A HEDONIC PRICE MODEL OF
CONSUMER DEMAND FOR URBAN LAND ATTRIBUTES

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Introduction

The market for urban residential land is clearly an important market. To the individual household the purchase of residential land represents a major (if infrequent) item of expenditure. At an aggregate level the behaviour of participants within the urban land market has implications for the formulation and efficacy of urban planning and policy.

A complication inherent in studies of the urban land market is the heterogeneous nature of land itself. Each residential lot is differentiated from all others in terms of one or more of its attributes such as size, location, topography, zoning and the availability of amenities. Hence there will at any one time be a distribution of prices for urban residential land rather than a single market price. Using a sample of transaction prices for Perth (Western Australia), this study provides estimates of the market valuation of individual land attributes. Particular attention is given to those attributes of the Perth residential land market that are subject to some form of public regulation.

Hedonic Price Model

Lancaster (1966) has pointed out that for a heterogeneous good such as residential land the consumer derives utility from the level of attributes embodied in the good rather than simply from the quantity of the good consumed. In the context of urban land market the implication is that residential lots consist of identifiable attributes and that it is these attributes which yield utility (or disutility) to the consumer. With land being a capital good the market price of a lot may be taken to represent the summation of the capitalised values of the stream of services provided by each attribute. It is in this sense that Wilkinson and Archer (1976) describe the consumer as effectively buying a stock of attributes when acquiring land (or housing in their case).

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Empirically, a hedonic price model may be specified with the price (\(P_i\)) of a residential lot being dependent upon its particular endowment of attributes \((X_1, X_2, \ldots, X_n)\).

\[
\text{i.e. } P_i = f(X_1, X_2, \ldots, X_n)
\]

This function can then be estimated from a sample of land prices using multiple regression analysis. King (1976) has explained that with such a procedure the price of land (or housing) is a measure of the total expenditure by the consumer on attributes embodied in it, while the estimated regression coefficients provide hedonic or implicit market prices for those attributes. Following Rosen (1974), these hedonic prices are interpreted as the result of a competitive market process in which consumers bid for and producers offer various attributes to the market that are packaged together to form a variety of residential lots.

The hedonic price model assumes that variations in the prices of residential lots are due solely to differences in their attribute mixes. If, however, market imperfections are present, there will not necessarily be a unique market price for residential lots of otherwise identical characteristics. An account of the types of imperfections likely to occur in house and land markets is provided by Kirwan and Martin (1971), while Ball and Kirwan (1977) discuss the circumstances in which these imperfections may lead to the formation of spatial sub-markets between which the valuation of land attributes may vary. The evidence provided by Schnare and Struyk (1976) and Goodman (1978) does, however, suggest that even if sub-markets can be identified any variation in the valuation of attributes is likely to be small. Within the scope of this study it is assumed that land price variability is accounted for solely by differences in attribute mixes and not by differences in the valuations of attributes.

**Functional Form**

In his discussion of hedonic price models Griliches (1971) stresses two major issues to resolve when applying such models. These are to identify and measure the attributes of the good, and to decide upon the appropriate functional form for use in the regression analysis. The choice of functional form is considered first.
The use of a linear functional form implicitly assumes that the market valuation placed on an attribute is independent of the amount of the attribute, and indeed of the amount of any other attribute. That land attributes may be treated in this simple additive manner does, however, seem unlikely. In the first place, the principle of diminishing marginal utility suggests that the valuation placed upon an additional unit of an attribute will be less, the greater the amount of that attribute already embodied in the land. This is supported by the results obtained in studies by Hushak (1975) and Colwell and Sirmans (1978) to the effect that the price per unit area of land will be less, the larger is the parcel of land. In addition, several trade-off models of residential location, including those by Mills (1967) and Muth (1969), imply that land prices fall at a decreasing rate with increasing distance from the city centre. Such non-linearities in the relationship between land prices and the quantity of an attribute do not support the use of a linear functional form.

It is also improbable that the market valuation placed upon an attribute is independent of all other attributes embodied in residential land. For example, the valuation of a larger residential lot is likely to be in part dependent upon factors such as whether the lot has a corner position, the shape of the lot and its street frontage. If the valuations of attributes are not independent, then they are not strictly additive in determining the total value of a residential lot. Wilkinson and Archer (1976) suggest a solution in terms of reformulating the hedonic price model so that the contribution of the attributes is multiplicative rather than additive. That is, they suggest the use of a logarithmic functional form.

The use of logarithmic functional form is well supported by previous empirical work. This may be traced back to the early success of Clark (1966) in establishing a negative exponential relationship between land prices and distance from the city centre with the best fit results being achieved with a logarithmic form. The logarithmic form was also found to be appropriate in the studies by Evans (1973) and Mills (1969). The available empirical evidence on the most appropriate functional form is, however, not conclusive. For example, Abelson (1979) found in his Sydney house price study that a linear form performed as well as any other functional form.
Some further issues concerning functional form and the interpretation of the hedonic price function are raised by Rosen (1974) and the discussion that has followed. As mentioned, Rosen interprets hedonic prices as the result of a competitive market process in which consumers bid for and producers offer various attributes to the market that are packaged to form a variety of models, or residential lots in the context of this study. Market clearing prices for attributes are seen as reflecting both consumer preferences and producer cost conditions. Estimated hedonic prices are thus the result of a competitive market process and reveal little concerning the underlying supply and demand for attributes. The hedonic price function is a reduced form equation reflecting the interaction of supply and demand.

Hence in the Rosen model it is not generally possible to make any structural interpretations of the hedonic price function. Rosen does, however, argue that the function is unlikely to be linear as that would imply constant prices for attributes. Constant prices would only be the case if consumers were able to arbitrage in units of individual attributes by somehow untying bundles of attributes to enter the market for attributes and then re-packaging bundles. As arbitrage in attributes is not possible in goods, such as residential land, Rosen considers the linear form to be generally inappropriate.

Lucas (1975) adds to the discussion of functional form by providing a summary of three possible interpretations that may be placed upon cross-sectional hedonic price equations. One of these interpretations is the competitive market version of the Rosen model that has been discussed above. The other two interpretations relate to consumer choice and profit maximisation behaviour by competitive firms.

The consumer choice interpretation is based upon Lancastrian utility theory. Lucas points out that this theory assumes that the utility derived from an attribute is independent of the existing quantity of that attribute and of the quantities of other attributes. Hence to be compatible with that theory the hedonic price equation should be specified in a linear form. The second interpretation discussed by Lucas is that related to production costs with profit maximising firms seeking to supply the most efficient commodity packages. In this case the estimated hedonic prices are regarded as being proportional to the marginal costs of supplying attributes with the implication being that a non-linear function form is generally the most appropriate.
Freeman (1979) follows the competitive markets approach of Rosen and gives specific attention to the circumstances in which estimated hedonic prices may be used to determine the inverse demand or marginal willingness to pay function for an attribute. Freeman describes a two-stage process for estimating the demand for an attribute; the first being to estimate hedonic prices, and the second to regress these against observed quantities and other determinants of demand such as household income. The result of the second stage is to provide an estimate of the inverse demand function for an attribute.

In practice the above approach requires details of the income and other characteristics of individual households. This information is rarely available in land (or house) price studies and is not part of the data set used in this study. Given this empirical constraint, the implication of Freeman's approach remains that household specific variables (such as income) should not be included as determinants in the hedonic price function. This does not, however, preclude the use of aggregative measures of neighbourhood socio-economic status as determinants of residential land prices.

In this study the approach followed is that of the Rosen–Freeman model. That is, estimated hedonic or implicit prices are seen as the result of a competitive market process. It is thus not possible to place any strict structural interpretations on the hedonic price equation with the result that the choice of functional form becomes largely an empirical matter. Hence use is made of both a linear and a logarithmic functional form with the expectation, for the reasons previously outlined, that better results will be obtained using the latter.

It may also be noted that while a linear functional form provides regression coefficients that measure the absolute effect on price of a one unit change in the quantity of an attribute, a logarithmic functional form provides regression coefficients that are elasticity estimates of the percentage change in land price resulting from a one per cent change in the quantity of an attribute.
The Land Price Sample

In selecting the land price sample for use in this study, care was taken to avoid the limitations of the samples used in some previous house and land price studies. These limitations relate primarily to the choice of the dependent variable and to the spatial distribution of the sample.

In the studies by Brigham (1965) and McDonald and Bowman (1979) the price per unit area of land was used as the dependent variable. Colwell and Sirmans (1978) have pointed out that this measure ignores the influence of lot size on price and hence implicitly assumes a linear relationship between the area of the lot and its price. In other studies it has not always been possible to make use of actual transaction prices. For example, Apps (1974) relied upon an estimate of price and Evans (1973) made use of the seller's asking price in their house price studies. Apart from the practical problems associated with either estimating or imputing land prices there is a further reason for preferring the use of actual transaction prices in that households in the process of making a locational decision are more likely to be expressing their true preferences with respect to land attributes than are other households who may continue to reside at their present location for reasons of inertia as much as anything else.

With respect to the spatial distribution of the sample, Ball (1973) has suggested that the insignificance of the distance variable in the study by Kain and Quigley (1970) may be attributed to their sample being concentrated at the periphery of the city thereby limiting the variability of the distance variable. In the study by Abelson (1979) the sample was limited to two suburbs of Sydney. Although this was compatible with the objectives of his study it did restrict the inclusion of cross-suburban variables and may thus have inflated the explanatory power of the remaining variables.
The sample used in this study consisted of transaction prices for 2,094 serviced residential lots sold in the Perth metropolitan area during the years of 1977 and 1978. The average price for the sample was $15,005. The lots were distributed across forty four distinct land subdivisions and included sales by private developers as well as by government bodies including the Urban Land Council, the State Housing Commission, the Rural and Industries Bank of Western Australia and several Local Government Authorities. Both auction and private treaty sales were included in the sample.

Specification and Measurement of Land Attributes

As has been explained the dependent variable used in the hedonic price model was the market price of each residential lot. The independent variables, or land attributes, are briefly summarised below.

The area of each lot was measured in square metres. Dummy variables were used to identify those lots with a corner position; the type of street on which they were situated (the reference category being a major access road); the availability of deep sewerage and below-ground power; and whether the lot was opposite or adjacent to an area of public open space.

The accessibility variables included were the road distance to the city centre and the linear distance to the coast and to the nearest area zoned for industrial use. Accessibility to local amenities was measured by the road distance to each of the nearest primary school and shopping centre.

Dummy variables were used to identify those lots zoned such that a duplex paid of dwellings could be constructed on them and those lots that were subject to special conditions of sale. These conditions applied to some of the land sold by public authorities and had the effect of restricting the re-sale of the land for a period of four years.

The socio-economic status of the different localities was measured by an objective index derived by a factor analysis of ten distinct socio-economic indicators. (These indicators were taken from collectors' district level tabulations of the 1976 Population Census).
The remaining variables were the age of the subdivision and a time of sale variable included to capture the general inflation of land prices that occurred during the period of data collection.

Results

The results of the regression analyses are presented in the accompanying table. The $R^2$ values indicate that the attributes included in the model accounted for a substantial proportion of land price variability. In addition, the sign and relative size of the regression coefficients were largely as expected with most attributes proving to be statistically significant determinants of price. The $R^2$ values and levels of significance also confirm that for urban residential land the hedonic price model is best specified in a logarithmic rather than a linear functional form. An examination of a correlation matrix (not reproduced here) revealed no serious problems of multicollinearity.

The regression coefficient for the area variable was of the expected positive sign and significant for both functional forms, although the level of significance for this variable was substantially higher for the logarithmic form. This latter point suggests that the price increment resulting from an additional unit of land is dependent upon the area of the lot itself. With an elasticity estimate of less than unity it may be further concluded that residential land prices rise at a diminishing rate with increases in the area of the lot. This result is consistent with the previously mentioned studies by Hushak (1975) and Colwell and Sirmans (1978).
## HEDONIC PRICES FOR URBAN LAND ATTRIBUTES

<table>
<thead>
<tr>
<th>Land Attributes</th>
<th>Linear Form</th>
<th>Logarithmic Form</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regression Coefficients</td>
<td>t Statistics</td>
</tr>
<tr>
<td>Area</td>
<td>2.61</td>
<td>9.32*</td>
</tr>
<tr>
<td>Corner (D)</td>
<td>-762.61</td>
<td>3.04*</td>
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<tr>
<td>Street Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cul-de-Sac (D)</td>
<td>1,066.33</td>
<td>2.76*</td>
</tr>
<tr>
<td>Way (D)</td>
<td>652.29</td>
<td>1.72</td>
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<tr>
<td>Minor Access (D)</td>
<td>804.20</td>
<td>2.18*</td>
</tr>
<tr>
<td>Deep Sewerage (D)</td>
<td>1,161.99</td>
<td>2.63*</td>
</tr>
<tr>
<td>Below Ground</td>
<td></td>
<td></td>
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<tr>
<td>Power (D)</td>
<td>-813.44</td>
<td>3.64*</td>
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<tr>
<td>Public Open</td>
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<tr>
<td>Space (D)</td>
<td>290.10</td>
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<tr>
<td>Distance City</td>
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</tr>
<tr>
<td>Centre (road)</td>
<td>-275.30</td>
<td>12.74*</td>
</tr>
<tr>
<td>Distance Coast</td>
<td>-191.97</td>
<td>10.88*</td>
</tr>
<tr>
<td>Distance Industry</td>
<td>270.18</td>
<td>4.35*</td>
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<tr>
<td>Distance School</td>
<td>-389.99</td>
<td>3.22*</td>
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<tr>
<td>Distance Shops</td>
<td>876.81</td>
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<tr>
<td>Duplex (D)</td>
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<tr>
<td>Conditions of Sale (D)</td>
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<tr>
<td>Socio-Economic Status</td>
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<td>13.00*</td>
</tr>
<tr>
<td>Age of Subdivision</td>
<td>263.48</td>
<td>20.08*</td>
</tr>
<tr>
<td>Time of Sale</td>
<td>151.05</td>
<td>2.82*</td>
</tr>
<tr>
<td>Constant</td>
<td>15,005.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R² = 0.66</td>
<td></td>
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</tr>
</tbody>
</table>

Dependent variable = price.
Average price = $15,323.
Sample size = 2,094
* = significant at the .05 level.
The results clearly reflect a lower market valuation for lots with a corner position and a higher valuation for lots that are not located on a major access road. The similarity in the absolute values of the street type dummy variables does, however, suggest that consumers may be largely indifferent between the alternative types of low traffic streets. The desirability of a lot being adjacent to or opposite an area of public open space was also evident, although the absolute effect of this variable on price was somewhat less than anticipated. The advantages of deep sewerage were seen to be capitalised within lot prices, however the results do not indicate the same for the provision of a below-ground power supply with the coefficient for that dummy assuming an unexpected negative value in the linear form. One possible explanation for this result is that connection costs (which are not part of the purchase price) are generally higher for a below-ground power supply when compared to an above-ground power supply.

The prices paid by consumers for residential land fell appreciably with increasing distance from the city centre, and to a lesser extent with increasing distance from the coast. Moreover, the explanatory power of the distance from the city centre variable was substantially greater for the logarithmic form with the implication being that land prices not only fall with increasing distance from the city centre, but that they fall at a diminishing rate. This result is supportive of the trade-off models of residential location theory and of previous empirical evidence including that by Clark (1966), Mills (1969) and Seyfried (1963).

There was some evidence from this study that residential land prices tend to be higher, the more distant is that land from areas zoned for industrial use. This does suggest that environmental externalities, such as pollution and congestion, may be internalised within residential land prices. The price effect of this variable was however quite weak, as was the case in the previous studies by Wieand (1973) and Anderson and Crocker (1971).
No clear relationship was evident between the price of residential land and the distance to either the nearest primary school or shopping centre. Although this may be partially attributed to collinearity between these variables it is of interest to note the results obtained in some previous studies. For example, Levin and Mark (1977) found that the distance to the nearest shopping centre was not a significant determinant of price, while Apps (1973) found that accessibility to a school was of importance only over relatively short distances.

For those larger residential lots upon which the construction of a duplex pair of dwellings was permitted there was an accompanying price increment beyond that which could be explained by the size of the lot alone. For the linear functional form this price increment was estimated to be $6,816, which was large relative to the average lot price of $15,323. In a similar manner a substantial price reduction of $3,472 was seen to accompany the imposition of restrictions on the re-sale of a residential lot.

The index of socio-economic status was found to be a highly significant determinant of price. This result is supportive of previous studies by Wilkinson (1973) and Apps (1974) in which similarly constructed indices were used. It was also evident from the correlation matrix that socio-economic status tended to decline with increasing distance from the city centre. This may be contrasted with the results of Brigham (1965) and Richardson et al. (1974) in which socio-economic status was seen to rise with increasing distance from the city centre.

The remaining variables indicate the preference of consumers for established residential areas, and the general price inflation that occurred during the period of data collection.
Some Policy Implications

Apart from the intrinsic interest in the estimated values of implicit prices for urban residential land attributes, some broader policy implications may be drawn from this study.

A well documented characteristic of Australian cities is their low level of residential density. The point is made by Neutze and Bethune (1979, p. 71) when they comment that "most of the growth of Australian cities since the second world war has been accommodated by extension of suburbs rather than by increased density". Given this pattern of urban development, and the studies by Daly (1968) in Newcastle and Troy (1973) in Melbourne, it is tempting to conclude that accessibility to the city centre is relatively unimportant to Australian households and hence that urban planning should seek to re-direct resources toward the improvement of neighbourhood amenities. The results of this study do not support such a conclusion. Accessibility to the city centre was found to be of major importance to Perth residents while at the same time attempts to improve the local environment, including the provision of below ground power and the creation of small areas of public open space, received a relatively low valuation.

This study also has implications for the efficacy of some specific instruments of public regulation within the urban land market, and in particular with respect to the imposition of restrictions on the re-sale of land, the taxation of betterment and the enforcement of minimum development standards.

Restrictions on re-sale applied to land sold by the Urban Lands Council, the Rural and Industries Bank of Western Australia and the State Housing Commission. The objective of these restrictions was to discourage speculative land purchases and hence to favour the "genuine homeowner". With an accompanying price reduction, estimated at $3,472, the results of this study provide support for the effectiveness of restrictions on re-sale in achieving the equity goal of lower land prices. The results do not, however, provide any indication as to the mechanism by which this price reduction occurs, nor whether there is a spillover effect resulting in a general reduction in the price of all urban land. An examination of the above, along with the efficiency implications for land-use, is necessary before firm conclusions may be drawn concerning the merits of restrictions on re-sale as an instrument of urban policy.
Another aspect of urban policy concerns the re-zoning of land and the taxation of betterment. Australian urban economists, including Rose (1973) and Neutze (1974), have concentrated on the effects of re-zoning land from rural to urban use and the taxation of the associated betterment accruing to land developers. The results of this study are of interest in that they indicate a substantial price increment which accompanies the granting of duplex status to a residential lot. This increment, estimated at $6,816, is an economic rent and hence a potentially important source of taxation revenue. It should be noted, however, that there are likely to be net social advantages associated with the granting of duplex status to selected lots within a subdivision, particularly with respect to the better utilisation of public sector infrastructure and services. Thus the taxation of this betterment would need to be of a form which did not remove the incentive for land developers to seek duplex status for residential sites. That is, the betterment tax should not seek to appropriate all of the economic rent.

A final policy implication concerns the enforcement of high utility service standards for new land subdivisions. The enforcement of high standards may be interpreted as a type of development or betterment tax that takes the form of public facilities provided at the expense of the private land developer. Such an interpretation does, however, raise the question as to who ultimately bears the burden of this tax. Kilmartin and Thorns (1978) and Eyers (1979) both contend that high service standards are reflected in higher land prices in Australia. Although the results of this study do indicate that a substantial proportion of the costs of providing deep sewerage are reflected in the final price of residential land, the same does not appear to be the case with respect to the provision of small areas of public open space and the installation of a below-ground power supply. These results do not support the proposition that development costs are necessarily passed on to the final consumer and point to the danger of generalising as to the effect of high development standards on the price of residential land.
REFERENCES


