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A CRITICAL REVIEW OF LITERATURE ON THE HEDONIC PRICE MODEL

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ABSTRACT

The hedonic price model, derived from Lancaster's (1966) consumer theory and Rosen's theoretical (1974) model, has been used extensively in the scientific investigation of various aspects of housing markets. This paper reviews the literature on the application of the hedonic price model. Theoretical background, major empirical issues, inherent limitations, and advantages are discussed. The applicability of the model to the housing market is critically examined. Previous empirical studies of the effects of locational, structural, and neighbourhood-related housing attributes on property prices are identified and reviewed. A list of common housing attributes used in the estimation of the hedonic price models and their effects on housing prices are identified. Although the set of prices influencing characteristics is different across different markets, and the variables included in the hedonic price model are also constrained by the availability of data, this list should serve as a useful basic checklist for the application of the hedonic price model in different markets.

Keywords:

Hedonic Price Model, Housing Attributes, Locational Attributes, Structural Attributes, Neighbourhood Attributes.

Introduction

The housing sector is very much associated with the economic health and wealth of a nation. A high demand for housing would trigger growth in many other economic sectors. Thus, research into the variables that impact property prices is essential because the purchase of a residential property is both an investment decision as well as a consumption decision. In the endeavour to model housing prices, two approaches have been widely used. The first approach is the monocentric model, where housing price is assumed to be a function of proximity to a single employment centre or workplace. The relative housing prices then reflect the relative savings in commuting costs associated with different locations.

However, unlike other consumption goods, the housing market is unique because it manifests the characteristics of durability, heterogeneity, and spatial fixity. Thus, to model this differentiation effectively, the second approach of the hedonic price model has been introduced. The hedonic price model posits that goods are typically sold as a package of inherent attributes (Rosen 1974). Therefore, the price of one house relative to another will differ with the additional unit of the different attributes inherent in one house relative to another house. The relative price of a house is then the summation of all its marginal or implicit prices estimated through the regression analysis.

Numerous studies have utilised this technique to examine the relationship between attribute preference and the price of properties (Gillard 1981; Li & Brown 1980; Sirpal 1994; Walden 1990). This is because the market price of a housing unit can be determined by the buyers' evaluations of the housing unit's bundle of inherent attributes, such as locational, structural, or neighbourhood attributes (Freeman 1979). Most of these studies were inclined towards housing markets in the West, America and Europe in particular. Only a few were conducted in the East, such as in Hong Kong (Chau, Ma, & Ho 2001; Chau, Ng, & Hung 2001; Chau and Ng, 1998; Mok *et al*, 1995; Chan, & Cho 1995; So, Tse, & Ganesan 1996), Taiwan (Hsueh 2000), and Japan (Edmonds 1984). This paper reviews the literature on the application of the hedonic price model in housing markets, and identifies a list of key variables to be included in hedonic price models.

Hedonic Price Model - Theoretical Framework

According to Triplett (1986), hedonic methods were developed and employed in price indices long before their conceptual framework was understood. Bartik (1987) claimed that the first formal contributions to hedonic price theory were those made by Court in 1941, although there were other informal studies. For instance, Colwell and Dilmore (1999) mentioned that Haas produced a hedonic study more than 15 years prior to Court, who first published the term "hedonic." Etymologically, the term "hedonics" is derived from the Greek word *hedonikos*, which simply means pleasure. In the economic context, it refers to the utility or satisfaction one derives from the consumption of goods and services.

Two main approaches contributed greatly towards the theoretical work on hedonic prices. The first approach was derived from Lancaster's (1966) consumer theory, and the second comes from the model postulated by Rosen (1974). Both of these approaches aimed to impute prices of attributes based on the relationship between the observed prices of differentiated products and the number of attributes associated with these products.

The Lancastrian model, Rosen's model, and the hedonic price model all surmised that goods possess a myriad of attributes that combine to form bundles of characteristics (or objectively measurable, utility-affecting attributes), which the consumer values; but these models have some fundamental differences. The Lancastrian model presumes that goods are members of a group, and that some or all of the goods in that group are consumed in combinations, subject to the consumer's budget. In comparison, Rosen's model assumes there is a range of goods, but that consumers typically do not acquire preferred attributes by purchasing a combination of goods. Rather, each good is chosen from the spectrum of brands and is consumed discretely. The hedonic price approach also does not require joint consumption of goods within a group. Thus, Lancaster's approach is more suited to consumer goods, whereas Rosen's model can be associated with durable goods.

Lancaster's theory also assumes a linear relationship between the price of goods and the characteristics contained in those goods. Implicit prices are constant over ranges of characteristic amounts. They can only change when there is a change in the combination of goods consumed. In contrast, Rosen postulated that unless it is possible for consumers to arbitrage attributes by untying and repackaging them, a nonlinear relationship between the price of goods and their inherent attributes would be more probable. A nonlinear price function implies that the implicit price is not a constant, but a function of the quantity of the attribute being bought, and, depending on the actual functional form of the equation, on the quantities of other attributes associated with the good as well.

Rosen's model has two distinct stages. The initial stage serves to estimate the marginal price for the attribute of interest by regressing the price of a commodity or good on its attributes. The first stage develops a measure of the price, but does not directly reveal the inverse demand function. The second stage estimation is to identify the inverse demand curve or the marginal willingness to pay function, derived from the implicit price function estimated in the first stage.

As Rosen incorporated income directly into the budget constraint of the consumer, when income increases, the consumer's marginal willingness to pay for a certain implicit attribute may also change. It is assumed that the buyer's demand price or willingness to pay for an attribute is a function of the utility level, the buyer's income, and other variables which influence tastes and preferences, such as age, education, and so on. Rosen opined that the inverse demand function, which takes into consideration the changes in income and utility levels, can be estimated by using the marginal price as an endogenous variable in the second-stage simultaneous equation. If it is possible to trace back the inverse demand function based on the implicit marginal price function, then measuring the utility change with respect to certain quality changes can also be estimated by integrating the inverse demand.

However, identification of the inverse demand function poses some problems because it depends on the assumptions made about the supply side of the implicit market for the attribute. If the supply of a commodity is perfectly elastic, or if the supply of an attribute is fixed, the marginal price of an attribute becomes exogenous in the estimation of the inverse demand function. Bartik (1987) did not agree with Rosen's approach of estimating the hedonic price model, and argued that the hedonic estimation problem is not the result of the interaction between demand and supply because the individual consumer cannot affect suppliers. Instead, the hedonic estimation problem is caused by the endogeneity of both prices and quantities of attributes in the context of a non-linear budget constraint. Hence, there is no necessity to model the supply side of the market.

The Hedonic Price Model – Empirical Issues

A major empirical issue pertaining to the hedonic price model is the choice of the functional form. There are several basic functional forms such as linear, semi-log, and log-log forms that can be applied to the hedonic price model. An incorrect choice of functional form may result in inconsistent estimates (Bloomquist & Worley 1981; Goodman 1978). Despite having a long history, the theory of hedonic pricing provides very little guidance on the choice of the proper functional form (Butler 1982; Halvorsen & Pollakowski 1981).

Rosen's (1974) model does not, *a priori*, specify a particular functional relationship between the attributes and commodities, although he adopted the "goodness-of-fit" criterion, and this was widely used in early empirical studies. The likelihood ratio test was used to compare the more restricted forms with the more complex forms derived from the Box-Cox transformation (Box & Cox 1964). Many researchers prefer the Box-Cox form, as the transformation process results in a better fit of the data (Rasmussen & Zuehlke 1990). The flexible Box-Cox transformation can also be used to test the statistical validity of alternative hypotheses about functional form.

Cassel and Mendelsohn (1985), however, contended that the Box-Cox flexible form also has some shortcomings. For example, the many parameters estimated in the Box-Cox transformation reduce the accuracy of any single coefficient. Hence, the best fit criterion resulting from the likelihood ratio test may not lead to more precise estimates of the implicit marginal prices of housing attributes. Linneman (1980) indicated a further limitation of the Box-Cox flexible form, which is, that the transformation cannot be applied to binary or dummy variables because dummy variables are not strictly positive (So, et al. 1996).

Another controversial issue is that of market segmentation. Feitelson, Hurd, and Mudge (1996) noted that in theory, hedonic price studies do not require the segmentation of housing markets. However, in practice, several types of market segmentation are likely to exist in most markets. This is because housing markets are not uniform (Adair, Berry, & McGreal 1996; Fletcher, Gallimore, & Mangan 2000). Hence, it is unrealistic to treat the housing market in any geographical location as a single entity. Unfortunately, the definition, composition, and structure of sub-markets have not been given much attention in the hedonic-price literature, although it is an important empirical issue.

As a result, even though most studies have used locational and political boundaries, or the demographic and socioeconomic characteristics of households such as race and income (Michaels & Smith 1990), questions remain as to what characteristics best differentiate sub-markets, and how best to identify and measure these differences. This is because too broad a geographical definition of a housing market would result in biased estimates due to an improperly aggregated sample (Linneman 1980). Conversely, if too narrow a definition (Schaffer 1979; Straszheim 1975) were used, it would give rise to imprecise estimates because the estimates were not based on all available information.

Another issue frequently associated with the hedonic price model is the misspecification of variables. Misspecification is a situation in which an irrelevant independent variable is included (over-specification), or where a relevant independent variable (attribute of a product) is omitted (under-specification). As the hedonic price model deals with the implicit prices of quantities of attributes of a product, the problem of misspecification of variables is inevitable. Over-specification gives estimated independent variables that are both unbiased and consistent, but inefficient because of the inclusion of the irrelevant variable, whereas under-specification results in estimated coefficients that are both biased and inconsistent. However, according to Butler (1982), since all estimates of hedonic price models are to some extent misspecified, models that use a small number of key variables generally would suffice.

Butler suggested that only those attributes that are costly to produce and yield utility be considered in the regression equation. Mok, et al. (1995) concurred that biases due to missing variables are small, and have negligible prediction and explanatory power on the equation. Finally, measurement errors may also arise if proxy variables are used in the hedonic price model when actual data is unavailable. Consequently, the results generated will be biased and inconsistent.

The Hedonic Price Model – Application to the Housing Market

The application of the hedonic price model to the housing market rests on several key assumptions. First, homogeneity of the housing product is assumed. This assumption, however, is arguable. It would be more accurate to view housing products as heterogeneous because they can be differentiated in terms of locational, structural, or neighbourhood attributes, or based on some other criteria as well, such as type of dwelling (bungalow, terrace house, high rise apartment, or condominium). Another underpinning assumption is that the market operates under perfect competition, and there are numerous buyers and sellers. This assumption is justified as there are many buyers seeking housing in the market, and there are also many housing developers that supply the housing. Thus, no individual buyer or supplier can significantly affect the price of the properties because the purchases or sales of each individual unit constitute a negligible portion of the market.

Buyers and developers are deemed to have freedom to enter and exit the market. Unlike some other industries, such as the petroleum and aviation industries that may have to comply with certain requirements, there are neither constraints artificially imposed on the demand and supply of housing, nor restrictions on the resources used to produce the housing product. In practice however, there might be some budget constraints for buyers. Likewise, for developers, only those with enough capital can contemplate property development.

The assumption that buyers and sellers have perfect information concerning housing product and price is quite reasonable, although one may still contend that perfect knowledge is impossible to achieve in reality. Buying a house involves a substantial capital outlay. Thus, buyers will endeavor to shop around to acquire as much information about the attributes of the units they desire before making the purchase. Most of the relevant information, such as availability of the housing unit, its price and attributes, is readily available in the newspapers, or can be obtained from brokers and real estate agents. As for suppliers, perfect knowledge of their core business and the market price enables them to increase their profits and utility, too. However, such perfect information may never be fully realized in practice.

Finally, the hedonic price model only works under the assumption of market equilibrium, and there are no interrelationships between the implicit prices of attributes (Dusse & Jones 1998). Market equilibrium is not plausible because there are imperfections in the real world property market. It is idealistic to assume that the price vector will adjust instantaneously to changes in either demand or supply at any point in time. The notion that there are no interrelationships between the implicit prices of attributes is also fallacious because it implies that the implicit price of an attribute does not vary throughout all areas and property types. Of course it is not necessarily true that all attributes will give the same level of utility or identical levels of disutility to all buyers.

Despite these disputable assumptions, which involve substantial simplification and abstraction from a complex reality, the hedonic price model has been deployed extensively in housing market research (Ball 1973; Chau, et al. 2001; Freeman 1979; Leggett & Bockstael 2000). As astutely observed by Freeman, the data may be inadequate; variables are measured with error; and the definitions of empirical variables are seldom precise, but these do not render the technique invalid for empirical purposes.

The hedonic price approach does have its merits, though. Its main advantage is that one only needs to have certain information, such as the property price, the composition of housing attributes, and a proper specification of the functional relationships. The marginal attribute prices are obtained by estimating the parameters of the hedonic price function. It is a straightforward approach because only the coefficients of the estimated hedonic regression are needed to indicate the preference structure. No information whatsoever about individual characteristics or personal particulars of either the house buyers or the suppliers is required.

Ridker and Henning (1967) were credited as the pioneers who applied the hedonic price approach in residential properties. They investigated the relationship between air quality and property values, but it was Freeman (1979) who was noted for giving the first theoretical justification for the application of this technique to housing. Specifically, Freeman used the hedonic price equation to measure the marginal implicit prices and the willingness to pay for housing attributes, such as environmental quality.

Residential properties are multidimensional commodities characterized by durability, structural inflexibility, and spatial fixity (Chau, et al. 2001; So, et al. 1996). Typically, housing attributes are classified into locational attributes, structural attributes, and neighbourhood attributes. These attributes encompass both quantitative and qualitative attributes (Goodman 1989; Williams 1991). The market prices of the property can therefore be expressed as a function of locational, structural, and neighbourhood variables.. The implicit price of each housing attribute, *ceteris paribus*, can be derived from the regression coefficients. Thus, the hedonic price approach allows us to estimate the individual effects of each housing attribute on housing prices, holding all other factors constant. A review of previous empirical studies shows that similar housing attributes are used in previous studies irrespective of the geographical location of these housing markets.

Locational Attributes

The location of a property has been conceived in most studies in terms of fixed and relative locational attributes. The fixed locational attributes (Follain & Jimenez 1985; Orford 1988) are quantified with respect to the whole urban area, and pertain to some form of accessibility measure. Locational attributes are quantified through surrogate measures such as socio-economic class, racial composition, aesthetic attributes, pollution levels, and proximity to local amenities (Dubin & Sung 1990).

In the traditional view of location, accessibility is measured in terms of access to the Central Business District (CBD). Accessibility, in whatever form it has been measured, has some influence on housing prices (McMillan, Jarmin, & Thorsnes 1992; Palmquist 1992; Ridker & Henning 1968). Transport accessibility is frequently associated with the ease of commuting to and from amenities, and is measured by traveling time, cost of travel, convenience, and availability of different transport modes (Adair, Greal, Smyth, Cooper, & Ryley 2000; So, et al. 1996). Buyers tend to trade off housing costs against transport costs, but this is not always true because Edmonds (1984) found that in Japan, it is customary for firms to reimburse employees for commuting. Thus, the only apparent "costs" of commuting were probably time and discomfort. The positive influence of good public transport services on housing prices has also been empirically examined. For example, So, et al.'s (1996) study on Hong Kong suggests that buyers are willing to pay more for properties with easy accessibility to public transportation.

View is sometimes considered a residential amenity usually associated with the location of a dwelling site (Benson, Hansen, Schwartz, & Smersh 1998). Numerous studies have indicated that buyers prefer sites with good views, such as lakes or golf courses, and are willing to pay a premium for such sites (Cassel & Mendelsohn 1985; Darling 1973; Gillard 1981; Mok, et al. 1995; Plattner & Campbell 1978; Rodriguez & Sirmans 1994).

Benson, et al. also noted that the view amenity may not be uniform; it varies by type (e.g., water view, mountain view, and valley view) and by quality (e.g., full view, partial view, or poor partial view). Classifying the views as oceanfront, ocean view, partial ocean view, and no view, they discovered that, relative to no view, an ocean frontage adds 147 % to a property's selling price, an ocean view 32 %, and a partial ocean view 10 %. So, et al. (1996) found a strong correlation between view and floor level because higher floors have better views. Thus, apartment or condominium units on higher floors usually fetch a higher price compared to those on lower levels.

A review of some other studies revealed that the existence of a view is not always statistically significant, although there is generally a positive association of price and view (e.g., Brown & Pollakowski 1977; Correll, Lillydahl, & Singell 1978). Brown and Pollakowski's study on the value of living near a lake in Seattle, Washington, found that a greater distance to the waterfront significantly reduces a property's selling price, but view was statistically insignificant. They justified this anomaly by the small sample sizes used. In Correll, et al.'s examination of valley views, where views were classified as excellent, moderate, and no view, the relationship between view and price was statistically insignificant.

Not much research, though, has been conducted on cemetery views except for the works of Tse and Love (2000), who found that a cemetery view has a negative impact on a property's price in Hong Kong. Generally, dwellings that have a cemetery view are avoided. This is because the view of a cemetery is regarded by the Chinese as inauspicious, as it connotes death and is definitely bad *feng shui* (geomancy).

Interestingly, there have been some studies that demonstrated the influence of *feng shui* in the power of "lucky" and "unlucky" properties. Bourassa and Peng (1999), who used sales transactions for 1989 to 1996, found that lucky house numbers (e.g. 3, 6, 8, and 9) have significant positive hedonic prices and are capitalised into the sale prices of houses in Auckland, New Zealand. Chau, Ma, and Ho (2001) also found this to be true in the predominantly Cantonese society of Hong Kong. Their results, however, showed that lucky floor numbers (e.g. 8, 18, or 28) are sold at significantly higher premiums during periods of property boom than during property slumps

Structural Attributes

Prices of properties are frequently related to their structural attributes. As Ball (1973) pointed out, if a house had more desirable attributes than others did, the valuation of these attributes would be reflected in higher market prices for the house. The single most important structural variable is floor area. Age and floor level are also important structural variables for multi-storey buildings. However, structural attributes preferred by buyers may not always be identical. Kohlhase (1991) found that the significance of structural attributes can change over time, and may vary between nations. While attributes relating to the number of rooms and floor area are relatively important across nations, other attributes change with the tradition of building style or the climate.

Numerous studies have revealed that the number of rooms and bedrooms (Fletcher, et al. 2000; Li & Brown 1980), the number of bathrooms (Garrod & Willis 1992; Linneman 1980), and the floor area (Carroll, Clauretie, & Jensen 1996; Rodriguez & Sirmans 1994) are positively related to the sale price of houses. This is because buyers are willing to pay more for more space, especially functional space. Residential properties with bigger floor areas are desired by big families and buyers who can afford a better standard of living. For example, Garrod and Willis discovered that an additional room increases a property's value by about 7 %, and an extra bathroom collects twice that premium.

Researchers also surmised that building age is negatively related to property prices (Clark & Herrin 2000; Kain & Quigley 1970; Rodriguez & Sirmans 1994; Straszheim 1975). This is because *ceteris paribus*, older houses are worth less because they incur more costs in maintenance and repair, and also have decreased usefulness due to changes in design, electrical and mechanical systems (Clapp & Giaccotto 1998). For example, Kain & Quigley's study showed that a new structure sold for $3,150 more than an identical unit that was 25 years old. However, Li and Brown's (1980) study found an opposite effect of age on some buildings. This increase in value was attributed to the historical significance or vintage effects of the buildings. This led Clapp and Giaccotto (1998) to conclude that there are two components to the age coefficient: a pure-cross sectional depreciation and obsolescence component, as well as a demand-side component that changes over time.

Other researchers claimed that lot size, the existence of a basement, garage (Forrest, Glen & Ward 1996), patio, water heating system, one or more fireplaces, and/or an air heating system are significantly related to the price of a dwelling (Garrod & Willis 1992; Li & Brown 1980; Michaels & Smith 1990). For example, Garrod and Willis noted that a single garage adds a 6.9% differential and a double garage three times this amount, while central heating adds about 6.5% to the price of the house.

There has been relatively little research on the effects of structural quality on housing price. This is due to the difficulty in measuring objectively and precisely the physical and environmental quality of the properties (Kain & Quigley 1970; Morris, Woods, & Jacobson 1972). Morris, et al., in their pilot study in San Juan, Puerto Rico, examined structural quality by using the dimension of availability of plumbing facilities and other service facilities such as cooking equipment, refrigeration, and lighting. They differentiated plumbing facilities into "inside, for exclusive use," "inside, shared," or "other". These measures, which reflected the quality of the dwelling without associating them with the locational or neighbourhood attributes, were found to be able to serve as proxies for measuring quality features. Kain and Quigley (1970) undertook the first major study to investigate the impact of housing quality on housing prices. They used measures such as the condition of drives and walks, exterior structure, condition of floors, windows, walls, and levels of housekeeping. These quality features were found to have as much effect on the price of housing as the number of rooms, number of bathrooms, and lot size.

However, Chau, et al. (2001) classified the physical conditions of the property such as size, floor level, age, and so forth as tangible attributes, whereas attributes such as environmental quality and developer's good will are regarded as intangible attributes. According to Chau, et al., buyers are willing to pay 7% more for housing units constructed by large, reputable developers.

Neighbourhood Attributes

Goodman (1989) argued that while neighbourhood attributes cannot be explicitly valued in the marketplace, they could be implicitly valued through hedonic pricing by comparing houses with differing neighbourhood qualities. Goodman's caveat that failure to model neighbourhood attributes can lead to substantive errors when valuing individual properties and the market in general, was validated by Linneman (1980). Linneman found that between 15 and 50 percent of the standardised variation in site valuations is attributed to neighbourhood attributes, and for structurally identical sites, as much as 100 percent of the differential in site valuations is induced by neighbourhood attributes. Kain and Quigley's (1970) study further demonstrated that higher income households with more education prefer to live in relatively high quality dwelling units located further away from the CBD.

Previous research classified neighbourhood attributes into the following categories:

(i) Socio-economic variables (Garrod & Willis 1992), e.g., social class of the neighbourhood (Richardson, Vipond, & Furbey 1974) and the occupations of the inhabitants.

(ii) Local government or municipal services, e.g., schools (Clauretie & Neill 2000; Hayes & Taylor1996; Jud & Watts 1981; Kain & Quigley 1970), hospitals (Huh & Kwak 1997), and places of worship (Carroll, et al. 1996).

(iii) Externalities such as crime rates (Thaler 1978), traffic noise (Williams 1991), airport noise (Espey & Lopez 2000; Feitelson, et al. 1996; Mieszkowski & Saper 1978), and shopping centres (Des Rosiers, Lagana, Theriault, & Beaudoin 1996).

For the socio-economic variables, Richardson, et al. (1974) found that the social class of the neighbourhood has an impact on property values, although there may be other determinants. Ketkar (1992) observed that whites in New Jersey tended to be sensitive about the proportion of non-whites in their neighbourhoods. Studies done elsewhere have found that non-whites pay higher prices to purchase a house in white neighbourhoods (Daniels 1975; Ridker & Henning 1967)

In terms of local government services, the quality of public schools was found to have a great impact on real house prices. School quality is more important to local residents (especially those with children) than either crime or environmental quality (Clark & Herrin 2000; Haurin & Brasington 1996). The quality of schools has been measured in terms of school input variables, such as expenditures per pupil or average cost per student (Ketkar 1992), student achievement levels or Standardised Aptitude Test (SAT) scores (Jud & Watts 1981; Ketkar 1992; Walden 1990). Generally, higher test scores have a positive impact on property prices (Clauretie & Neill 2000; Jud & Watts 1981).

With respect to hospitals, Huh and Kwak's (1997) study in Seoul revealed that hospitals exhibit a significant negative effect on property prices. The presence of a hospital is a liability in Seoul because of cultural norms in Korea. When someone dies in Korea, the corpse is placed in the hospital mortuary, and condolences are extended to family members and relatives for three days. Proximity to hospitals and health centres is not desirable due to the commotion that ensues including the nuisance value of ambulance sirens, the general congestion in the vicinity of hospitals, and superstitious beliefs.

Places of worship, such as churches, irrespective of denominations and size, are amenities that generally enhance the value of neighbourhood properties (Carroll, et al. 1996). However, Do, Wilbur, and Short (1994) dissented by suggesting that the presence of churches meant increased traffic and noise from church bells. Hence, property values in such "theocratic environments" were reduced.

Undeniably, buyers are wary of areas of high crime and vandalism. Using the percentage of persons aged between 16 and 21 years who are high school dropouts as a proxy measure for crime and vandalism, Li and Brown (1980) found that buyers do not favour areas associated with high rates of crime or vandalism. Clark and Herrin (2000) found that prices of properties in Fresno County, California are 7.28% lower in areas with each additional murder per 10,000 people. Crime has also been measured by other variables such as robbery, rape, aggravated assault, motor vehicle theft, and arson per 1,000 residents (Haurin & Brasington 1996).

There are also studies on the externality of noise from traffic and its effect on property values (Palmquist 1992). However, the reaction towards noise, or quiet, is dissimilar among different groups of people. Palmquist provided evidence stating that the marginal willingness of lower income groups to pay for quietness is comparatively lower than that of higher income groups.

Airport proximity can be both positive and negative. Tomkins, Topham, Twomey, and Ward (1998) found that the benefits of easy access to the airport and its associated transport infrastructure outweigh the costs. For instance, a standard dwelling located 2.5 km from the airport terminal commanded a price of about 19% higher than one at the mean distance. Feitelson, et al. (1996), however, found that beyond a certain "disturbance" level, buyers' willingness to pay declines to zero, as they are no longer interested in the properties. Espey and Lopez (2000) also found that there is a statistically significant negative relationship between airport noise and prices of properties in proximity to the Reno-Sparks airport, with houses where the noise level has been recorded at 65 decibels or more selling at $2400 less than homes in relatively quieter environments.

Proximity to shopping complexes and the size of shopping centres, have both been found to exert an influence on the value of the surrounding residential properties (Des Rosiers, et al. 1996; Sirpal 1994). Proximity to a shopping centre could mean easy access to facilities, and reduced traveling costs, but this also might provide disadvantages in terms of noise pollution and congestion. Shopping centre size affects the utility of centres. Des Rosiers, et al. found that each additional shop adds about $27 to the market value of the properties in the vicinity of the shopping centre.

The availability of facilities also affects housing prices. For example, Mok, et al. (1995) and Tse and Love (2000) indicated that the provision of facilities in large housing estates, such as a private clubhouse, swimming pool, landscaped garden, gymnasium, and various kinds of sports facilities tend to increase the prices of such properties

External benefits, including pleasant landscape, unpolluted air, serenity, quiet atmosphere, and the presence of urban forests have been empirically studied by Tyrvainen (1997) using apartment sales data for residents in North Carelia, Finland. On average, the results showed that the inhabitants appreciate green housing districts and accessibility to forested recreation areas. However, the effect of urban forests on prices of properties is non-linear, as nearby forests may lower housing prices when located too close, while their impact of increasing effect on price is dependent on their distance, size, and quality.

Chattopadhyay (1999), who conducted a study to gauge the willingness of buyers to pay for reduced air pollution, found that residents in Chicago were willing to pay for a reduction in the pollution level of particulate matter (PM-10) and sulphur dioxide. As for the quality of water, Leggett and Bockstael (2000) reported that water quality, which was measured based on the concentration of faecal coliform bacteria, has a significant effect on property values, too.

The significant negative impact of toxic waste sites on housing prices was validated by Ketkar (1992) and Kohlhase (1991). Ketkar found that if the number of hazardous waste sites in a municipality decreases by one, it leads to an increase in the median property value of $1255, or a rise of 2% in property values.

Reviews of previous empirical studies have suggested that there are a number of key housing attributes that are included in most hedonic price models. Table 1 shows a list of these commonly used variable. Although the set of price-influencing characteristics are different across different markets, and the variables included in the hedonic price model are also constrained by the availability of data, this list should serve as a useful basic checklist for application of hedonic price model in different markets.

Conclusion

The hedonic price model is a very useful scientific tool. With sufficient data, this tool allows us to estimate the individual effects of different housing attributes on housing prices. Since housing researchers cannot conduct controlled experiments in the laboratory, the hedonic price model is the major scientific method by which we can observe the effects of one or more housing attributes on housing prices, with the other factors holding constant. This allows us to understand the behaviour of players in the housing market and how the housing market operates. This is very important for developers, development consultants, investment consultants, and policy makers.

The hedonic price approach is not purely statistical, but with a theoretical foundation rooted in consumer theory. This approach, however, is not without limitations. First, the hedonic price model is very data consuming. For some places, transaction data is simply not available (e.g. due to thin transactions), or is available at very high prices. Second, mis-specification of the function due to missing variables (data not available) may lead to bias in the estimates. The choice of functional form is also difficult to determine when no prior knowledge about how independent variables affect housing prices exists. Furthermore, the heterogeneous nature of housing makes it difficult to observe the parsimony principle. The more independent variables are included, the higher the chance of mis-specification of the hedonic price model. The coefficients tend to be very unstable when a large number of independent variables are included. A smaller homogenous sample can help reduce this problem, but the result is normally a sharp reduction in the number of usable transactions. Although recent developments in statistical theories help detect and resolve partially some of these problems, the use of the hedonic price model in empirical studies requires not only technical skills, but also experience and judgement.

TABLE 1: List of Commonly Used Housing Attributes in Hedonic Price Models.

Attribute		**Expected effect on housing price**
Locational	Distance from CBD	-ve
	View of the sea, lakes or rivers	+ve
	View of hills/valley/golf course	+ve
	Obstructed view	-ve
	Length of land lease	+ve
Structural	Number of rooms, bedrooms, bathrooms	+ve
	Floor area	+ve
	Basement, garage, and patio	+ve
	Building services (e.g. lift, air conditional system etc)	+ve
	Floor level (multi-storey buildings only)	+ve
	Structural quality (e.g., design, materials, fixtures)	+ve
	Facilities (e.g., swimming pool, gymnasium, tennis court)	+ve
	Age of the building	-ve
Neighbourhood	Income of residents	+ve
	Proximity to good schools	+ve
	Proximity to Hospitals	?
	Proximity to Places of worship (e.g., mosques, churches, temples)	+ve
	Crime rate	-ve
	Traffic/airport noise	-ve
	Proximity to Shopping centers	?
	Proximity to Forest	?
	Environmental quality (e.g., landscape, garden, playground)	+ve

+ve – positive impact oh housing prices; -ve – negative impact oh housing prices
? – varies from place to place, the actual effect is an empirical question

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