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Original article

VALUING THE ECOLOGICAL QUALITY OF THE URBAN ENVIRONMENT USING HEDONIC PRICING METHOD

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Abstract. Development of sustainable cities needs the natural and human living in a harmony way. River is an important natural attribute, which has a closed relationship with the development of the city. The purpose of the study is to use hedonic pricing method to assess the economic value of the river in Nanyang city. The novelty of the study lies in the development of econometric models, which use two explanatory variables as metrics of environmental quality – the distance from the residential property to the river and the beauty of the river landscape. Three hedonic pricing models using dummy variables to reflect distance and landscape were developed and analyzed. Simulation results showed that the distance to the river has a positive effect on property price when the distance between them is less than 200 meters. The price of property with river vision will be 9.8 % higher than the price of property without river vision. The results of the study demonstrate a fairly high economic value of the river and the need to implant economic assessments of the ecological quality of the urban environment into the strategic management of sustainable cities' development.

Keywords: environmental valuation, hedonic pricing method, river vision, proximity to the river, pricing model

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ОЦЕНКА ЭКОЛОГИЧЕСКОГО КАЧЕСТВА ГОРОДСКОЙ СРЕДЫ С ИСПОЛЬЗОВАНИЕМ МЕТОДА ГЕДОНИСТИЧЕСКОГО ЦЕНООБРАЗОВАНИЯ

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Аннотация. Развитие устойчивых городов требует гармоничного сосуществования природы и человека. Река является важным природным атрибутом, определяющим развитие города. Цель исследования – оценка экономической ценности реки в китайском городе Наньян с использованием метода гедонистического ценообразования. Новизна исследования состоит в разработке эконометрических моделей, в качестве метрик экологического качества в которых использованы две объясняющие переменные – расстояние от жилой недвижимости до реки и красота речного пейзажа. Разработаны и проанализированы три модели гедонистического ценообразования с использованием фиктивных переменных для отражения расстояния и пейзажа. Результаты моделирования показали, что расстояние до реки оказывает положительное влияние на цену недвижимости, когда расстояние между ними составляет менее 200 м. Цена недвижимости с видом на реку будет на 9,8 % выше, чем цена недвижимости без него. Результаты исследования демонстрируют достаточно высокую экономическую ценность реки и необходимость имплантации экономических оценок экологического качества городской среды в систему стратегического менеджмента устойчивого развития городов.

Ключевые слова: экологическая оценка, метод гедонистического ценообразования, речной пейзаж, близость к реке, модель ценообразования

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Sustainable development and environmental quality of the urban environment

Sustainable development has become a popular topic in recent years. In 2015, the United Nations development program adopted the 2030 Agenda for sustainable development. In the agenda, sustainable city is one of the 17 goals. Environmental attributes play an important role in achieving sustainable cities. The presence of environmental attributes in urban areas increase the quality of life greatly [1]. Although it has become a consensus to govern the environment and improve the quality of the environment its importance has changed. It has been neglected to a large extent due to the nature of the "commodity" itself, the quality of the environment. From economics perspective, the environment is a public good. Although the improvement of environmental quality is important to improve the welfare of residents, its economic value is difficult to express because of the lack of a direct market. It is this difficulty in valuation that makes policymakers often underestimate the importance of environmental quality [2]. So, to help decision makers to better formulate and implement related environmental policies, the economists actively explore reasonable environmental valuation methods and establish a scientific environmental policy evaluation system [3]. Like air condition, green spaces and so on. In recent years, the environmental valuation is still focused by economists in novel ways related to the environmental attributes. Chen & Hua used economic valuation method to value the urban heritage trees in Guangzhou, China [4].

Safety drinking water is another topic which draws the economists' great interest. Chatterjee et al. studied the safety of drinking water in the city of Jacksonville, Florida. The result showed the average WTP for safety drinking water is $6.22 [5].

In recent years, water resources have been widely cited as an environmental attributes in environmental economics, especially when the issue is economic valuation [6]. In our study, we are trying to estimate the value of water resources concerning with some social attributes. And the basic method we use in this study is the hedonic pricing method. Besides the basic social attributes which are commonly used in hedonic pricing method, like schools, hospitals, public facilities, we included the attribute – river vision. The vision of river is not only concerned with the river, but also could be regarded as a social indicator.

In this paper, we will give the theoretical foundation of environmental valuation in the second part including the theory of environmental valuation, and the theory that used in our research – hedonic pricing method. In the third part, we will talk about the case study, and the data. The reason why to choose the Nanyang city as our case study. How and where to collect the data is another topic in this part. In the fourth part, we will introduce the three kinds of variables used in our study. And in this part, we will show the mathematical and econometric ways of building up the models. 7 models are represented in this part. In the fifth part, we estimate the models using econometric regression method. The reports will be represented in this part and be explained. In the sixth part, we will discuss the results of the study. Besides we will compare our study with previous studies, deliberating the novelty in our study. Meanwhile the disadvantages will also be discussed in this part. In the final part, we will make some conclusion based on the results and discussions.

Methodology for assessing the environmental quality of the urban environment

Two main environmental valuation methods are revealed preference method and stated preference method. Travel cost method (TCM) and hedonic pricing method (HPM) are most used revealed preference method. Contingent valuation method (CVM) and choice experiments (CEs) are usually used stated preference method.

After Rosen [7] first proposed the hedonic pricing method, research on the impact of air quality on property prices began to emerge in large numbers. In Rosen's study, the author proven that the price of property is the sum of marginal willingness to pay (MWTP) for the characteristics of the property. A great number of researches used HPM to value the air pollution [8, 9] and water resources [10]. Among them valuation of air pollution is the most common research topic. Bender et al. utilized the quadratic Box-Cox flexible form in attribute demand work. In their work, they use functional forms in both the hedonic pricing function and demand stages [11]. Brucato et al. compared two approaches to evaluating the benefits of improving air quality. The first approach uses a bottom-up methodology. The second approach uses a top-down approach, which is the hedonic price method [12]. Kim et al. improved the methodology of hedonic price functions considering the inherently spatial data [13].

Over the past 10 years, as the importance of environmental issues has increased, the literature on air quality assessment has begun to increase. From the perspective of research methods, the recent literature has two major breakthroughs. The first is the use of space metrology technology. The traditional hedonic pricing method often ignores the spatial correlation of house prices, causing bias in the estimation results.

Catma used spatial error hedonic pricing model to assess the economic value of beach width [14]. The spatial hedonic pricing model could better explain the spatial dependency among the error terms. The second is to introduce migration and other behaviors into the analysis, combining hedonic pricing method and discrete selection model for analysis. For example, Lorde et al. studied the impact of the price-setting behavior of hosts on the property market in the Caribbean [15].

Results and proposals

In our study, we tried to include spatial correlation to decline the traditional hedonic pricing method bias. We build up a model with six spatial dummy variables related to the proximity to the river. We choose Nanyang city as the case study. Nanyang city is a prefecture-level city in the southwest area of Henan Province, China. Nanyang has 10,263,660 inhabitants, at the 2010 census. Among them, 1,811,812 residents live in the urban areas. There are three districts in the urban areas of Nanyang, which are Wolong district, Wancheng district, and High-Tech development district. White river has a total length of 264 kilometers and a drainage area of 12,270 square kilometers.

We collect property transaction data from a Chinese real estate website: Anjuke.com. We collect environmental data about the river from Google map, using GIS program to get distance data. And for the social related data, like hospitals and schools around property, we combine the property transaction data and Google maps.
In the Anjuke website, we collected property transaction data in 2018. The total number of transactions in 2018 is 1506, which cover all districts of Nanyang (including the rural areas). So, we choose the transaction data only happened in Wolong district, Wancheng district, and High-Tech development district. The total number is 837. Considering our research is related to the valuation of river attribute. We selected 300 data from those 837 data, which are in a less than 3 kilometers distances from the White river.

Our study uses the hedonic pricing method to measure the valuation of the White river. The basic consumer's utility function is $U_i(W_i, x, z_i, M_i, \alpha_i)$. In this function, W_i represents the characteristics of the river, x_i represents property characteristics, z_i represents neighborhood characteristics, M_i represents built-up areas, α_i represents other social characteristics. The basic assumption: $\frac{\partial U_i}{\partial W_i} < 0$, which represents that people think the river has a good impact on their utility. So, the consumer's optimizing problem becomes:

$$\max_{W,x,z,M,\alpha} U_i(W_i, x_i, z_i, M_i, \alpha_i) \quad (1.)$$

$$\text{s.t. } p_i(W_i, x_i, z_i, M_i, m_i)M_i + \alpha \leq y_i \quad (2.)$$

The setting form of the price equation will seriously affect the estimation results of the hedonic price method. We'll use two forms to make the estimation results robust. The first form of estimation function is linear function, which is our first model.

$$P = \alpha + \beta W + \gamma X + \delta Z + \epsilon \quad (3.)$$

In equation (3), X is a vector of structural characteristics of the property; Z is a vector of neighborhood characteristics.

The second form of estimation function is log-linear function, which is model 2, represented by equation (4). The dependent variable is in log form, and the independent variables are in linear form.

$$Ln(P) = \alpha + \beta W + \gamma X + \delta Z + \epsilon \quad (4.)$$

The third form of estimation function is linear-log function, which is model 3, represented by equation (5). In this form, it is the opposite with the second form. The dependent variable is linear, while the explanatory variables are in the log form.

$$P = \alpha + \beta Ln(W) + \gamma Ln(X) + \delta Ln(Z) + \epsilon \quad (5.)$$

The fourth form of estimation function is log-log function where both the dependent and independent variables regressed in the log form. This is the fourth model, represented by equation (6).

$$Ln(P) = \alpha + \beta Ln(W) + \gamma Ln(X) + \delta Ln(Z) + \epsilon \quad (6.)$$

Since we choose three characteristics related to the river, the first one is the proximity to the river, the second one is the view of the river, the third one is the direction of the river. We use these three attributes to create three models with different dummy variables. The first model is focused on the proximity. We created six dummy variables about the distance from the property to the nearest river. The second model, we added the dummy variable about the view of the river; the third one, we added the dummy variable, which measures the direction of the property to the river.

In equation (7), D_1 represents the distance from the property to the river is less than 200 meters; D_2 represents the distance from the property to the river is between 200 meters and 500 meters; D_3 represents the distance from the property to the river is between 500 meters and 800 meters; D_4 represents the distance from the property to the river is between 800 meters and 1200 meters; D_5 represents the distance from the property to the river is between 1200 meters and 1500 meters; D_6 represents the distance from the property to the river is more than 1500 meters.

$$Ln(P) = \alpha + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \gamma X + \delta Z + \epsilon \quad (7.)$$

In equation (8), we add the dummy variable – view of the river. V denotes the dummy variable view.

$$Ln(P) = \alpha + \beta D + \gamma X + \delta Z + \theta \boldsymbol{V} + \epsilon \quad (8.)$$

In equation (9), we add the dummy variable – direction of the river. R denotes the dummy variable direction.

$$Ln(P) = \alpha + \beta D + \gamma X + \delta Z + \theta \boldsymbol{V} + \eta \boldsymbol{R} + \epsilon \quad (9.)$$

Table 1 presents the description data results (300 observations). Table 2 presents the results of the baseline hedonic price models.

Таблица 1– Описательная статистика[1]

Table 1 – Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
hp	300	9163	1809	5993	15324
dist	300	793.8	518.9	120	2304
years	300	2009	4.078	2000	2017
area	300	119.2	21.34	42	198
bedroom	300	2.913	0.578	1	4
livingroom	300	1.690	0.491	0	3
floors	300	16.74	8.727	5	33
ages	300	9.950	4.078	2	19
direction	300	0.523	0.500	0	1
decoration	300	0.633	0.483	0	1
view	300	0.477	0.500	0	1
schools	300	1.990	0.875	1	5
hospitals	300	1.527	0.686	0	3

Таблица 2 – Результаты базового гедонистического моделирования[2]

Table 2 – Results of baseline hedonic price models

	(1) m1	(2) m2	(3) m3	(4) m4
VARIABLES	hp	lnhp	hp	lnhp
dist	-2.095***	-0.000232***		
	(0.154)	(1.58e-05)		
ages	-95.98***	-0.00998***		
	(20.75)	(0.00215)		
area	-7.866	-0.000815		
	(7.474)	(0.000739)		
bedroom	319.5	0.0326		
	(211.9)	(0.0214)		
floors	10.14	0.00122		
	(9.454)	(0.000964)		
schools	382.4***	0.0379***		
	(94.89)	(0.00954)		
hospitals	518.3***	0.0530***		
	(111.8)	(0.0117)		
lndist			-1,701***	-0.184***
			(122.1)	(0.0124)
lnage			-843.8***	-0.0896***
			(166.7)	(0.0172)
lnfl			76.92	0.0110
			(144.2)	(0.0146)
lnb			1,060*	0.108
			(637.7)	(0.0656)
lnl			206.2	0.0193
			(320.2)	(0.0331)
lns			660.6***	0.0646***
			(163.5)	(0.0168)
lnh			794.7***	0.0802***
			(175.1)	(0.0183)
Constant	9,605***	9.171***	23,578***	10.63***
	(579.5)	(0.0607)	(4,357)	(0.436)
Observations	300	300	290	290
R-squared	0.547	0.580	0.606	0.626

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

[1] Составлена автором.
[2] Составлена автором по результатам моделирования.

Model 1 is the linear model, model 2 is the log-linear model, model 3 is the linear-log model, and model 4 is the log-log model. In all these four models, the distance variable was statistically significant at the 1% level. And the relationships between the property price and the distance from the river are negative correlated, which indicates that the more far away from the river, the property price will become lower. From the model 1, we cloud calculated that 1 meter away from the river, the price of the property will decrease 2 yuan per square meter. And the neighborhood variables are statistically significant at 1% level. Both these two neighborhood variables show a positive impact on the price of the property.

Table 3 presents the results of the models with distance dummy variables. To have a more accurate and detailed analysis of the relationship between the proximity to the river and the price of property, we created 6 distance dummy variables.

Таблица 3 – Результаты 1 включения в модель фиктивных переменных[1]

Table 3 – Results 1 of inclusion of dummy variables in the model

VARIABLES	(1) model1 hp	(2) model2 hp	(3) model3 lnhp	(4) model4 lnhp
D1d	5.930*	5.369*	0.000699**	0.000643**
	(3.139)	(2.854)	(0.000324)	(0.000294)
D2d	0.774	1.398	0.000143	0.000211**
	(1.023)	(0.931)	(0.000106)	(9.59e-05)
D3d	-1.267**	-0.881	-9.10e-05	-4.88e-05
	(0.588)	(0.538)	(6.08e-05)	(5.55e-05)
D4d	-1.983***	-1.629***	-0.000192***	-0.000153***
	(0.398)	(0.368)	(4.12e-05)	(3.79e-05)
D5d	-1.826***	-1.457***	-0.000185***	-0.000144***
	(0.363)	(0.338)	(3.76e-05)	(3.48e-05)
D6d	-1.489***	-1.358***	-0.000157***	-0.000141***
	(0.222)	(0.207)	(2.30e-05)	(2.13e-05)
ages		-96.93***		-0.0104***
		(19.14)		(0.00197)
area		-8.799		-0.000864
		(6.997)		(0.000721)
bedroom		421.8*		0.0420*
		(226.3)		(0.0233)
livingroom		125.6		0.0101
		(185.9)		(0.0192)
decoration		31.54		-0.00241
		(155.4)		(0.0160)
schools		340.4***		0.0344***
		(84.79)		(0.00874)
hospitals		570.8***		0.0586***
		(108.0)		(0.0111)
Constant	10,079***	8,834***	9.183***	9.066***
	(351.1)	(606.0)	(0.0363)	(0.0625)
Observations	300	300	300	300
R-squared	0.439	0.554	0.466	0.578

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[1] Составлена автором по результатам моделирования.

We use linear model, and log-linear model to estimate the six different distances effects. From the results we could found that, when the distance is smaller than 500 meters, the relationship between the distance and the price is positive at a statistically significant level of 5%. This result shows that in a very short distance to the river, the property price is not the most expensive. Otherwise, the price will decrease with the distance closer to the river. But this relationship only exists in the distance smaller than 400 meters. When the distance is larger than 400 meters, the relationship between the distance and price, represents a negative effect.

The larger the distance is, the cheaper the property's price will be. The results of the distance 800 – 1200 meters, distance 1200 – 1500 meters and distance larger than 1500 meters show statistically significant at the level of 1% in all models. While the distance from 500 meters to 800 meters only shows a negative effect at a statistically significant level of 5% in the linear model.

Table 4 presents the results of the models with view and direction dummy variables. For the view dummy variable, when the property has a view of the river, the variable equals 1, otherwise equals 0.

The reason we consider the property's direction to the river is based on a geographical rule. The south of the mountain, and the north of the river are called "Yang", otherwise it will be called "Yin".

Таблица 4 – Результаты 2 включения в модель фиктивных переменных[1]

Table 4 – Results 2 of inclusion of dummy variables in the model

VARIABLES	(1) M1 lnhp	(2) M2 lnhp	(3) M3 lnhp
dist	-0.000167***	-0.000230***	-0.000173***
	(1.74e-05)	(1.53e-05)	(1.75e-05)
area	-0.000946	-0.000799	-0.000916
	(0.000738)	(0.000690)	(0.000692)
bedroom	0.0411**	0.0325	0.0400**
	(0.0207)	(0.0205)	(0.0201)
livingroom	0.0193	0.0114	0.00896
	(0.0198)	(0.0190)	(0.0187)
ages	-0.00895***	-0.00950***	-0.00864***
	(0.00209)	(0.00206)	(0.00199)
floors	0.000760	0.000658	0.000303
	(0.000900)	(0.000950)	(0.000886)
decoration	0.00713	0.00300	0.00585
	(0.0153)	(0.0152)	(0.0147)
schools	0.0374***	0.0370***	0.0366***
	(0.00909)	(0.00884)	(0.00851)
hospitals	0.0549***	0.0526***	0.0544***
	(0.0115)	(0.0110)	(0.0109)
view	0.0980***		0.0865***
	(0.0208)		(0.0211)
direction		0.0710***	0.0642***
		(0.0144)	(0.0144)
Constant	9.064***	9.158***	9.065***
	(0.0611)	(0.0562)	(0.0572)
Observations	300	300	300
R-squared	0.608	0.613	0.634

Robust standard errors in parentheses:*** p<0.01, ** p<0.05, * p<0.1

[1] Составлена автором по результатам моделирования.

When direction dummy variable equals one, it represents the north side of the river. Otherwise is the south side of the river. The results of these two dummy variables are both statistically significant at the 1% level. And both show a positive effect on the property price. The results indicate that if the property located on the north side of the river, the price will be around 7% higher than the property located on the south side of the river. And for the other dummy variable, it indicates if the property has a vision of the river, the price will be around 9% higher than the property without a river vision.

In baseline hedonic pricing model, as well as in the models with view and direction dummy variables, the robustness regression test has been done. The results show that the distance larger than 800 meters is negatively related to the property price at the statistically significant level of 1%.

With the development of city, people pay more attention to the industrialization and urbanization. Environmental resources have become invisible attributes among the city developing. In our study, we have proved that the value of river in the city using the hedonic pricing method. We choose two attributes: proximity and view as our main environmental variables. The results have proved that the proximity to river will cause the higher price of the property. The proximity has a positive effect on the property's price when the distance is less than 200 meters. But when the distance is larger than 400 meters, the coefficients become negative. When other conditions are the same, the distance far away from the river 1 meters, the price of the property will decrease $1.6 RMB/m^2$. Similar, the view of the river does have a positive effect on the price of the property. The river view hold by the property will also make the price higher. When other conditions are the same, the price of property with river vision will be 9.8% higher than the price of property without river vision. Based on these studies, we cloud conclude that the environmental goods, such as forests, rivers, and so on, have great value, especially those in the urban areas. They are ought to be regarded as luxury goods for protecting.

From a sustainable development perspective, the river could be regarded as an ecological system. The river will generate the wetland for increasing the species diversity. The more closed relationship with human is the supply water system. Because of the lack of data about the quality of the river, we could not evaluate the economic value of improving the water quality. However, in the future, with more environmental data related to the water quality, we could build up better model for assessing the economic valuation of the water. Our study only chooses two attributes of the water quality, in the future more attributes related to water could be valued.

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