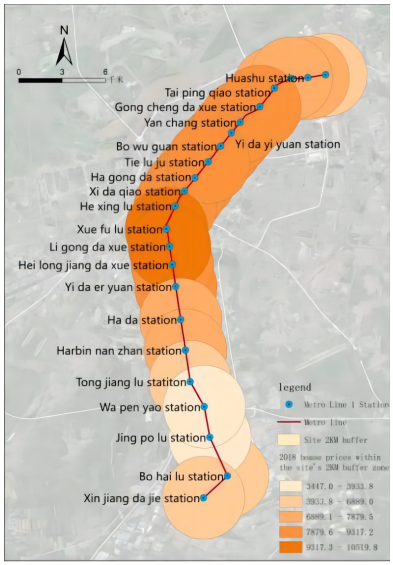

Figure 6. Average price of dwellings within the 2km buffer zone of rail stations, 2018. Source: Author's own drawing.

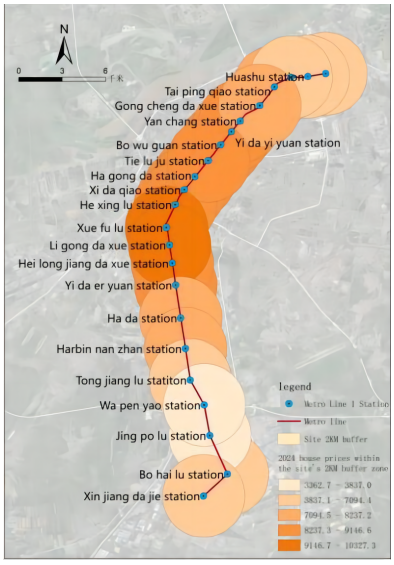

Figure 7. Average price of dwellings within the 2km buffer zone of rail stations, 2024. Source: Author's own drawing.

3.2 Identification of price spatial distribution characteristics

Using the residential value prediction model to analyse the distribution of house prices, the regression analysis of the model shows that the significance of the F-value test is lower than 0.001, and the R^2 coefficient reaches 0.775, which indicates that the model fits well; the distance between the residential area and the metro station and the city centre has a significant decreasing negative premium effect on the house prices. Factors such as building age, medical facilities, and shopping centres show significant linear negative premium effects on house prices; and factors such as the number of bus lines, green coverage, and leisure parks have significant linear positive premium effects on house prices(as shown in the table2).

Table 2 Regression results of the model Source: Author's own drawing.

Variable	Coefficient	Variable	Coefficient
lnX1	-0.034*	*X8*	0.012
lnX2	-0.651**	*X9*	0.137**
X3	0.339**	*X10*	-0.359**
lnX4	0.193	*X11*	-0.035*
X5	-0.058*	*X12*	0.083**
X6	0. 263**	*X13*	-0.045
X7	0.008	*X14*	-0. 126**

Note: ** and * indicate significant at the 1 per cent and 5 per cent levels, respectively.

3.3 Temporal effects of urban rail transport on residential prices along the route

Early stages of urban rail transport planning and operation (2013):House prices in the four administrative regions traversed by the line are generally on an upward trend, and residential prices in the area covered by the metro are generally in line with average regional house price conditions.

Urban rail construction period (2018): Nangang District and Xiangfang District residential prices in the underground radiation area began to exceed the regional average; in contrast, Pingfang District and Daowai District residential prices are generally higher than the underground neighbourhood. The reason for this is that Nangang District and Xiangfang District is located in the old city of Harbin, industrial concentration, rapid economic development.

Urban rail maturity (2024): Average house prices in all regions as well as prices of homes in metro-affected areas hit record highs, with prices of homes in metro-affected areas increasing by 16% to 32% compared to the early stages of construction. In Nangang and Xiangfang districts, the price of residences around the metro line increased due to the opening of the metro, exceeding the regional average house price.

A quantitative study of the role of urban construction of rail transit on the market value of neighbouring residences at various stages was conducted by applying the time dummy variable in the characteristic price model. It was found that the initial construction phase of rail transit and its operational phase had a significant positive contribution to the market value of neighbouring residences (as shown in the table). This suggests that the construction of rail transport makes a significant positive contribution to enhancing the value of homes along the route, and that the positive contribution to home prices is more pronounced during its formal operational phase than during the construction phase. The opening of the railway significantly improves the accessibility of the route, which in turn brings a positive price increase effect to the residential market(as shown in the table3).

Table 3 results of hedonic price models with different distance intervals Source: Author's own drawing.

Model	Dependent variable			
	Within 0.5 km from the subway	0.5 -1 km from subway	1-1.5 km from the subway	1.5-2 km from subway
Initial stage of rail transit construction	0.555*	0.563*	0.419*	0.456*
Rail transit operation period	0.774*	0.764*	0.624*	0.714*

Note: ** and * indicate significant at the 1 per cent and 5 per cent levels, respectively.

4. Conclusion and discussion

Taking the residential areas along Harbin Metro Line 1 as a case study, the study explores the mechanism of urban rail transport on residential market price, and also examines the spatial and temporal impacts on residential price at different stages of rail transport construction. The research findings are as follows:

The spatial impact of rail transit on residential prices is analysed using a characteristic price model, which shows that the price of residences near the Polytechnic University Station of Metro Line 1 reaches the highest level, and then declines drastically towards the south, while the price of residences towards the

north does not fluctuate much. There is a significant negative correlation between residential price points and the distance to the rail station, with the most significant price reductions occurring in the range of 0 to 0.5km, and the effect of the rail transit on residential price points becoming weaker after more than 2km. In addition, the impact of rail access on residential price points varies by location, with non-city centres affected to a greater but lesser extent than city centres.

The analysis of the factors affecting the price of homes along the rail transit line through the characteristic price model and regression method shows that a total of 14 factors have a significant impact on the price of homes, and the rail transit has a significant effect on the price of homes, and this effect is closely related to the distance of the homes from the station as well as the period of construction of the rail transit.

The analysis of the temporal impact of rail transport on residential price shows that from the early stage of construction to the mature period of operation, rail transport has always had a positive impact on residential price along the line. After taking macroeconomic factors into account, the opening of rail transport still has a significant impact on residential price appreciation.

This study only analyses the residential price level, and future research can be expanded to compare the spatial and temporal effects of different real estate types, such as commercial and industrial, in order to enrich the research results.

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