HEDONIC PROPERTY VALUATION MODEL: THEORY AND APPLICATION

Nguyen Thi Hong Thu (MA.)

School of Economics

Previous research has established that the commonly applied the methods of property valuation can be broadly divided by two groups such as traditional and advanced methods (Xiao & Webster, 2017). These traditional methods in the field of property valuation include the sales comparison method, cost method, residual/development method, profits method, and investment method (capitalization/discounted cash flow - DCF method). Advanced methods focus on techniques, for instance, hedonic pricing model, spatial analysis methods, artificial neural networks (ANN), and case-based reasoning that mentioned in technology and machine/engineering. This topic will only reveal clearly hedonic property values models and applied valuation. From the many hedonic property valuation studies of the impacts of related determinants, this studies also suggests some topics that related to analyze the factors or attributes of housing affect of property value. Appraisal, household, developers and Policymakers could draw on this synthesis of site characteristics' effects to property value.

Theoretical basis

The Hedonic pricing theory is well established method based on consumer theory (Lancaster,1966), relying on the premise that the amount of money an individual is willing to pay for a particular good is dependent upon the individual attributes of that goods (Rosen, 1974 and Freeman, 1979). Consumer utility is defined over two goods: Z, the differentiated good ($Z=z_1, z_2, z_3,\dots, z_n$ – the differentiated commodity with characteristics), and x, a composite commodity representing all other goods (i.e., income left over after purchasing Z). Consumer j, with demographic characteristics α^j has utility defined as:

$$U^j (x, z_1, z_2, z_3, \dots , z_n, \alpha^j)$$

The budget constrain is $y^j = x + P(z)$. The consumer seeks to maximize utility by choosing the model of the differentiated product z, and the amount of x to purchase, subject to this budget constrain.

The marginal rate of substitution ($\frac{\partial P}{\partial z_i} = \frac{\partial U/\partial z_i}{\partial U/\partial x}$) between any characteristic, z_i and the numeraire commodity, x is equal to the rate at which the consumer can trade z_i for x in the market.

Hedonic analysis of markets for differentiated goods consists of two related steps often referred to as a first-stages and second-stages analysis. In the first-stages analysis, the hedonic function is estimated using information about the prices of a differentiated commodity and the characteristics of the commodity. This analysis allows authors to recover the implicit prices of characteristics and reveals information on the underlying preferences for these characteristics. Once the first-stage analysis is completed, authors may then use the implicit prices obtained in the first-stage to estimate the demand functions for the characteristics of the commodity (the second-stage).

Such as hedonic price models aim at estimating implicit price for each attributes of a good, and a property could be considered as a bunch of attributes or services, which are mainly divided into structural, neighborhood, accessibility attributes, etc. Individual buyers and renters, for instance, try to maximize their expected utility, which are subject to various constraints, such as their money and time.

Hedonic pricing has its origin in labor and property and different varieties of the hedonic approach can be found. However, the most common application of hedonic pricing in environmental valuation is in relation to the public's willingness to pay for housing. In this context, each property is assumed to constitute a distinct combination of characteristics that determines the price which a potential purchaser or tenant is willingness to pay. Freeman III (1979b) argued that the housing value can be considered a function of its characteristics, such as structure, neighborhood, and environmental characteristics. In general, most property value studies include three type of characteristics: (i) the house and the lot, (ii) features of the neighborhood such as the quality of the school district, the level of the crime, and the environment health, (iii) the property's location such as its proximity to a recreation area or an employment center.

Functional forms

The hedonic price regression models can be classified into four simple parametric functional forms such as linear, semi - log, double - log, and Box-Cox. In the following the hedonic regression function, the researchers must determine how the characteristics affect price. Moreover, they must decide on the functional form of the hedonic price function that is estimated.

Table 1: Functional forms for the hedonic price function

Name	Equation
Linear	$P = \alpha_0 + \sum \beta_i z_i + \varepsilon$
Semi-log	$\ln P = \alpha_0 + \sum \beta_i z_i + \varepsilon$
Double-log	$lnP = \alpha_0 + \sum \beta_i lnz_i + \varepsilon$
Quadratic	$P^{(\theta)} = \alpha + \sum_{i=1}^{N} \beta_i z_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \delta_{ij} z_i z_j + \varepsilon$
Quadratic Box-Cox	$P^{(\theta)} = \alpha + \sum_{i=1}^{N} \beta_i z_i^{(\lambda)} + \frac{1}{2}\sum_{i,j=1}^{N} \delta_{ij} z_i^{(\lambda)} z_j^{(\lambda)} + \varepsilon$

Source: summarized by Laura O. Taylor (2003)

a. Linear specification: both the dependent and explanatory variables enter the regression with linear form.

$$P = \alpha_0 + \sum \beta_i z_i + \varepsilon$$

where

P denotes the property value;

ε is a vector of random error term;

β_i indicates the marginal change of the unit price of the i^{th} characteristics z_i of the good

b. Semi-log specification: in a regression function, dependent variable is log form and explanatory variable is linear, or dependent variable is linear and explanatory variable is log form.

$$\ln P = \alpha_0 + \sum \beta_i z_i + \varepsilon$$

where,

P denotes the property value;

ε is a vector of random error term;

β_i indicates the rate at which the price increases at a certain level, given the characteristics x

c. Log–log specification: in a regression function, both the dependent and explanatory variables are in their log form.

$$lnP = \alpha_0 + \sum \beta_i lnz_i + \varepsilon$$

where

P denotes the property value;

ε is a vector of random error term;

β_i indicates how many percent the price p increases at a certain level, if the i[th] characteristic z_i changes by 1%

d. Box–Cox transform: determine the specific transformation from the data itself then enter the regression in individual transformed form.

$$P^{(\theta)} = \alpha + \sum_{i=1}^{N} \beta_i z_i^{(\lambda)} + \varepsilon$$

where

$$P^{(\theta)} = \frac{P^{(\theta)} - 1}{\theta}, \theta \neq 0 \; and \; P^{(\theta)} = lnP, \theta = 0$$

$$z_i^{(\lambda)} = \frac{z_i^{(\lambda)}}{\lambda}, \lambda \neq 0 \; and \; z_i^{(\lambda)} = lnz, \lambda = 0$$

From the Box–Cox transform equation, we can see if the θ and λ are equal to 1, the model will transform to the basic linear form. If the θ and λ are equal to 0, the model will transform to the log-linear form. If the value the θ is equal to 0 and λ are equal to 1, then the model can be the semi-log form.

Property attributes and applied valuation

The basic hypothesis of hedonic property valuation models is that housing price can be considered as willingness to pay for a bundle of characteristics. Empirical studies have generally grouped determining variables into four group:

(a) Structural or internal attributes describing the physical characteristics of housing.

(b) Locational attributes including the distance to major places of employment, to major amenities and to road infrastructure and transport accessibility.

(c) Environmental attributes describing environmental quality and environmental amenities.

(d) Neighborhood attributes depicting the quality of the economic and social characteristics of the neighborhood.

These are examined in the following Table 2. Furthermore, based on this table, some problem studies in property valuation will be mentioned by the authors.

Table 2: Review previous research in Hedonic pricing models

Types of housing attributes	**Characteristics/Variables**	**References/Authors**
Structural characteristics	Area of a house	Roebeling et al. (2017); Park et al (2017); Sander & Haight (2012); Escobedo et al. (2015)
	Number of bathrooms	Park et al (2017)
	Number of bedrooms	Park et al (2017)
	House types	Escobedo et al. (2015)
	Age	[Roebeling et al. (2017); Park et al (2017); Sander & Haight (2012); Escobedo, et al. (2015)
	Garage	
	Size/number of units of apartment complex	
	Level	
Locational characteristics	CBD/Downtown	Sander & Haight (2012); Payton, et al. (2008); Hwang, et al. (2008)
	Elementary school district	Ko, et al. (2011); Oh, & Lee (2003); Kim & Kim (2007)
	High school district	Sander & Haight (2012);

		Hwang, et al. (2008)
	Tax rate	Sander & Haight (2012); Payton, et al. (2008)
	Accessibility to employment	Payton, et al. (2008)
	Distance to bus stop	Ko, et al. (2011); Kim & Kim (2007)
	Distance to subway station	Hwang, et al. (2008)
	Distance to shopping mall	Ko, et al. (2011); Kim & Kim (2007) [25,26,35]
Environmental characteristics	Lake/rivers/oceans/ mountains	Ko, et al. (2011)
	Park	Ko, et al. (2011); Kim & Kim (2007); Hwang, et al. (2008); Sander & Haight (2012); Park et al (2017)
	Recreational zone	
	Tree cover	Sander & Haight (2012); Escobedo et al. (2015)
	Distance to hazard (air, water, traffic)	Brasington and Hite (2005); Grislain-Letrémy & Katossky (2014)
Socio-economic/neighborhood characteristics	Population	Roebeling, et al. (2017); Jim & Shan (2013)
	Income status	
	Crime	Dubin & Goodman (1982); Jim & Shan (2013)
	Education	
	Race/racial composition	
	Primary school performance	Gibbons & Machin (2003)
Others characteristics	Information value	Kuang (2017)
	Green/Environmental Certification	Abdullah, et al (2016); Holtermans & Kok (2017)
	Cemetery view	Tse & Love (2000)
	Teardown/Historical building	McMillen &O'Sullivan(2013)
	Health (obesity)	Madgin, et al. (2016)
	Walkability (bus, railway, airport, ect)	

Source: Reviewed by Author

The hedonic pricing method was revealed preference method to quantify a value from non-market goods purchased with a housing properties. In recent years, these studies focus on environment amenities and property value.

There are a large of literature that estimates the use value of urban green space, using a revealed preference approach (Brander & Koetse, 2011). Early studies focused mainly on investigations into the characteristics of green space and their impact on property value. For example, the size of urban open space has been shown to have a positive impact on the value of housing nearby (Diewert, 2016; Chen & Jim, 2010; Voicu & Been, 2008; Donovan & Butry, 2011; Song & Zenou, 2012; Zheng et al., 2012). Some studies have investigated the effects of the number of green spaces and the types of green space (parks, urban forest, wetland, cemetery, greenways, golf courses and so on) (Daams, 2016; Escobedo, 2015; Xiao et al., 2016; Czembrowski & Kronenberg, 2016). The results are mixed, with positive, negative and insignificant effects being variously reported for the same category of green space.

Some have sought to decompose the locational effect and to categorize zones of benefits (Daams et al., 2016; Song & Zenou, 2012). Crompton (2001) using meta- analysis to study the impact of parks on the value of homes located between 500–2000 feet from the nearest green space. This result comes almost completely from western cities with traditional industrial city density profiles. As well a general proximity effect, there is also a binary categorical effect (park visible/not visible from a home) (Bourassa et al., 2004; Jim and Chen, 2010).

The study conducted by Zhang et al, (2012) found that urban green had positive and statistically significant influences on neighboring property values; on average was a 5%-20% premium. City parks are more highly more valued with an average premium of 10.9% with parks inside 2nd ring road can increase property value by about 14.1% while the parks beyond 5th ring road only add 0.5% in house prices. They also found a property located on the edge of a park could potentially attract a premium of between 0.5% and 14.1% in Beijing. The most recent on this study can be refer to Panduro and Veie (2013) and Park et al. (2017), mentioned that proximity to parks and size of the park is associated with higher prices, the effect of size is small with approximately 0.01% increase in the price with a one percent increase in size. The size of common area is associated with statistically significance higher property prices. 1% increase in the size of common area coincides with a 0.01% increase in property price. They also suggested that proximity is measured in Euclidian distance in steps of 100 meters from property to all types of green except green common area and lakes. It’s included a house with view of lake will gained into 7% of higher prices. Housing which having a view of a park is associated with price premium of almost 6%.

Other studies have looked at the relationship between revealed preference valuation captured in home prices and people's actual use of green space and this suggests that hedonic valuations of green space should be dependent on residents' demographic and economic characteristics (Fuerst, 2016). Studies that show a positive association between green space value and people's income, imply that green space is a 'normal good' (demand rises with income). A study by Panduro and Veie (2013) found that neighborhoods contrasting in income and home-type (apartments and houses), showed different capitalizations for the same type of green space, with a significant positive effect on the size of common areas for apartments, but no effect for houses.

Summary

This topic presents a wide ranging literature review of hedonic property valuation models, which can be summarized from numbers of aspects. Moreover, this session also suggests some topic that related to analyze the factors or attributes of housing affect of property value.

REFERENCES

Abdullah, L., Mohd, T., & Sabu, R. (2016). A Conceptual Framework of Green Certification Impact On Property Price. In *MATEC Web of Conferences* (Vol. 66, p. 00033). EDP Sciences.

Brander, L. M., & Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of environmental management*, *92*(10), 2763-2773.

Chen, W. Y., & Jim, C. Y. (2010). Amenities and disamenities: a hedonic analysis of the heterogeneous urban landscape in Shenzhen (China). *The Geographical Journal*, *176*(3), 227-240.

Chin, H. C., & Foong, K. W. (2006). Influence of school accessibility on housing values. *Journal of urban planning and development*, 132(3), 120-129.

Cho, S. H., Bowker, J. M., & Park, W. M. (2006). Measuring the contribution of water and green space amenities to housing values: an application and comparison of spatially weighted hedonic models. *Journal of agricultural and resource economics*, 485-507.

Czembrowski, P., & Kronenberg, J. (2016). Hedonic pricing and different urban green space types and sizes: Insights into the discussion on valuing ecosystem services. *Landscape and Urban Planning*, 146, 11-19.

Escobedo, F. J., et al. (2015). Urban forest structure effects on property value. *Ecosystem Services*, *12*, 209-217.

Grislain-Letrémy, C., & Katossky, A. (2014). The impact of hazardous industrial facilities on housing prices: A comparison of parametric and semiparametric hedonic price models. *Regional Science and Urban Economics*, *49*, 93-107.

Holtermans, R., & Kok, N. (2017). On the Value of Environmental Certification in the Commercial Real Estate Market. *Real Estate Economics*.

Hwang, H. K., et al. (2008). Effect of visibility of the Han River on housing price. *Housing Studies Review*, *16*(2), 51-72.

Jim, C. Y., & Shan, X. (2013). Socioeconomic effect on perception of urban green spaces in Guangzhou, China. *Cities*, *31*, 123-131.

Kim, Y. J., & Kim, K. H. (2007). Valuation of Urban Leisure Parks: An Application of Hedonic Price Model. *J. Tour. Sci*, *31*, 265-286.

Ko, H. J., Yun, K. B., Shim, Y. J., & Hwang, H. Y. (2011). Impact Analysis of an Eco-Park on the Adjacent Apartment Unit Price by Using the Hedonic Model-With a Focus on the Cheongju Wonheung-ee Park and Adjacent Apartments. *Journal of the Korean housing association*, *22*(5), 47-57.

Kuang, C. (2017). Does quality matter in local consumption amenities? An empirical investigation with Yelp. *Journal of Urban Economics*, *100*, 1-18.

Madgin, R., Bradley, L., & Hastings, A. (2016). Connecting physical and social dimensions of place attachment: What can we learn from attachment to urban recreational spaces?. *Journal of Housing and the Built Environment*, *31*(4), 677-693.

McMillen, D., & O'Sullivan, A. (2013). Option value and the price of teardown properties. *Journal of Urban Economics*, *74*, 71-82.

Oh, D. H., & Lee, C. B. (2003). An Analysis on the effect of view and story on the price of Hanriver Riverside apartments. *J. Korea Plan. Assoc*, *38*, 247-257.

Park, J. H., Lee, D. K., Park, C., Kim, H. G., Jung, T. Y., & Kim, S. (2017). Park Accessibility Impacts Housing Prices in Seoul. *Sustainability*, *9*(2), 185.

Payton, S., et al. (2008). Valuing the benefits of the urban forest: a spatial hedonic approach. *Journal of Environmental Planning and Management*, *51*(6), 717-736.

Roebeling, P., et al. (2017). Assessing the socio-economic impacts of green/blue space, urban residential and road infrastructure projects in the Confluence (Lyon): a hedonic pricing simulation approach. *Journal of Environmental Planning and Management*, *60*(3), 482-499.

Sander, H. A., & Haight, R. G. (2012). Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. *Journal of environmental management*, *113*, 194-205.

Sander, H. A., & Polasky, S. (2009). The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. *Land Use Policy*, 26(3), 837-845.

Voicu, I., & Been, V. (2008). The effect of community gardens on neighboring property values. *Real Estate Economics*, *36*(2), 241-283.

Xiao, Y., & Webster, C. (2017). *Urban morphology and housing market*. Springer Singapore.

Zhang, H., Chen, B., Sun, Z., & Bao, Z. (2013). Landscape perception and recreation needs in urban green space in Fuyang, Hangzhou, China. *Urban Forestry & Urban Greening*, *12*(1), 44-52.