Study on the Factors Influencing Housing Price Based on the Radiation Effect of Commercial Center

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Abstract. By analogy with the electromagnetic radiation effect in physics, the commercial center has a radiation effect on housing price. The author establishes a model of the radiation effect of commercial center on housing price. Select the brand influence, scale and distance of the commercial center as the characteristic indicators, Hedonic Price Model (HPM) is used to solve the model. 200 houses in Dao Li District of Harbin were selected for research. The results show that brand influence has a significant influence on housing price, influence coefficient is 0.024. The distance of commercial center has significant influence on residential buildings, influence coefficient is −0.026. The scale of commercial center and brand influence has collinearity.

Keywords: Housing Price · Commercial Center · HPM · Intensity of radiation effect

1 Introduction

Housing is coupled and coordinated with the quality of urban economic, social, cultural and ecological development to varying degrees [1]. Stimulated by land finance, urbanization, market-oriented reform of commercial housing and other factors, housing prices in big cities continue to rise, and public space resources lead to significant spatial differences in housing prices [2]. Housing prices are affected by urban structure and show differences in spatial pattern. For example, urban multi-center structure will affect housing prices while easing resource allocation [3]. Krystyna Waszak analyzed the consumer behavior in Poland and found that the establishment of a new business district would affect consumers' consumption habits and living habits, and promote the improvement of residents' purchasing power [4]. In order to further conduct quantitative research on the radiation effect of commercial centers, Zolfani (2013) constructed a multi-objective decision-making model to conduct quantitative analysis on the radiation radius and intensity of commercial centers [5].

Hedonic Price Model (HPM) has been widely used in the analysis of the relationship between housing prices and influencing factors [6, 7]. The characteristic price theory focuses on the analysis of the influence of various attribute characteristics on prices,

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and believes that housing prices depend on these attributes and the utility they bring [8]. Compared with the explanatory power of supply and demand theory on the inter-city housing price level, characteristic price theory is more often used to analyze the housing price differentiation within a single city. Empirical results show that factors such as location conditions [9–11], neighborhood environment [12–15], community and building attributes [16, 17] all have varying degrees of influence on housing prices.

Through the study of literature, it is found that the current research has two shortcomings: 1. The radiation effect of commercial center is analyzed in isolation, and the radiation intensity of commercial center is not quantitatively studied in combination with the property of residence itself; 2. There is no specific analysis of the impact of commercial center indicators on housing prices.

2 Model

In physics, electromagnetic radiation model is used to elaborate the radiation influence of central particles on surrounding materials. The influence degree of central particles is called, and the formula of electric field intensity is [18]:

$$\mathrm{E} = \sum_{i}^{n} \frac{F}{q} = \sum_{i}^{n} \frac{kQ}{r^2} \tag{1}$$

where:

E—Electric field intensity
F—Electrostatic field force
q—Test charge
Q—Elementary charge
k—Electrostatic constant (k = 9.0 × 109 N·m2/C2)
r—Distance between Elementary charge and Test charge

The scale and brand influence of commercial center are analogous to the mass of particles and the structural attributes of particles. The relative distance between commercial center and housing is analogous to the relative distance between particles. The radiation effect of urban commercial center on housing price is shown in Formula (2):

$$\mathrm{P}_B = \sum_{i}^{n} \frac{{U_i}^{\alpha} {W_i}^{\beta}}{{R_i}^{\gamma}} + \varepsilon \tag{2}$$

where:

P_B—Intensity of radiation effect
U—Scale quantization value
R—Distance between commercial center and housing
W—Brand influence
α—Scale influence coefficient
β—Brand influence coefficient
γ—Distance influence coefficient

i—Commercial center
ε —Random error term

The radiation effect intensity of urban commercial center on housing price refers to the influence of the construction of urban commercial center on the rise of surrounding housing price, as shown in formulas (3) and (4):

$$\mathrm{P} = P(\mathrm{S}) \tag{3}$$

$$\mathrm{P}_B = \mathrm{P}^{'}(\mathrm{S}) = \partial P(\mathrm{B})/\partial B \tag{4}$$

P represents the influence function of housing price, S represents the set of characteristic attributes affecting housing price, B represents the set of characteristic attributes related to commercial center in S, and PB represents the intensity of radiation effect of urban commercial center on housing price.

To build $P_B = f(B)$, Two steps should be completed first: 1. Analyze and study the specific influencing factors in the characteristic attribute set B of commercial center; 2. Establish the basic model of specific characteristics and attributes of commercial centers according to the law of urban radiation effect.

Logarithms base 10 are taken from the left and right sides of formula (4), and the logarithmic function form is used to transform the radiation effect model, and formula (5) is obtained:

$$\mathrm{Ln}P_B = \sum_{i}^{n}(\alpha \mathrm{Ln}U_i + \beta LnW_i - \gamma LnR_i) + \varepsilon \tag{5}$$

3 Methods

In addition to the characteristic attributes of commercial center, the architectural characteristics, location characteristics and environmental characteristics of housing will have an impact on housing prices.

HPM is mainly used to describe the relationship between characteristic differences and prices of heterogeneous commodities. Its main theoretical basis is Lancaster's consumer preference theory and Rosen's supply and demand equilibrium principle [19, 20]. According to the analysis of characteristic price model, we can believe that commodity is composed of many different characteristic attributes, and different characteristic attributes constitute commodity price:

$$\mathrm{S} = (s_1, s_2, \ldots, s_n) \tag{6}$$

$$\mathrm{P} = f(s_1, s_2, \ldots, s_n) \tag{7}$$

where:

S—Collection of commodity characteristic attributes

s_i—The ith characteristic attribute contained in the commodity
P—The characteristic price of a commodity

By calculating partial derivatives of each characteristic variable of the commodity price function $P = f(s)$, the price elasticity of each characteristic attribute of the commodity can be obtained, and the sensitivity of the change of characteristic attribute to the change of commodity price can be expressed, as shown in Formula (8).

$$P_i = \partial P(s_i)/\partial s_i \tag{8}$$

where:

P_i—The price elasticity of the ith characteristic attribute of a good
s_i—The ith characteristic attribute contained in the commodity

From the basic formula of the characteristic price model, we can deduce (9).

$$P = f(S) = f(L, C, V, B) \tag{9}$$

where:

L—Housing location characteristics
C—Housing architectural features
V—Housing environment characteristic
B—Features of housing business center
S—Collection of housing characteristic attributes
P—Housing price

Through the study of relevant literature on influencing factors of housing price and the induction and sorting of characteristic variables with high frequency, 23 commonly used characteristic variables are screened out. According to the difficulty of obtaining index data and the actual situation, 19 characteristic variables are selected for quantitative analysis in the form of discrete variable, dummy variable and continuous variable.

4 Case

4.1 Tentative Regression Analysis

Dao Li District Harbin was selected as the research object, and the data were obtained through BeiKe and Home link. Through the first tentative regression, the significance and multicollinearity test results of 19 variables were obtained, as shown in Table 1:

From the analysis of Table 1, it can be seen that the initial fitting regression effect of the model is very unsatisfactory, due to the following three reasons: (1) There is strong correlation between characteristic variables; (2) Deviation caused by special data samples.

Table 1. Analysis table of tentative regression test

Model	Test of significance		Collinearity test	
	t	Sig	Tolerance	VIF
(Constant)	73.930	0.000		
Subway distance	−2.711	0.011	0.145	7.132
Number of buses	2.398	0.018	0.181	5.528
Number of schools	1.137	0.261	0.259	3.798
Hospital distance	2.397	0.018	0.479	2.084
Park distance	−3.861	0.000	0.114	8.538
House age	−1.554	0.731	0.201	5.101
Floor area	−1.722	0.198	0.758	1.302
Develop corporate	2.247	0.027	0.291	3.433
Building type	0.065	0.952	0.423	2.321
Decoration kit	−0.116	0.911	0.541	1.863
Supporting infrastructure	1.301	0.029	0.332	2.972
Volume ratio	−0.912	0.359	0.335	12.988
Greening rate	1.279	0.086	0.411	2.444
Parking space	0.181	0.866	0.621	1.631
Property expense	1.755	0.283	0.243	13.948
Cleaning frequency	−0.816	0.421	0.055	16.452
Commercial distance	−2.414	0.019	0.099	8.648
Commercial scale	0.948	0.342	0.185	11.313
Commercial brand influence	2.061	0.043	0.086	5.844

4.2 Optimization Model Regression Analysis

After the initial regression and the feature attribute index screening, the sample data and the research index were processed. The integrated characteristic price regression model is returned again, and the explanatory ability of the regression model is tested. For the fitting effect of regression model, the model summary table and variance analysis table after model regression estimation are shown in Tables 2 and 3:

It can be seen from the goodness of fit table in Table 2 that the explanatory ability of the model is good. The model passed the autocorrelation test of random error terms.

Table 2. Model summary table

R	R^2	Adjusting R^2	Estimated standard error	DW
0.889[a]	0.79	0.761	0.014591	2.111

Table 3. Analysis of variance

Model	Sum squares	Degree freedom	Mean square	F	Sig.
Regression	0.419	12	0.042	196.700	000[b]
Residual error	0.013	191	0.000		
Total	.432	203			

It can be seen from the analysis of variance table in Table 3. The significance test value of the equation is 0.000, Sig < 0.05, the equation is significant.

4.3 Model Estimation Result

11 characteristic variables are finally determined to enter the regression model. The multicollinearity test was conducted again, and the variance inflation factor (VIF) of the selected 11 characteristic variables were all less than 10, and there was no multicollinearity among the characteristic variables of the equation. Table 4 lists the command output:

According to Table4, the logarithmic model equation of housing characteristic price including the characteristic variables of urban commercial center is obtained, as shown in Formula 10:

$$\begin{aligned} \mathrm{LnP} = 3.954 - 0.032\mathrm{LnL}_1 + 0.003\mathrm{Ln}L_2 - 0.022\mathrm{Ln}L_4 - 0.021\mathrm{Ln}L_5 \\ - 0.019\mathrm{Ln}C_1 + 0.068\mathrm{Ln}C_3 + 0.007\mathrm{Ln}C_7 + 0.005\mathrm{Ln}V_1 \\ + 0.034\mathrm{Ln}V_3 - 0.026\mathrm{Ln}B_1 + 0.024B_3 \end{aligned} \tag{10}$$

where:

P—Housing price; L1—Subway distance; L2—Number of buses;
L4—Hospital distance; L5—Park distance; B1—Commercial scale;
C3—Develop corporate; C7—Supporting infrastructure; V1—Greening rate;
V3—Cleaning frequency; C1—House age; B3—Commercial brand influence

5 Conclusions

According to the regression coefficient of the characteristic attributes of urban commercial center obtained by the characteristic price method, the model of the effect of urban commercial center on the radiation effect of housing price is substituted into Formula 11:

$$\mathrm{Lny} = \sum_{i}^{n}(0.024\mathrm{LnW}_i - 0.026\mathrm{LnR}_i) + \varepsilon \tag{11}$$

Table 4. Regression coefficient analysis table

Characteristic variable name	Unstandardized coefficient		Standard coefficient	t	Sig.	confidence interval (95%)	
	B	standard deviation				Lower	Upper
Constant term	3.954	0.043		89.008	0.000	3.853	4.029
Subway distance	−0.032	0.005	−0.200	−3.652	0.001	−0.034	−0.026
Number of buses	0.003	0.002	0.077	1.577	0.019	0.001	0.005
Hospital distance	−0.022	0.007	−0.109	−2.868	0.005	−0.024	−0.016
Park distance	−0.021	0.005	−0.104	−3.798	0.000	−0.021	−0.017
House age	−0.019	0.001	−0.219	−6.112	0.015	−0.025	−0.015
Develop corporate	0.068	0.008	0.065	3.879	0.028	0.062	0.079
Sup infrastructure	0.007	0.004	0.075	1.739	0.084	0.001	0.013
Greening rate	0.005	0.001	0.139	2.976	0.018	0.003	0.005
Cleaning frequency	0.034	0.003	0.112	2.559	0.028	0.026	0.038
Commercial dis	−0.026	0.007	−0.145	−2.187	0.032	−0.039	−0.012
Commercial brand	0.024	0.008	0.098	1.725	0.040	0.014	0.034

At the same time, both ends of the equation are reversely logized to obtain the parameter fitting model of the radiation effect of urban commercial center on housing price. Formula 12:

$$y = \sum_{i}^{n}\left(\frac{W_i^{0.024}}{R_i^{0.026}}\right) + \varepsilon \tag{12}$$

where:

y—The radiation intensity of urban commercial center to housing price
R—Distance between commercial center and housing
W—Brand influence
i—Commercial center
n—Number of business centers
ε—Random error term

From Formula 12, the distance from and to residence in the brand influence of urban commercial center has a significant influence on the housing price radiation, while the size of commercial center has no significant influence. Through the analysis, we can draw the following conclusions:

1. From the perspective of urban construction, the construction of urban commercial center can drive the development of surrounding land and produce housing agglomeration effect.
2. From the perspective of urban location distribution, urban commercial centers have an obvious radiating effect on surrounding housing prices.
3. From the perspective of characteristic attributes of commercial center, brand influence of commercial center and distance from housing are the key factors influencing the intensity of radiation effect.

References

1. Du Jinying, and Wang Degen. 2022. Analysis of the Coupling Coordination Degree between Housing Prices and Urban Development Quality: The Case of Nanjing Metropolitan Area, Su-Xi-Chang Metropolitan Area and Xuzhou Metropolitan Area. Areal Research and Development, 41 (1): 45–52.
2. Zheng Siqi. 2013. A Review of Research on the Interaction between Public Goods Allocation and Housing Market. Urban Problems, (8): 95–100.
3. Wang Xiulan, Fu Jiyuan, and Lü Tianyu. 2022. A Study on the Spatial Heterogeneity of Residential Price Influencing Factors in the Perspective of Functional Differentiation of Urban Centers: Wuhan City as an Example. Prices Monthly, (2): 1–9.
4. Waszak K. The key success factors of investing in shopping malls on the example of Polish commercial real estate market [J]. Research Papers of the Wroclaw University of Economics, 2015.
5. Zolfani S.H, Aghdaie M.H, Derakhti A., Decision making on business issues with foresight perspective; an application of new hybrid MCDM model in shopping mall locating [J]. Expert Systems with Applications, 2013, 40(17): 7111–7121.
6. Yang Shengfu, Zhang Peng, and Zou Qiuli. 2021. The Impact of Education Resource Disparity on Housing Prices: The Case of Jiangan District, Wuhan City. Resources Science, 43(4): 790–798.
7. Marrouch W, and Sayour N. 2021. Hedonic Housing Prices and Environmental Quality in Lebanon. International Journal of Housing Markets and Analysis, 14(5): 953–968.
8. Wang De, Huang Wanshu. Hedonic House Pricing Method and Its Application in Urban Studies [J]. City Planning Review, 2005, 29(3): 62–71.
9. KIEL K A, ZABEL J E. Location, Location, Location: The 3L Approach to House Price Determination [J]. Journal of Housing Economics, 2008, 17(2): 175–190.
10. Gu Yizhen, Zheng Siqi. The Impacts of Rail Transit on Property Values and Land Development Intensity: The Case of No. 13 Line in Beijing [J]. Acta Geographica Sinica, 2010, 65(2): 213–223.
11. Feng Changchun, LI Weixuan, ZHAO Fanfan. Influence of Rail Transit on Nearby Commodity Housing Prices: A Case Study of Beijing Subway Line Five [J]. Acta Geographica Sinica, 2011, 66(8): 1055–1062.
12. Zhang Shaoyao, SONG Xueqian, DENG Wei. Impact of Public Services on Housing Prices in Different Functional Spaces: A Case Study of Metropolitan Chengdu [J]. Progress in Geography, 2017, 36(8): 995–1005.

13. Yin Shanggang, SONG Weixuan, MA Zhifei, et al. Spatial Differentiation and Influencing Factors Analysis of Housing Prices in Nanjing: Based on Geographically Weighted Regression Model [J]. Human Geography, 2018, 33(3): 68–77.
14. LI H, WEI Y D, WU Y, et al. Analyzing Housing Prices in Shanghai with Open Data: Amenity, Accessibility and Urban Structure [J]. Cities, 2019, 91: 165–179.
15. YUAN F, WEI Y D, WU J. Amenity Effects of Urban Facilities on Housing Prices in China: Accessibility, Scarcity, and Urban Spaces [J]. Cities, 2020, 96: 102433.
16. TANG Qingyuan, XU Wei, AI Fuli. A GWR-Based Study on Spatial Pattern and Structural Determinants of Shanghai's Housing Price [J]. Economic Geography, 2012, 32(2): 52–58.
17. OOI J T, LE T T, LEE N. The Impact of Construction Quality on House Prices [J]. Journal of Housing Economics, 2014, 26: 126–138.
18. Gramotnev D K, Bozhevolnyi S I. Nano focusing of electromagnetic radiation [J]. Nature Photonics, 2014, 8(1):13–22.
19. Lancaster K J. A New Approach to Consumer Theory [J]. Journal of Political Economy, 1966, 74(Volume 74, Number 2): 132–157.
20. Rosen S. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition [J]. Journal of Political Economy, 1974, 82(Volume 82, Number 1): 34–55.