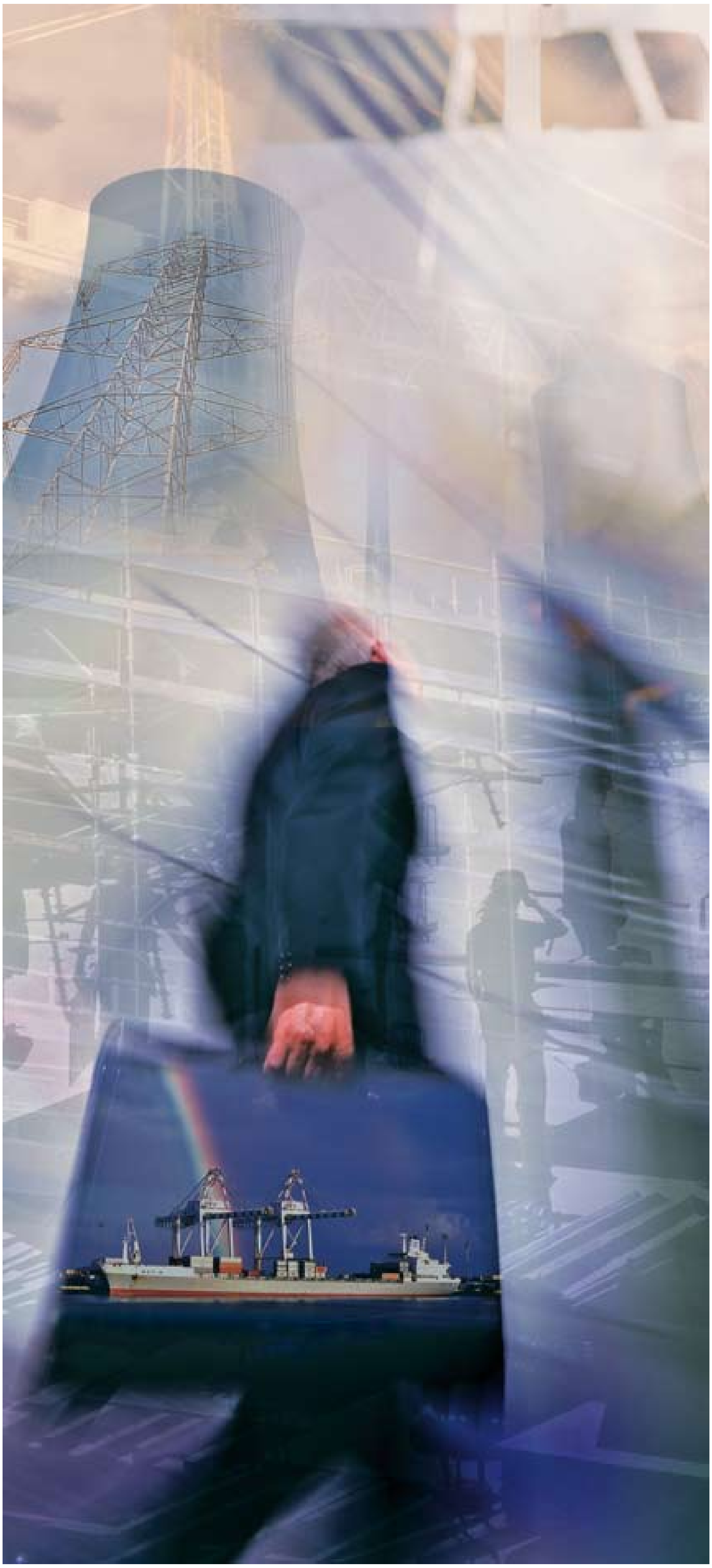

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The Economic Society of Australia warmly welcomes you to the Gold Coast, Queensland, Australia for the 37th Australian Conference of Economists.

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Community valuations of environmental quality in coastal lakes: Lake Illawarra case study*

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Community valuations of environmental quality in coastal lakes: Lake Illawarra case study

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Abstract

This study illustrates how the hedonic pricing method can be used to help assess the benefits associated with environmental improvement expenditure in an urban setting. It provides a case study for Lake Illawarra in southern NSW, utilising relatively easily accessible secondary data, and a semi-logarithmic regression form. The HPM valuation assumes households will pay more for a property near a desirable environmental feature, holding all other determinants of price constant. The value achieved here was substantially greater than either expenditures to date or the actuarial valuation of the Lake. The study demonstrates the applicability of the technique and recommends its further development and use for this type of public decision-making, and so justifies further environmental improvements on this asset. A range of other data was also generated by the methodology that adds to the usefulness of this approach for general planning purposes.

JEL classification: C21; D12; Q51

Keywords: Hedonic pricing model; Environmental quality, evaluation; New South Wales (NSW); Australia

1. Introduction

Australia's population is concentrated around the coastline, and particularly along the eastern coast of New South Wales (NSW). The NSW coastline contains a string of water features including ‘drowned’ river estuaries, estuary lakes and lagoons. Population growth and a growing ‘sea change’ preference among retirees have resulted in increasingly dense urban development around these waterways, with added pressure from recreational use. At the same time, urban populations are becoming more environmentally conscious and this has become manifest in demands for environmental protection and improvements to waterways nearby to their residences, whether it be their usual family home or a holiday cottage.

A growing issue for public policy is to balance the need to provide more housing within this coastal strip with the need to maintain environmental quality in these increasingly urbanised waterways. Growing demands for environmental improvements have to be met from limited budget allocations. Questions as to how these budgets are allocated should ideally be subjected to benefit / cost analyses for each waterway of concern. However, the practicalities of such an approach mean that actual allocations usually occur on an *ad hoc* basis, often reflecting ‘squeaky wheels’ or demands from the most vocal and political astute communities. The difficulties in assessing the benefits from environmental improvements in monetary terms so that they can be compared with expenditure outlays, also mean that benefit / cost allocations are rarely attempted. Where they are used, it may involve an actuarial valuation of the environmental asset. This, however, does not necessarily represent the value that the community itself would put on that asset.

Community valuations of environmental assets such as urban waterways can be conducted using the Hedonic Pricing Method (HPM), developed from actuarial studies for use in environmental economics. This methodology uses relatively standard regression analysis to deduce the value of the asset from differentials in residential home prices, holding other property price determinants constant. In this paper, the issue of evaluating environmental assets is addressed by assessing whether commercially available property sales databases can be utilized in evaluating urbanised waterways. Such databases are relatively cheap to obtain and do not require access to information held by public authorities such as local government valuers. It is argued that if these resources can be used in HPM studies, it will make it more feasible to undertake benefit / cost studies in this area. Such studies will provide some justification to the funding authority that further expenditures on environmental improvements to that waterway are appropriate.

This proposition is tested here using Lake Illawarra in southern NSW and a database obtained from RPdata. This database was developed for use by real estate agents but includes historical records covering Australia and New Zealand, which can be used for HPM purposes. Lake Illawarra is an intermittently closed and open lake with an outlet to the Pacific Ocean located completely within the urban area of the Cities of Wollongong and Shellharbour in the Illawarra Region of NSW, approximately 100 kilometres south of Sydney. It is almost completely surrounded by residential development, and in the past heavy industry has been located along its shoreline. The Port Kembla industrial area is nearby. As a consequence, the lake has been affected by both residential and industrial pollution and run-off, resulting in relatively poor water quality. The area around the lake's entrance, however, is a long established recreational area. The lake's waters provide both recreational and commercial fishing for mullet, prawns, and other species, sailing, public swimming and other water based activities. The residential development around the lake has generally been in the lower price bracket, with a high proportion of public housing built during the 1960s and 1970s.

Since 1988, the Lake Illawarra Authority has undertaken a major program of improvements to the Lake's water quality, habitat values and foreshores. The asset value of the lake bed was placed at $19.5 million in 2005. In addition to the lake bed, the NSW State Government through the Lake Illawarra Authority owns the foreshores surrounding the lake and improvements worth $36.5 million had been undertaken or are planned to these lands to

2006. In the 2005-2006 Annual Report, the value of land, buildings and improvements owned by the Authority was placed at $33.8 million (DNR 2006b). These figures would suggest that costs and benefits were roughly in line. However, the benefit figure only reflects the book value of the assets, not the community's evaluation of the improvements undertaken. There are continued demands for further remedial and landscaping work in the area, which has intensified as the conflict between further residential development in the remaining green spaces and the need to preserve the ecological value of the lake have become more pertinent.

The aim of this study is to measure the 'use' values of Lake Illawarra and its foreshore, most particularly the recreational and aesthetic value associated with this environmental asset. This valuation will be undertaken using the hedonic pricing method. The HPM takes an indirect approach to measuring environmental value. It utilizes observations of house sale prices in the suburbs surrounding the lake to observe whether, once all other factors influencing house prices are held constant, there is a premium being paid for houses that are closer to the lake compared with the same house if it were located further from the lake foreshore. This premium is said to reflect the community's 'willingness to pay' for a location near the lake and hence acts as an indirect valuation of the lake assets by that community (Wills, 2005). As house purchase is generally considered the most significant investment commitment made by Australian households, it can be expected that such purchases involve careful consideration of the value of the house being purchased, compared with alternatives available. Thus, if a premium is being paid for proximity to the lake, this is a genuine reflection of their valuation of the 'user' benefits of Lake Illawarra. It thus will provide a lower range valuation of the lake as option and existence values which need to be measured through direct methods such as Contingent Valuation are not included.

The rest of this paper is structured as follows. Section 2 reviews previous studies utilizing HPM to measure recreational and aesthetic values of waterways, predominantly coming from the USA. Section 3 discusses the construction of the database and specification of the regression model used in this analysis. Section 4 provides the results from this analysis, while section 5 uses these results to place a valuation on Lake Illawarra. Section 6 concludes by highlighting the usefulness of this type of analysis in public decision-making.

2. Hedonic pricing studies of recreational improvements and water quality

No Australian hedonic pricing studies of waterways were found in literature searches. However, a number have been conducted overseas, particularly in the USA. HPM has been used to measure the value of recreational features, the environmental quality of waterways and the benefits of living in proximity to water bodies such as urban lakes, all of which have some relevance to this study.

Valuations of recreational features have investigated willingness to pay for land use features such as open space, forests, wildlife habitats and sport fisheries. These studies included a range of socio-economic variables, location factors and environmental amenity as well as the target recreational features. Studies focused on open space were conducted by Acharya and Bennett (2001) in New Haven, Johnson, et al. (2001) for Suffolk County, New York, Lutzenhiser and Netusil (2001) in the City of Portland, and Irwin (2002) for Maryland, which all showed a positive valuation for open space in urban areas. Further, large areas of undeveloped or natural land areas were most highly valued, indicating that ecological significance and farmland were regarded as more important than amenity use. Most of the open space around Lake Illawarra has been developed for amenity use. However, there are some remaining natural areas at the western end of the lake, either as farmland, remnant native plant reserves, or endangered salt-marsh ecological systems (Allely 2007). It thus would be expected that community valuations in areas bordering these natural areas would be at least no lower than those for the developed open space.

Other papers have used HPM to value the environmental quality of waterways. Poor water quality was found to have a negative effect on house prices in studies on water clarity by Boyle, et al. (1999), on fecal coliform counts by Leggett and Bockstael (2000) and from sedimentation by Hill, et al. (2007). Further, Michael, et al (1996) found that improvements in water clarity had a positive impact on property prices. Boyle, et al (1999) concluded that the benefits of environmental protection exceed those of correction in that the surplus associated with preventing a decrease in water quality is nearly seven times greater than that from an increase. Water quality in Lake Illawarra was relatively poor with ammonia, total nitrogen and total phosphorus values on average above the 'trigger point', which initiates investigation. Chlorophyll values and turbidity were generally below or consistent with recommended targets (DNR 2006a). Poor water quality is thus likely to have a depressing impact on house values in this study. There were a number of reported incidents of smells, algae blooms and noxious weeds between 2002 and 2006, but the regularity of these problems has reduced in recent years suggesting that water quality is improving.

The HPM has also been used to value riparian corridors. These showed that the value of a house increased if located closer to a riparian corridor (Colby and Wishart 2002, Netusil 2006). Netusil (2006) also found that property owners placed a premium on lots with higher ecological habitat values. However, Mooney and Eisgruber (2001) found that streamside residential properties reduced in value in response to planting wider treed riparian buffers due to loss of views. These results indicate that natural riparian corridors are valued by communities, but attempts to replant in already developed residential areas are not. It thus supports the retention of remaining natural habitat areas, rather than attempting to rehabilitate degraded environments at a future time.

Of most relevance to this project were HPM studies that valued living in proximity to waterways such as rivers, the ocean and lakes, due to the recreational or visual amenity provided. Recreational and aesthetic (view) values are normally measured in terms of the decline in house prices associated with increasing distance from the water body. All these studies found that house values declined as distance from the water body increased. Bin and Polasky (2005) found that property values in North Carolina increased by $US1,010 as distance to the nearest coastal wetland was reduced by 1,000 feet. They found, however, that inland wetlands had a negative effect on property prices. Rush and Bruggink (2000) analysed the price effect of distance to ocean on house values in Long Beach Island, New Jersey. This study found that as a representative house was moved further from the beach, values dropped by $US 75,128 for the first house block move backwards, and by an additional $US8,789 and $US8,526 for the second and third moves thus indicating that considerable value was provided by close proximity to the beach.

Several studies have measured the value of locations in close proximity to a lake. Hill, et al. (2007) indicated that with suburban lakes in the Atlanta area, for each additional percent increase in the distance from a lake that a house is located, the housing price will decrease by 1.89 per cent. In a study of Lake Austin in Texas, Lansford and Jones (1995a, p.218) found that proximity to the lake was the most important variable, with recreational and aesthetic value declining at the average rate of $US4.21 per foot. The marginal price was $1,248 per foot at the waterfront, but declined rapidly to $US32.29 per foot at 150 feet and then more gradually to $US3.17 per foot at 3,000 feet. The estimated average recreational amenity was $US42,191 or 22 per cent of the prevailing price. Their study of Lake Travis, Texas similarly found that recreational value declined at the average rate of $US6.19 per foot, with the waterfront price being about $US56 per foot, declining to $US12 per foot at 150 feet and $US5.41 at 3,000 feet (Langsford and Jones 1995b, p. 349). The estimated average amenity value per house was $US13,389 in this study.

Studies also showed that having a waterfront location added a sizable premium to house prices. In a U.K. study by Garrod and Willis (1994), this premium was £1,909 (about 2.93%) of the average price in London, while a canal-side location in the Midlands added £1,589 or just over five per cent of the average price. In the two studies of Texan lakes by Lansford and Jones (1995a, 1995b), the waterfront premium was valued at $US59,826 and between $US79,297 and $US101,635 depending on elevation for Lakes Austin and Travis, respectively.

A variety of methods were used to gather and analyse data in these studies. Projects which were aimed at measuring ecological values either utilized longer time series data as issues such as water quality, habitat quality and riparian corridors take some time to register discernable changes, or compared a series of similar water bodies at various locations with different qualities. Such projects are complicated by situations whereby the exogenous impacts on the target variables will increase over time, e.g. changes to the property market or economic conditions, or among sites due to geographical and cultural variations. By contrast, valuations of recreational and aesthetic amenity can be conducted on a relatively short time period and for one location at a time. Given that most of the expenditures on Lake Illawarra to date have related to improving recreational amenity, this project will focus on that aspect. A larger project comparing environmental quality across a series of NSW coastal lakes would also be warranted.

3. Methodology and conceptual framework

The hypothesis tested in this study was that the economic value of living near Lake Illawarra will have increased due to the recent program of improvements and this will be reflected in increased house prices. The increased value of the lake will result from both improvements in water quality and foreshore amenity. It is thus expected that proximity to the lake's foreshore will raise the value of these houses, holding all other characteristics constant. The hedonic pricing method is used to place a value on proximity to lake, as an indirect community use valuation of the lake.

3.1 Data collection

A review of previous studies in this area identified a range of variables used in HPM analyses of amenity values. These were screened in terms of relevance to the issue of concern in this project and availability of data. The dependent variable is house price. Data were collected for all single residential properties sold in the calendar year 2006 in the ten suburbs surrounding Lake Illawarra. The data were mainly collected from a commercial bank of historical sales provided by RPdata Pty Ltd, which is linked to the State Government's Valuer Generals records yielding 521 observations.

It is necessary to include all factors which can influence sales price other than location in the specified model in order to control for house characteristics, financial aspects, access and neighbourhood characteristics. In this study, house characteristics included number of bedrooms, number of bathrooms (including en suite), car spaces, lock-up garages, and lot size. These data are common to most studies and was available from the RPdatabase. It was expected that these data would have positive relationships with house price. 'Double story' was included as a dummy indicator of housing quality. A number of access variables have been included in other studies. This study used distance to major shopping centre and distance to junction with major road or highway. The study area is poorly served with public transport and it was expected that most people use a private motor vehicle for transport. Again, these data were available using a GIS function on the RPdatabase allowing distances to be measured in metres for each identified property. It was expected that the coefficients of these variables to be negative, implying that the longer the distance, the poorer the access, and so the lower the house price.

The property market in the Illawarra region has been relatively buoyant since the year 2000, but had stabilised in 2006 (Sturrock 2007). Exogenous demand for housing would increase the average house price in the study region. To control for this factor, a short time span of one year was used to collect data. In addition, a financial variable, the variable home loan interest rate from the Commonwealth Bank of Australia was included. This rate rose three times in 2006, so four rates were included to reflect the prevailing rate at the time of the sale. It was expected the coefficient would be negative.

The following neighbourhood variables were also considered in the initial stage of modelling: education level as percentage of population who had completed year 12 (high school), medium household income, percentage of owner/occupier dwellings, birthplace as percentage of population born in Australia, plus incidence of malicious damage to property as a crime rate statistic. All of these variables other than the crime rate were calculated from the 2006 Australian Census of Populations and Dwellings and were available at suburb level. The crime rate data were only available at post code level from the NSW Bureau of Crime Statistics and Research. It was expected that the coefficients of the Census variables would be positive, and that of the crime statistic would be negative. In addition, a series of dummy variables were used for each suburb. [1]

Environmental quality can be measured in a variety of ways depending on the objective of the study. These include physical or psychological variables related to ecological quality, distance to natural feature, or aesthetic (view) factors. As the main improvements to Lake Illawarra to date have affected the foreshores and thus its recreational value, a 'distance to lake' variable was used to measure valuation of the lake. This distance was measured in metres using the GIS function on the RPdatabase as distance from house to nearest lake foreshore. A dummy was included to indicate if the house had a lake frontage. Infrastructure work has been undertaken to open the Lake to the ocean in order to regularly flush the lake to improve water quality. At the time of this study, the lake had not been open on a regular basis so changes to water quality indicators were not frequent enough to utilize in this study. Water quality is only measured at two points in the lake, so did not provide enough data to use in a short term study such as this one.

3.2 Specification of the Hedonic pricing model

The conceptual framework and theoretical justifications for various explanatory variables in the model were presented in the previous section. Based on this conceptual framework, a Hedonic Pricing Model is specified below in equation (1) to analyse how the price of a property in the lake area is determined by various specific features. These characteristics include house-specific factors (Z_{1i}) such as lot size, number of bedrooms, number of bathrooms, etc. , the amenity variables (Z_{2i}) such as the distance to the nearby highway, lake frontage and distance to lake and some external macro factors (Z_{3i}) (i.e. the

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1 It should be noted that with the exception of only one neighbourhood variable (medium household income) and the suburb-specific dummy variables all of the other neighbourhood variables were not jointly or individually significant at 5 or even 10 per cent levels and as a result they have not been included in our final model. These results are available from the authors upon request.

interest rate and the average weekly income of the households in the area), while Z_{4i} includes the suburb dummies. We have used the following semi-logarithmic model in our estimation process which also passed the Ramsey RESET test:

$$PRI_i = e^{\beta_0 + Z_{1i} + Z_{2i} + Z_{3i} + Z_{4i} + \varepsilon_i} \quad (1)$$

where

$$Z_{1i} = \beta_1 BED_i + \beta_2 BAT_i + \beta_3 CAR_i + \beta_4 LUG_i + \beta_5 SIZ_i + \beta_6 DBS_i \quad (2)$$

$$Z_{2i} = \gamma_1 FRO_i + \gamma_2 DIL_i + \gamma_3 DIH_i \quad (3)$$

$$Z_{3i} = \lambda_1 INC_i + \lambda_1 INR_i \quad (4)$$

$$Z_{4i} = \sum_{i=1}^{10} \alpha_i DU_i \quad (5)$$

We have defined the explanatory variables above as follows: *PRI*=price of property, *BED*=number of bedrooms, *BAT*=number of bathrooms, *CAR*=number of car spaces, *LUG*=number of lockup garages, *SIZ*=the size of lot, *DIL*=the distance from the house to the lake, *DIH*=the distance from the house to the nearest highway, *INC*=the household average weekly income, and *INR*=the rate of interest. In addition to the above quantitative variables, the following twelve categorical variables are also considered as they may impact on the endogenous variable:

DBS=1 if the house is a double story house, zero otherwise; *FRO*=1 if the house has a frontage to the lake, zero otherwise; *DU1*=1 if the house located in Kanahooka, zero otherwise; *DU2*=1 if the house located in Windang, zero otherwise; *DU3*=1 if the house located in Warrawong, zero otherwise; *DU4*=1 if the house located in Lake Illawarra, zero otherwise; *DU5*=1 if the house located in Lake Heights, zero otherwise; *DU6*=1 if the house located in Oak Flats, zero otherwise; *DU7*=1 if the house located in Berkeley, zero otherwise; *DU8*=1 if the house located in Koonawarra, zero otherwise; *DU9*=1 if the house located in Primbee, zero otherwise; and *DU10*=1 if the house located in Mount Warrigal, zero otherwise.

We have adopted a semi-logarithmic function in this paper for two reasons. First, the use of the Box-Cox transformation in the literature by Milon et al. (1984), Cropper et al. (1988), Acharya and Bennett (2001) and Bastian et al. (2002) has revealed that semi-logarithmic models are more appropriate and effective in capturing the curvature in the distance-related variables than all other alternative models. Second, in addition to several categorical variables, four of our independent variables are discrete variables (*BED*, *BAT*, *CAR, LUG*) with some zero values and this makes taking the natural logarithm on the right hand side of the equation problematic. It is argued that when many of exogenous variables can take on zero values, the results of logarithmic functions (*i.e* log-log models) will become less interpretable, inaccurate and misleading (Cassel and Mendelsohn, 1985, Green 1993).

In our semi-logarithmic model, the estimated coefficients have a particularly intuitively appealing interpretation as they reveal the extent to which each factor affects the price positively or negatively. In equation (1) the first six explanatory variables (represented by Z_{1i}) capture various specific features of the house which can influence the price of a property (*i.e.* the β coefficients). The three γ (and ten α coefficients) control for different characteristics of the surrounding neighbourhood and finally the two λ coefficients can explain the effects of two very important external macroeconomic variables influencing the price of a house (*i.e.* income and the rate of interest).

It should be noted that 521 (i=1,2,…,521) houses for which data for all variables could be obtained as shown in equation (1), are scattered in 10 different suburbs. The estimated α coefficients then indicate that, after controlling for the effects of all independent variables, how much the price of a house in a particular suburb would be different from the average price benchmark. Given the use of the semi-logarithmic functional form, the magnitude of the marginal effect of each variable depends on the value of PRI as well as the corresponding estimated coefficients. *Ceteris paribus*, the higher the value of a house, the more pronounced would be the extent of positive or negative effects on its value. That is:

$$\frac{\partial PRI_i}{\partial BED_i} = \beta_1 PRI_i,\ \frac{\partial PRI_i}{\partial BAT_i} = \beta_2 PRI_i, ..., \frac{\partial PRI_i}{\partial DIL_i} = \gamma_2 PRI_i,\ \frac{\partial PRI_i}{\partial DIH_i} = \gamma_3 PRI_i, ...,$$
$$\frac{\partial PRI_i}{\partial INC_i} = \lambda_1 PRI_i,\ \frac{\partial PRI_i}{\partial INR_i} = \lambda_2 PRI_i \qquad (6)$$

While the expected sign for the majority of coefficients is positive (all of the six β coefficients, γ_1 and γ_3 and λ_1), the coefficients on the distance to the lake (γ_1) and the interest rate (λ_2) are expected to be negative. Whether the ten α coefficients, capturing the location effect of each of the ten suburbs in which the houses in our sample are positioned, have positive or negative sign is a matter of empirical investigation. A general-to-specific methodology is used to omit insignificant variables in Equation 1 on the basis of maximum likelihood tests. In this method, joint zero restrictions are imposed on explanatory variables in the unrestricted (general) model to obtain the most parsimonious and robust equation in the estimation process. Other possible explanatory variables such as crime rate, education level, proportion of population born in Australia, and distance from house to shops, were also initially included in the model. However, as mentioned earlier, when the general-to-specific modelling strategy was adopted, they were statistically insignificant and we then decided to excluded them from equation (1) to make it neater and more compact for representation purposes.

4. The Empirical results

Table 1 presents a summary of descriptive statistics for the data employed. The sample includes 521 houses sold between 1 January 2006 and 31 December 2006. Sample means, mediums, maxima, minima, and standard deviations are shown in Table 1. The average sale price was $307,035 with a median price of $297,000 and a range between $105,000 and $820,000; the lot size averaged 636 square meters and the distance to lake averaged 599 metres.

[Tables 1 and 2 about here]

The semi-logarithmic function in equation (1) is initially estimated by the OLS method using 521 cross-sectional observations, with the results shown in Table 2. The model performs very well in terms of goodness of fit statistics as the adjusted R^2 value indicates that approximately 46 per cent of the total variability of the log of sale prices about their mean value is explained by the model. For a cross-sectional regression, this is quite high. Also, all variables are significant at the 8 per cent level or better and consequently, the regression F-statistic rejects very strongly the null hypothesis that all slope coefficients are zero. However, according to the results of the White and ARCH diagnostic tests presented in Table 2 it is clear that the model suffers from heteroscedasticity. As a result, the model was re-estimated using the White heteroscedasticity consistent standard errors and covariance to deal with an unknown form of heteroscedasticity. The resulting new *t*-ratios and p-values of the coefficients are reported in columns 5 and 6 of Table 2. As can be seen, the use of the White matrix did not change the statistical significance of the estimated coefficients in any tangible manner. All variables are still statistically significant at 7 per cent or better and the estimated equation passes the Ramsey RESET test. Thus it can be argued that the estimated model shows no sign of misspecification and it has the minimum Akaike information criterion and the minimum Schwarz criterion among all other possible alternative models (which have not been reported here but are available from the authors upon request).

As indicated earlier, the general-to-specific econometric methodology was applied to eliminate the insignificant variables. It appears that apart from the variables discussed earlier and DU1, DU4 to DU9 and DU10, all the variables included in equation (1) are statistically significant and most have the expected theoretical signs. Based on the magnitude of the estimated coefficients shown in Table 2, the varying-effects of a change in each of the explanatory variables on the sale price, while other factors kept unchanged, can be computed using relations presented in equation (6).

The various marginal effects at mean value of PRI=307035 were computed and the results have been presented in column 7 of Table 2 and are discussed below. For example, while the average effect of 'distance to the lake' is -24 (i.e. 0.000080*307035=-24), the one for 'distance to the nearest highway' is +37 (=0.000122*307035). This means that it is usually viewed as desirable to live close to the lake but not near a noisy highway, everything else being equal. In this instance, on average being one more metre further away from the lake leads to a $24 decrease in the value of a property but conversely a metre distance from the highway results in $37 gain in the average sale price. To offer a few illustrations, the marginal effects of *BED* and *BAT* show that, *ceteris paribus*, one additional bedroom and bathroom will lead to an increase in the sale price of an average property by $19,748 and $25,824, respectively. Similarly one extra car space (*CAR*) and lockup garage (*LUG*) will increase the average sale price by $7,264 and $16,234, respectively. All other factors remaining unchanged, one square metre increase in the size of a property can raise the price by $53. If the property is a double story building (*DBS*), the boost in the average price will be $32,577 while a house with the lake front (*FRO*) can add an extra $48,326 to the value of the house.

Consistent with theoretical expectations, after controlling for other relevant factors, one additional dollar rise in the weekly household income positively impacts on the average price by $209 and one per cent rise in the rate of interest can reduce the average sale price by $20,031. Finally, *ceteris paribus*, the suburb and location of a property has also important implications for the average market value. Our results indicate that, while being located in Windang, Warrawong and Mount Warrigal[2] lead to an additional value of $84,243, $42,879 and $66,976 to the mean value of a property respectively, the effects of other suburbs were insignificant and consequently they have been excluded from the model presented in Table 2.

5. Estimation of the lake value and the validation of the results

The Hedonic Pricing Method hypothetically assumes that if a specific house was moved from an environment which contains one undesirable feature to one with that desirable feature, the difference in selling price, with all other features held constant, provides a measure of that environmental factor. In this case, the desirable feature is to be located near to Lake Illawarra. Thus if houses currently located at some distance to the lake could be moved to its foreshore, the difference in their sale price is a measure, for that household, of the value of proximity to the lake.

As outlined earlier, there are two ways of estimating the valuation of Lake Illawarra from the results of the regression equation reported in Section 4. The first, and traditional, method is to identify a representative house from the suburbs surrounding the lake and then estimate a sale value for that house from the estimated model in Table 2. The 'distance to lake' variable is then set at a minimum value and a new price estimated. The difference in the two prices measures the added value of proximity to the lake or that household's evaluation of the lake. As this is a representative house, that household valuation can then be multiplied by the total number of houses in these 10 suburbs to get total community valuation of the Lake. Alternatively, the distance to the lake (*DIL*) could hypothetically be assumed to be as

[2] The differential value for the suburb Windang is explained as it is also located on an ocean beach. Mt. Warrigal is elevated with many houses offering good views of the lake, ocean and escarpment. Warrawong, although considered a low income suburb, has attractive, elevated areas around Port Kembla ocean beach.

specified value, in this case 2.5 metres[3] for all 521 properties in the sample, and their new price values calculated. This alternative method was used in this study.

Using the estimated model reported in Table 2, such proximity to the lake (*i.e.* being just 2.5 metres from the lake, all other factors remaining constant) would increase the average property price (with an average lot size of 636 square meters) by $13,596. The total number of occupied single residential dwellings in the study area from the 2006 census was 12,779. By multiplying $13,596 by 12,779, a lake value of 174 million dollars added benefits is obtained. However, as mentioned earlier and is explicitly clear from relations indicated in equation 6, the more expensive the house, the larger the benefit. To understand this value-dependent effect of the distance to lake on a price a property, Figure 1 shows the marginal effect of the distance from the lake for all 521 houses in our sample. The computed marginal effect of one additional metre distance from the Lake on the price basically varies from a minimum of |-$8.4| for a $105,000 house to a maximum of |-$65.6| for a $820,000 property, the average effect being |-$24| for a house with an average price of $307,035. Therefore, the more expensive houses have benefited more from proximity to the lake.

[Figure 1 about here]

This estimation process only included single residential buildings in both the sample and the valuation calculation. In addition, a further 4,827 residences exist in these suburbs, comprising unoccupied dwellings, flats and apartments, caravans, etc. Households in these dwellings would presumably also value the Lake, although probably at a lower value than households in single residential dwellings. Thus, the valuation of $174 million is a conservative estimation. If, for example, it was assumed that households in these other dwellings valued the Lake at half that of dwellings included in the sample, this would add a

[3] 2.5 metres was chosen as this was the closest any dwelling was to the lake shoreline in our database.

further $32.8 million to the valuation of the Lake. Further the premium for waterfront properties of $48,326, was not included in the valuation.

5.1 Validation of results

From the literature review, the following studies measured distance to lake or water feature, although a number of these used number of houses from water rather than an actual distance measure: Langsford and Jones (1995a, 1995b), Rush and Bruggink (2000), Hitzhusen, et al. (2000), Archarya and Bennett (2001), Bin and Polasky (2005), and Hill, et al. (2007).

The result obtained from this study was that for each metre that a residence is located away from the lake, its property value declined by $A24. In order to justify this result, it can be compared with values obtained from similar studies identified above. The study most comparable with this one is by Lansford and Jones (1995b) reported in the *Journal of Agricultural and Resource Economics*. They estimated a value of -$US6.19 per foot for residences in proximity to Lake Travis in central Texas. This would convert to -$US20.6 per metre or about -$A23.4 at an exchange rate of $US.88c to the $A. That study estimated the recreational benefits of that lake for an individual single family residence to have an average value of $US13,389 which is very similar to the value obtained here. Given that their study was undertaken in 1995, it indicates that the value of -$A24 per metre is both realistic and conservative. Lansford and Jones (1995b, p.349) argue that once residences are more than 2,000 feet (or 600 metres) from the shore, the marginal value of distance becomes minimal, while most of the value is captured in waterfront properties. In our study, while the value of distance declines as distance from the lake increases, it does not become zero, although it reaches a minimum of $A8 per metre. As only properties in lake side suburbs were included in the database, all households in those suburbs appear to put some value on Lake Illawarra.

Rush and Bruggink (2000, p.146) also used a semi-log transformation in their study of privately owned houses on Long Beach Island, New Jersey, USA. That study related to a considerably more expensive location than the Lake Illawarra study and to ocean rather than lake locations and thus produced considerably higher location values. The distance – value relationship was shown to be negative and not necessarily linear, similar to the overall trend exhibited in Figure 1 in our study. Hitzhusen, et al. (2000) also incorporated diminishing marginal utility of proximity to the Muskingum River in Ohio, USA, using a log-linear mixed form transformation. The most recent study of the relationship between property values and proximity to lakes was by Hill, et al. (2007) in Georgia, USA, which found that for a one per cent increase in distance from lakes, sales price will decrease by 1.89 per cent.

Bin and Polasky (2005 p.9) also address the issue of a probable curvature in the estimated distance – value relationship by estimating a semi-parametric equation which included the distance related variables in the nonparametric component and the other variables in the parametric component. Their results produced a higher premium for frontage but a lower value per metre than the Lake Illawarra study. It indicated that the price effect of proximity to the coastal wetland was exhausted at around 6,000 feet (or 1,818 metres). Their study is less comparable with the Lake Illawarra one as it relates to rural water bodies.

A number of hedonic pricing studies on issues related to this study have been undertaken predominantly in the USA, although only Lansford and Jones (1995a, 1995b) actually measure the impact of distance from an urban lake from property values. These studies all demonstrate that a significant, negative relationship exists between distance from lake and property prices and that a substantial premium exists for water frontage properties, as was found in this study.

6. Concluding remarks

Environmental economists have been developing a tool box of techniques that can be used to place monetary values on environmental assets and negative spillover impacts from pollution, etc. for several decades. These methodologies were largely ignored by public policy makers until bought to the fore by the recent climate change debate. There is now an opportunity to apply these tools in other environmental policy questions including lower profile issues such as restoration and development around NSW coastal lakes.

This study provides the first application of the hedonic pricing technique to an evaluation of an urban waterway in Australia, with the evaluation measured on the basis of proximity to that water body. We draw on a prior body of research primarily conducted in the USA. This study used a semi-log functional form for the regression as developed in those studies to allow for a non-linear relationship between value and distance to lake. The results were conceptually similar to previous analyses and produced values similar to a 1995 study of Lake Travis in central Texas. However, there is ongoing debate regarding the most appropriate form for this type of regression. While the semi-log form is preferred over the Box-Cox transformation used in the early studies and is arguably more reliable than full logarithmic functions for this type of data, other methodologies such as semi-parametric equations are being developed. Semi-parametric estimations require substantially more complex mathematical computations than the semi-log version used here, and thus are less adaptable for use in general public policy applications. Thus, while the general HPM approach is well established, further applications are needed to refine the methodology for use in this analysis.

This study highlights some valuable issues for environmental policy making. Firstly, it demonstrates another economic tool that can be used to make better benefit-cost decisions on environmental questions in Australia. It demonstrates that the data required for this type of analysis can be relatively easily and cheaply obtained from existing sources and that this type of study could be undertaken by public authorities with an in-house economic capacity such as State and Commonwealth Environment Protection Authorities.

Secondly, this study clearly demonstrates that local communities value both protection of existing environmental amenity and works undertaken to improve the recreational and aesthetic values of urban water bodies. We produced a substantially higher value of $A174 million compared with an expenditure to 2006 of $A36.5 million. This indicates that further expenditure on both recreational improvements and environmental protection can be justified. The results also run counter to the argument that environmental protection is mainly demanded by higher status households. While a small positive significant relationship was found between income and lake value, the other demographic variables were insignificant indicating that households did not vary in their valuations based on ethnicity, education or home ownership. Further, no negative suburb dummy values were found, which might have suggested that some suburb populations placed a lower value on the improvements than others. Thus environmental improvements are generally appreciated throughout the Lake Illawarra community.

Thirdly, this methodology yielded as a by-product, a range of data which is useful for general planning purposes. It provided estimates of value for additional bedrooms, bathrooms, car spaces, lock-up garages and lot size and differential suburb effects that may be of interest to the real estate industry and home buyers. Values of other control variables that can be used in these studies such as crime rates, distance to shopping or transport, open space, schools, etc. generate valuable planning information. It is also interesting to note that, in an era of rising interest rates, a one percent increase in home mortgage rates reduced price by around $20,000 in this study.

These results were promising enough to warrant further research on this and related topics using the hedonic pricing method. Such research would both contribute to efficient decision-making on environmental issues and help refine the methodological aspects of the analysis.

Table 1
Summary statistics of the data employed

Variable name	Description	Mean	Median	Maximum	Minimum	Std. Dev.
PRI	Sale price ($)	307035	297000	820000	105000	91400
BED	Number of bedrooms	2.89	3	5	1	0.73
BAT	Number of bathrooms	1.31	1	4	1	0.61
CAR	Number of car parks	0.90	1	4	0	0.77
LUG	Number of lockup garages	0.48	0	4	0	0.80
SIZ	Lot size (sq meters)	636	601	1442	240	152
DIL	Distance to the lake (meters)	599	543	1680	0	394
DIH	Distance to highway (meters)	387	323	1346	0	258
INC	Weekly Income ($)	1025	1060	1220	736	153
INR	Interest rate (%)	7.6	7.6	8.1	7.3	0.27

Source: Authors' calculations.

Table 2
The estimated hedonic pricing model using 521 observations

Variable (1)	Coefficient (2)	t-ratio* (3)	P-Value* (4)	t-ratio** (5)	P-Value** (6)	Marginal effect at mean (7)= (2)* 307035
Constant	11.9	37.8	0.00	38.7	0.00	3641226
BED	0.0643	3.7	0.00	4.0	0.00	19748
BAT	0.0841	4.4	0.00	4.2	0.00	25824
CAR	0.0237	1.9	0.05	1.8	0.07	7264
LUG	0.0529	4.7	0.00	4.0	0.00	16234
SIZ	0.0002	1.9	0.06	2.7	0.01	53
DBS	0.1061	3.7	0.00	3.6	0.00	32577
FRO	0.1574	3.5	0.00	3.7	0.00	48326
DIL	-0.000080	-3.0	0.00	-3.0	0.00	-24
DIH	0.000122	3.1	0.00	3.1	0.00	37
INC	0.0007	6.6	0.00	6.1	0.00	209
INR	-0.0652	-1.8	0.08	-1.8	0.07	-20031
DU2- Windang	0.2744	4.8	0.00	5.6	0.00	84243
DU3- Warrawong	0.1397	2.3	0.02	2.6	0.01	42879
DU10-Mount Warrigal	0.2181	5.2	0.00	4.8	0.00	66976
R-squared	0.463					
Adjusted R-squared	0.448					
F statistics	31.10		0.00			
Akaike info criterion	-0.225					
Schwarz criterion	-0.102					
Ramsey RESET Test	F(1,505)= 2.45		0.11			
	F(2,504)=1.60		0.20			
ARCH test	F(1,503)=86.1		0.00			
White test (no cross terms)	F(23,497)=3.64		0.00			

Note: (a) * based on the OLS standard errors; (b) ** are based on the White Heteroskedasticity-Consistent Standard Errors & Covariance; and (c) the minimum DIL and DIH are assumed to be 2.5 meters and 11.5 meters, respectively.

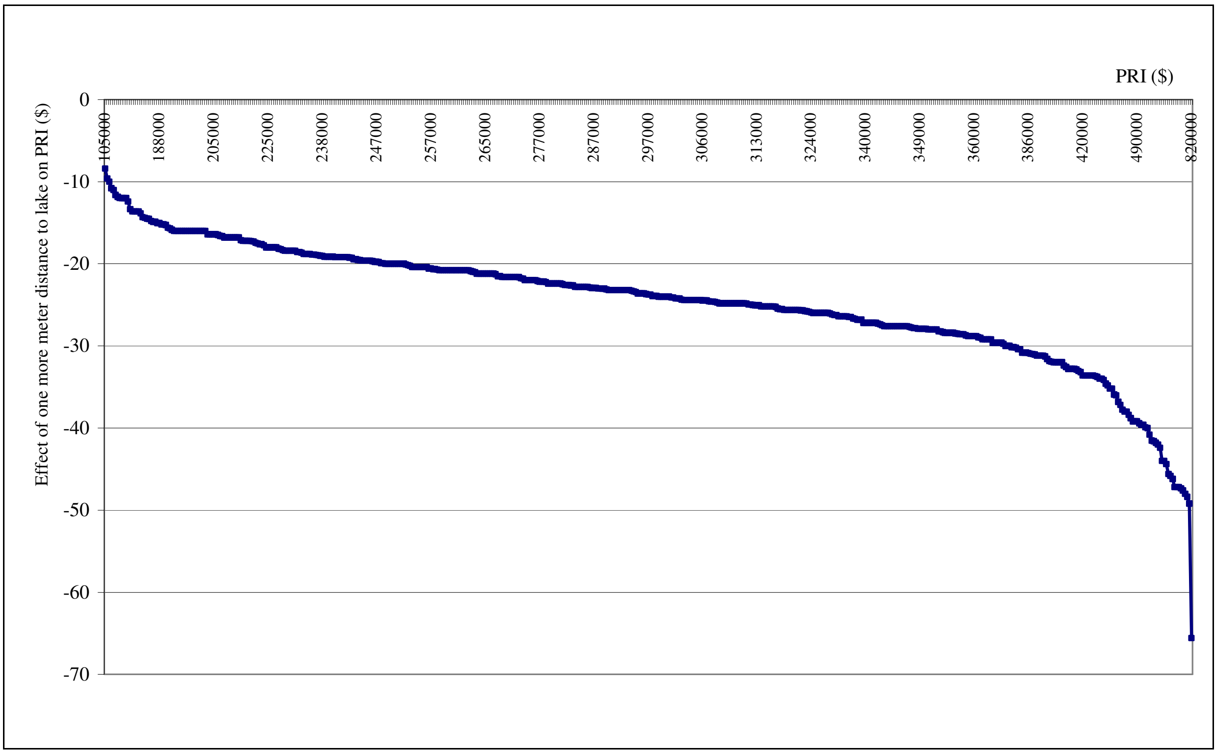

Fig 1. Marginal effect of one additional meter distance to the lake on price (PRI_i), *source*: Using the sorted *PRI* data (in ascending order), the effect is calculated by equation 2 or more specifically $\partial PRI_i / \partial DIL_i$ = -0.000080PRI_i .

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