A Review of Applications of Hedonic Pricing Models in the New Zealand Housing Market

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RIMU Research and Evaluation Unit

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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Executive summary

New Zealand is a spatially unique landscape where urban and environmental amenities shape the urban configuration of each city and determine land-use regulations. Hedonic pricing models supply information to make appropriate decisions regarding the provision of those amenities and to design more effective zoning and land-use regulations. Those models contribute to informing planners on how individuals value amenities and developers on how to design development projects that preserve profit-maximization behaviour (Heal, 2001; Anderson and West, 2006). Planners and policymakers may use those models to inform the ongoing discussions about the direction and typology of growth that is sought for any city.

Hedonic models use data on housing market transactions to determine the implicit price of housing attributes. Essentially, hedonic models analyse the price differential between two houses that vary only by one characteristic and the monetary trade-offs individuals are willing to make with respect to the changes in that characteristic. These models have been extensively applied to housing markets in New Zealand in order to explain the variations in housing prices as a reflection of the value of housing attributes (e.g. number of bedrooms, land area). The attributes that have received the most interest are environmental and urban amenities.

Research using hedonic models in New Zealand is largely applied and focused in the major cities (Auckland, Christchurch and Wellington). For the case of Auckland, research has addressed the valuation of environmental amenities (water views and parks), urban amenities (schools), housing and household features, policy (school zones, zoning), and market behaviour.

This paper is a literature review of applications of hedonic models in New Zealand and describes three current studies led by staff of Auckland Council. This paper then summarises empirical applications in terms of their research questions, methods and data, and contributions. Researchers and policymakers will find this paper useful to locate their own work within the context of existing literature.

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1. Introduction

Policymakers have shown an increasing interest in the economic value of environmental amenities (and associated ecosystem services), as well as the potential impacts of changes in the quality and quantity of those amenities. Economists measure those impacts (gains or losses) as a monetary payment or a monetary compensation (as subtractions from or additions to income) that leave people equally economically satisfied with or without a change in the services provided by an environmental amenity. Those value estimates are of importance because they are used as an input into decision-making and for aiding the assessment of policy choices or trade-offs concerning management options (Heal *et al.*, 2005).

As amenities are not traded in conventional markets, no price exists that could be ascribed as a measure of value. Thus, it is not possible to reveal how much any individual would be willing to pay for the benefits of those amenities (Wakeford and Meyer, 1996; Heal *et al.*, 2005). Non-market valuation methods are therefore employed to explore the implications of amenities on welfare, and how they can be monetised for policy analysis. There are two key non-market valuation techniques: stated preference (SP) and revealed preference (RP) methods. SP methods entail direct questioning to stakeholders for them to state a value that reflects their attitudes toward amenities. RP methods use surrogate markets (housing or labour) to infer the value ascribed to the amenities.

Hedonic pricing models belong to the RP methods. The hedonic models estimate the demand or value of a good by decomposing its attributes and estimating their implicit prices or contributions to the formation of the good's market price (Rosen, 1974). Hedonic models are applied to the housing market to explain sale price variations as a reflection of the variation of housing attributes (e.g. number of bedrooms, land area). The attributes jointly constitute a housing bundle traded in the market, which are not necessarily produced or consumed in isolation (Domberger, 1977; Baltas and Freeman, 2001). The hedonic model then estimates the value of each attribute with a focus on those that are not traded in a conventional market, like environmental and urban amenities.

The literature on hedonic models is extensive. For example, it has been used to value the following:

- Air quality (Kim, Phipps and Anselin, 2003; Bayer, Keohane and Timmins, 2009).
- Beaches (Gopalakrishnan *et al.*, 2011).

- Rural open spaces (Conway *et al.*, 2010; Gibbons, Mourato and Resende, 2014; Czembrowski and Kronenberg, 2016; Daams, Sijtsma and Vlist, 2016).
- Urban open spaces (Geoghegan, 2002; Jiao and Liu, 2010; Liebelt, Bartke and Schwarz, 2018).
- Urban river pollution and restoration (Bin *et al.*, 2016; Chen, 2017).
- Woodlands (Garrod and Willis, 1992).
- Harbour and mountain views (Jim and Chen, 2009).
- Sea views (Latinopoulos, 2018).
- Land use and forests (Schläpfer *et al.*, 2015).
- Government-funded urban amenities (Wu, Dong and Zhang, 2015).
- Water quality (Bin *et al.*, 2016).
- Clean-up of hazardous waste sites (Gamper-Rabindran and Timmins, 2013).
- Aesthetic value of historical and cultural heritage (Deodhar, 2004; Ahlfeldt and Maennig, 2010; Moro *et al.*, 2013).
- Soil contamination (Peeters *et al.*, 2017).
- Visual environmental impacts (Gibbons, 2015).
- Incidence of wildfires (Mueller and Loomis, 2014).
- Flood risk (Rajapaksa *et al.*, 2017).
- Segmentation of the housing market (Goodman, 1978; Goodman and Thibodeau, 2007).
- Preservation and affordable housing (Heintzelman and Altieri, 2013).
- Places of worship (Thompson, Butters and Schmitz, 2012; Brandt, Maennig and Richter, 2014).
- Traffic noise reduction (Seo, Golub and Kuby, 2014; Swoboda, Nega and Timm, 2015).
- Waste management alternatives (Rivas Casado *et al.*, 2017).
- Nuisances of oil and gas wells (Bennett and Loomis, 2015).
- Energy efficiency ratings (Fuerst *et al.*, 2015).

Some works focus on multiple amenities to capture their interaction with housing preferences. Gibbons, Mourato and Resende (2014) estimate the amenity value associated with proximity to natural (e.g. habitats, designated areas, domestic

gardens and wetlands) and cultural amenities (e.g. churches) in England. Brasington and Hite (2005) estimate the value of proximity to environmental hazards coupled with local school quality in the state of Ohio, USA. They find that environmental quality and school quality are purchased together, environmental quality and house size are substitutes, and environmental quality and lot size are not related goods. Izón *et al.* (2016) explore the behaviour of prices in the state of Arizona, USA, and the influence of amenities such as national forests, wilderness areas, water sources or urban features such as landfills. Schläpfer *et al.* (2015) examine how land-use and environmental amenities and disamenities affect rental prices across communities in Switzerland. Positive effects on rental prices are identified for views, recreational infrastructure and vicinity of lakes, wetlands, undisturbed areas, nationally significant landscapes and cultural sites.

Several applications of the hedonic model in New Zealand are found. They address the valuation of environmental amenities (water views and parks), urban amenities (schools), housing and household features, policy (school zones), and market behaviour. This paper is a literature review of those studies. Its purpose is to inform the Auckland Council's decision-making process about economic valuation of amenities. This paper then summarises empirical applications in terms of their research questions, methods and data, and contributions. Researchers and policymakers will find this paper useful to locate their own work within the context of existing literature.

This paper is structured as follows: Section 2 is a brief description of the setup of hedonic models. Section 3 is the literature review. Section 4 describes three current applications in Auckland. Section 5 concludes.

Auckland Council's Research and Evaluation Unit discussion papers are intended to generate and contribute to discussion on topical issues related to Auckland. They represent the views of the author and not necessarily those of Auckland Council.

2. Hedonic models for housing prices

The hedonic models use data on market transactions to determine the implied value or implicit price of housing attributes. Hedonic models are used to observe the price differential between two houses that vary only by one characteristic (e.g., distance to the nearest park). The approach aids in understanding the monetary trade-offs individuals make with respect to the changes in this characteristic. In the above example it would be the value of the increase in the distance to the nearest park is the difference in the prices of the two houses (Taylor, 2003).

The housing market is complex. Prices depend on many characteristics such as internal features (number of bedrooms), urban and environmental amenities (infrastructure, transport corridors, coastal views), and location (distance to CBD or labour markets). Using house sales, estimates of the implicit prices of component characteristics can be derived.

A hedonic model consists of a regression of prices on housing characteristics and may be specified as follows:

$$p = \alpha_0 + \sum_{i=1}^{h} \beta_i H_i + \sum_{j=1}^{n} \beta_j N_j + \sum_{s=1}^{a} A_s + \sum_{k=1}^{L} \beta_k L_k + \epsilon \quad (1)$$

where p is the sales price of a house; H represents internal housing characteristics (number of bedrooms, living area); N, neighbourhood characteristics (ethnic representation, income distribution); A, urban and environmental amenities (parks, beaches); L, locational characteristics (distance to CBD); and, ϵ is the random error term (Taylor, 2003). The contribution of each variable to the formation of the housing price is captured by an estimated coefficient. The coefficients may be interpreted as the marginal effect on prices of changes in any of the variables[1].

Hedonic models have used Ordinary Least Squares (OLS) to estimate the implicit prices. The OLS estimates are interpreted as the response of the conditional mean of housing prices to a change in any of the attributes or covariates, holding other things constant (Peeters *et al.*, 2017). Other applications acknowledge that spatial correlations may exist between neighbouring houses which introduces biases if omitted from the regressions, for which spatial regressions should be used (Won Kim, Phipps and Anselin, 2003; Brasington and Hite, 2005; Conway *et al.*, 2010;

[1] Alternative specifications of Equation 1, to incorporate non-linear relations, include the double-log where the coefficient is interpreted as a price elasticity with respect to a given variable, or the semilog form where the coefficient is rather interpreted as a price semi elasticity. The selection of the proper specification form depends on the context.

Sunding and Swoboda, 2010; Helbich *et al*., 2014; Wu, Dong and Zhang, 2015; Allpress, Balderston and Nunns, 2016). While the OLS provides consistent estimates, it assumes that the response of prices, to changes of covariates, is constant in the whole distribution of housing prices. Conditional and unconditional quantile regressions have been used to explore heterogeneous responses across the price distribution as a representation of housing submarkets. Mueller and Loomis (2014) estimate the impact of repeated wildfires on prices in Southern California using (conditional) quantile regressions (CQR) and find heterogeneous responses across the price distribution, where variation is as much as 73 per cent between the 25th and 75th quantiles. Similarly, Rajapaksa *et al*. (2017) find for Brisbane, Australia, that the effects of information on flood risks differ between submarkets. Uematsu, Khanal and Mishra (2013) investigate price effects of environmental factors on farmland values in the United States and find that amenities are positively correlated with values, and their impact is more pronounced at the upper-end of the price distribution. Peeters *et al*. (2017) estimate hedonics models for cadmium pollution of soil in the region of Campines in Belgium, and find negative effects in the middle range of the price distribution only.

3. Applications in New Zealand

Hedonic models have been used in New Zealand to value amenities or to evaluate public policies. This section summarises their findings and implications, contributions and how they address their research questions.

3.1 Environmental amenities

Studies on environmental amenities have been applied to evaluate aesthetic externalities associated to water views, exposure to sunlight, parks and open spaces.

Filippova (2009) examines the influence of water view premiums in Auckland and concludes that premium ranges from five per cent in West Harbour to 54 per cent in Mission Bay. She also concludes that greater accuracy on premiums estimates is achieved by using submarket models rather than a region wide model. Samarasinghe and Sharp (2008) estimate the value of views characterised as type of view, scope and distance to the coast. This work incorporates potential spatial autocorrelation to improve the accuracy of the hedonic estimates, and find that wide water views closer to the coast add a price premium of 44 per cent. Similarly, Bourassa, Hoesli and Sun (2005) explore the implicit prices of water views, the appearance of nearby improvements, and the quality of landscaping in the neighbourhood. Using transactions from 1986 to 1996 for Auckland, Christchurch, and Wellington, this research finds that price premiums for water views are the greatest in Christchurch, which has the smallest percentage of properties with water views, and lowest in Wellington, which has the highest percentage of properties with views.

Rohani (2012) analyses views and the amenity services of Auckland's Hauraki Gulf, and concludes that they could increase land value by 50 per cent. The work also suggests that if the distance between a house and access to a beach is doubled, the land price would decline by 17 per cent. Bourassa, Hoesli and Sun (2004) explore the impact of views in Auckland. They characterise views in terms of type, scope, distance to coast, appearance of surrounding improvements, average quality of landscaping in the neighbourhood, and average quality of structures in the neighbourhood. They find that wide views of water add a price premium of 59 per cent to a waterfront property, attractive buildings a premium of 37 per cent to houses in surrounding areas, and houses in neighbourhoods with only poor-quality landscaping experience a 51 per cent discount on price. Similarly, Sharp and Krausse (2015) use 10,000 sales recorded during 2004 in the Auckland Region and find that a flat contour adds a premium of 49 per cent, water views add 28 per cent, and a wide scope of view adds 19 per cent.

Plimmer (2014) indicates that water view premiums correlate positively with market growth, suggesting that for a short time after a market has recovered from a crash, the water view premium has a period of dramatic positive growth that is greater than the growth of the market.

Likewise, the urban configuration of Auckland is defined by its parks and open spaces. Allpress, Balderston and Nunns (2016) explore whether parks capitalise into housing prices. They find that for every 500 metres an apartment is away from the nearest regional park (or neighbourhood park), there is a price discount of 13.7 per cent (16.4%). However, they do not find any statistically significant relationship between distance to the nearest park and sale prices for standalone houses and flats.

Furthermore, Fleming *et al*. (2018) use data for Wellington to estimate that each extra daily hour of sunlight exposure is associated with a 2.6 per cent increase in house price. Wellington is relevant for the analysis for its abrupt topography and over-shadowing buildings. They argue that their results may be used to shift from a regulatory to a price-based planning approach.

3.2 Urban and locational features

Hedonic models have also been used to explore the effects on housing prices of urban amenities (or disamenities) such as flood hazards, cellular phone base stations and towers, transmission lines, windfarm visibility, school zones, lot position and risk of explosions.

Samarasinghe and Sharp (2010) examine the impact of flood-hazard zone location on prices interacted with the public availability of flood maps. They use data from over 2000 sales that occurred during 2006 in the former North Shore City. Through spatial autoregressive models they find that a house located in a flood plain and sold before flood plain maps were available has a price discount of 6.2 per cent. Yet the discount decreases to 2.3 per cent if flood plain maps become available by the time of transaction.

Bond (2007) examines the effect that proximity to cellular phone base stations has on prices in Christchurch. She finds that if the distance between a station and a house is 50 metres, prices decrease by 5.1 per cent. Similarly, Filippova and Rehm (2011) investigate if proximity to cell phone towers influences prices in the Auckland region. They use sales transaction data between 2005 and 2007 but did not find any significant effect, with the exception of armed monopole towers which are associated to a discount of 11 per cent if there is a tower in a 100 metre radius around a house.

In addition, Bond and Hopkins (2000) analyse the effect of high voltage overhead transmission lines and supporting pylons on prices in in the suburb of Newlands, Wellington. Their results reveal a discount of 2.7 per cent if a pylon is less than 100 metres near a house. However, the presence of a transmission line in the area has a minimal effect and is not a statistically significant factor in the price.

McCarthy and Balli (2014) examine the effect of windfarm visibility on prices in the township of Ashhurst. They use 945 sales transactions occurring between 1995 and 2008. They find that the turbines located between 2.5 and 6 kilometres from Ashhurst have no significant impact on property value.

Thorsnes, Alexander and Kidson (2015) test the effect of local variation in several natural amenities (views, exposure to the sun and proximity to the beach) on two house and neighbourhood characteristics: house size and median census block income. They use data from all sales in 2005 in Dunedin. They find that house sizes and household incomes are lower in areas of private housing proximate to public housing neighbourhoods, consistent with disamenities associated with concentrations of low-income households. That is, public housing developments built in high-amenity areas have displaced a large amount of private development targeted toward higher-income households. In addition, ex-state houses sell for a significant six per cent discount after controlling for their small size and location in lower-income neighbourhoods.

Gibson, Boe-Gibson and Kim (2004) use sales transactions in 2004 and 2005 in Northwest Christchurch; and, by accounting spatial autocorrelation into the hedonic models, they find a price premium of about 20 per cent for an average house zoned for a popular secondary school, Christchurch Girls High School.

Likewise, Rehm and Filippova (2008) explore the impact of geographically defined school zones on house prices in Auckland. They use house sales transactions between 1986 and 1996, and a geographic information system to divide the study area into effective school zones and then further subdivide into suburbs, thus offering a vital indicator of internal validity. They find that the influence of school zoning on house prices is not uniform and the variation in price effects is largely a function of the uncertainty of future zone boundary definitions.

Filippova and Rehm (2009) quantify the influence that residential lot position has on prices in the former Auckland City during 1997 and 1998. They find that a house occupying a rear lot off a noisy arterial road is equally as desirable as an equivalent house sited on an inside lot fronting a quiet street. However, corner lots fronting a busy road suffer a price discount of 6.5 per cent; and, the more sheltered inside lots facing busy roads are subject to a discount of 2.6 per cent. These results reflect

homebuyers' willingness-to-pay for refuge from the air and noise pollution generated by vehicles travelling on arterial roads.

Kask and Maani (1992) develop a study in Auckland and evaluate a consumer's willingness to pay to avoid the risk of damage due to an explosion from a high-pressure natural gas pipeline. They claim their study provides a good example of the problems arising when estimating hedonic prices under conditions of uncertainty. They explore the decision to pay a higher price for a comparable home that has a reduced probability of damage due to the location of the home, which reflects the consumer's expenditure to self-protect. They report that buyers are willing to pay an additional 14.9 per cent to reduce their risk of damage from a pipeline explosion and to avoid the negative impacts of its construction. Nonetheless, after construction is completed, the discount decreases to 9.7 per cent.

Rehm, Filippova and Stone (2006) analyse 1996 sales transactions in Auckland, Wellington, Christchurch and Dunedin to determine if a home's vintage creates price premiums or discounts. They find a nonlinear effect on sales prices that differs between markets. Wealthier markets witness a greater vintage effect, with turn-of-the-century homes realising 15 per cent price premiums over new homes. In contrast, less wealthy markets tend to apply discounts of 20 per cent to 40 per cent to houses of the same vintage.

3.3 Method

The use of hedonic models is not constrained to environmental valuation. They have been used to test methodological approaches for the identification of housing market segments.

An important body of literature on hedonics is devoted to the segmentation of the housing markets. Bourassa, Cantoni and Hoesli (2007) compare different methods of controlling for the spatial dependence of house prices in a mass appraisal context. They assess the utility of spatial statistical methods relative to each other and to simpler OLS methods for a hedonic model. They claim that their approach allows the relevant submarket to vary from house to house, and for transactions involving other houses in each submarket to have varying impacts depending on distance. They conclude that for Auckland the gains in accuracy from including submarket variables in an OLS specification are greater than any benefits from using geostatistical or lattice methods.

The practical importance of their study is that a hedonic model with submarket dummy variables is substantially easier to implement than spatial statistical methods. Bourassa and Hoesli (1999) examine if the structure of constrained submarkets

constructed according to three a priori classifications (property type, house value and geographical areas) differs from that of unconstrained submarkets constructed by means of principal component analysis and cluster analysis. They use data for Auckland and find that the structure of submarkets relates to the physical characteristics of properties. They claim that a priori classifications are found to lead to submarkets whose structure does not reflect the dimensions of housing submarkets in Auckland.

3.4 Market behaviour

Hedonic models also help to explain market behaviour, in particular, movements in prices and changes in the composition of dwellings. Price indexes have been developed based on hedonic models and are critical to understanding housing markets, and to inform decision-making about housing affordability or housing bubbles (Bourassa, Hoesli and Sun, 2006).

Rehm, Chen and Filippova (2018) approach numerical superstition as a potential influence on the purchasing house in Auckland. Their results reveal that ethnic Chinese buyers display superstitious home buying behaviour between 2003 and 2006 by attributing value to houses with street addresses starting or ending with the lucky number eight. The estimated premium amounts to 1.4 per cent. However, this effect vanishes in the for sales transactions between 2011 and 2015, the authors argue probably because ethnic Chinese have, over time, assimilated New Zealand's Western culture and become less superstitious. Similarly, Bourassa and Peng (1999) use sales data between 1989 and 1996 for Auckland CBD and find that houses with lucky numbers are sold with a premium of 2.4 per cent.

Rehm (2009) quantifies leaky building stigma associated with monolithic claddings in the Auckland region. The results show that a leaky building stigma exists and is discounting prices of monolithic-clad single family houses by five per cent and multi-unit dwellings by 10 per cent. Additionally, roughly 37,500 monolithic-clad dwellings have been built in the region since 1992 and their homeowners have suffered an estimated $1 billion reduction in property values due to leaky building stigma.

Dotzour, Moorhead and Winkler (1998) compare the sale prices of houses in Christchurch sold at auction with those sold by private treaty. Their results indicate that in some cases auctions can result in premiums ranging between 5.9 per cent and 9.5 per cent. Also, they do not find that auctions result in lower prices than private-treaty sales.

Filippova and Fu (2011) analyse the impact of marketing time on house sale price in Auckland. They find that a one per cent increase of time on market (in days) implies

a price discount ranging between 0.27 and 0.55 per cent, the differences arise due to changes in market conditions where properties in a booming market are sold more quickly than properties sold in a declining market.

Bourassa *et al.* (2009) investigate the heterogeneous rates of market appreciation, whether they are due to changes in fundamentals or market-wide bubbles. They use data from 1989 to 1996 in Auckland, Wellington and Christchurch, and find that houses will appreciate at different rates depending on the characteristics of the property and the change in the strength of the housing market. That is, in a strong market, smaller, older, centrally located houses are increasingly appealing to investors and exhibit larger price increases than the market.

Krsinich (2009) reviews the estimation approach of the housing rentals index and test whether there is any residual pure price change being smoothed out of the index due to the matched approach used to construct survey samples. She explores different approaches to the specification of the hedonic regression models and the index calculation from the model parameters. Her results suggest that the index based on hedonic models is appropriate to control for compositional change in the measurement of rental movements.

Limsombunchai (2004) compares the predictive power of the hedonic model with an artificial neural network model on house price prediction. He uses a sample of 200 houses in Christchurch, and by controlling internal features of the house (size, age, type, number of bedrooms, number of bathrooms, number of garages, amenities around the house and geographical location), he finds that artificial neural networks have better performance on house price prediction.

3.5 Policy

Hedonic models have also been used to assess policy making related to land-use regulations, thermal insulation and housing tenure choice.

Lees (2017) explores if land-use regulations hinder the flexibility of housing supply. He finds that house prices outstrip construction prices in New Zealand cities; the extensive price of land is about five to six times the intensive price of land; density and house prices are only weakly correlated; and, apartment and townhouses outstrip construction prices.

Similarly, Grimes and Liang (2009) evaluate the effects of the metropolitan urban limit (MUL) on land prices between 1992 and 2003 in Auckland. By controlling for spatial autocorrelation they find strong zoning boundary effect on land, in particular, that land just inside the MUL boundary is valued (per hectare) at approximately 10 times land that is just outside the boundary.

Filippova *et al. (*2018) investigates the economic effect of disaster-mitigation regulations on the commercial building stock due to the marked increase in the awareness of earthquake risk following the Canterbury earthquakes. Using a difference-in-differences framework, they determine whether earthquake risk has been capitalised into the property prices of buildings constructed prior to 1976, as a response to the national policy requiring assessment and strengthening (or demolition) of the existing earthquake-prone building stock. A negative externality is found in the policy announcement on affected (pre-1970s) office and retail buildings which caused office buildings to suffer a 12.5 per cent stigma discount. However, retail properties were less impacted suffering a 2.3 per cent stigma loss.

Thorsnes and Bishop (2013) take advantage of wide variation in thermal insulation in a sample of house sales in Dunedin and estimate the market value of basic code-level insulation. Insulation levels vary across the houses in their sample because standard practice in New Zealand was to build houses with no thermal insulation prior to implementation of insulation standards in 1978, and the extent of insulation retrofits varies across the sample. They find that newer houses built under insulation requirements have a price premium of 8.5 per cent relative to older houses. This premium exceeds the higher cost of retro-fit installation.

Hargreaves (2003) explores the determinants of housing tenure choice in New Zealand in order to explain the decline the rate of ownership from 73 per cent to 67 per cent between 1986 and 2001. He reports that financial considerations such as saving for a deposit and lack of job security were the main reasons for renters not switching to home ownership. He estimates hedonic models to confirm that household income is one of the key variables determining household tenure, particularly in the lower rent suburbs.

4. Current applications

This section describes applications of three current studies applying hedonic models and led Auckland Council's Research and Evaluation Unit. The first is about the effects of environmental amenities across market segments and time. The second estimates the price premiums or discounts associated to heritage protection regulations. The third estimates the price premiums or discounts associated to churches. All studies take Auckland as a case study.

4.1 Heterogeneous effects of environmental amenities

Fernandez and Bucaram (2018) argue that attitudes toward environmental amenities change across submarkets and time. The capitalization of amenities is heterogenous, which, in addition to the complexity of housing markets, may obscure the interpretation of hedonic models. They use house sale transactions between 2000 and 2016, and estimate hedonic models using unconditional quantile regressions, to control for submarkets, and include interactions between all amenities and time effects to explore any changes in the capitalisation pattern. Environmental amenities are represented by the distance between any house and the nearest coastal feature (coastline, beaches, harbours and bays), marine areas, and open spaces. They take advantage of a detailed categorisation of parks: owned or maintained by the Auckland Council (AC) or the New Zealand Department of Conservation (DOC), conservation areas, ecological areas, marginal strips around waterways, golf courts, and wetlands. They also explore whether the size of the nearest amenity is an indirect mechanism to add value in the housing price.

A further complication is that parks are often contiguous to wetlands, waterways or coastal areas, which may enhance the value of an amenity. Hedonic estimations accounting only for the distance between a house to the nearest open space, may then disregard valuable information, such as contextual or regulatory backgrounds. For example, volcanic parks may provide landscape benefits but these may be outweighed by height construction restrictions or land-use regulations. Thus, households incur in a trade-off between environmental amenities and development potential.

The research finds a heterogeneous capitalisation pattern of amenities. For instance, relatively large regional reserves should add value to houses whose prices are below the median and close to the CBD. But for the most expensive houses in the dataset, regional reserves in turn become disamenities. Likewise, for houses around the median of the price distribution and relatively far from the CBD, large neighbourhood parks imply price discounts rather than any amenity value. Also, houses in the upper-

end of the price distribution tend to locate in the proximity of beaches, where price premiums are observed. But discounts are also observed for houses in the lower-end of the distribution in these same areas.

4.2 Price effects of heritage in Auckland

Heritage features shape the layout of any city. This configuration is affected not only by designations or regulations intended to protect and conserve heritage, but also by the trade-offs that homebuyers are willing to incur between house location, prices and the aesthetic or landscape amenities associated to heritage.

Heritage has been found to have positive effects on housing prices (Ahlfeldt *et al.*, 2017). The literature examines internal effects, for houses that have been listed as heritage and for which particular construction or renovation rules apply; and, external effects in the form of externalities on surrounding houses because of landscaping or aesthetic value. In both cases, heritage (similarly to other environmental amenities, such as parks or beaches) is a public-good, where maintenance and preservation costs are not necessarily shared among those who enjoy the benefits. This disparity between public benefits and private costs leads to a perceived burden with owning heritage and justifies public intervention for preservation (Moro *et al.*, 2013; Koster and Rouwendal, 2017)

Bade *et al.* (2018) investigate the external effect, if any, that heritage sites have on housing prices in Auckland. In Auckland there are approximately 2300 heritage sites comprising archaeological sites, chapels, churches, halls, industrial buildings, monuments, residences, shops, lighthouses and schools, and 50 special character areas covering streetscapes. They differentiate heritage sites between heritage areas (i.e. residential areas), individual heritage features and special characters areas (SCA), which are residential or business street-scape areas identified as having collective and cohesive values, cultural importance, relevance and interest to communities.

The research uses sales data between 2006 and 2016 to construct a model where the dependent variable is the logarithm of the price per square metre of floor area, and the variables of interest are the effects of heritage areas (HA) and SCA (represented by dummy variables for whether the house is located within any of them), and the distances from a house to the nearest heritage feature, HA or SCA.

To further identify the source of the heritage price premium, the analysis accounts for heritage density effects; density is the number of heritage sites in a radius of 50 or 100 metres around each house. The focus is on the external effects of heritage and

the price effects of two forms of local government heritage protection (scheduled heritage sites and Special Character Areas).

They find a significant price discount of 10 per cent for a house located inside a heritage area. For houses outside HAs there is a premium of about 1.7 per cent for an additional heritage site in a radius of 50 metres around a house. This premium slightly decreases to 1.4 per cent for a radius of 100 metres, and decreases to 0.5 per cent for a radius of 200 metres. They also find a price premium of four per cent for a house being located within a Special Character Area. Furthermore, when controlling for time dynamics, they find that the SCA premium vanishes in 2016 because of the introduction of densification and rezoning regulations that removed the heritage protection in some Auckland neighbourhoods.

4.3 Places of worship (churches)

Sites of spirituality or religious heritage are also part of the urban configuration of Auckland. Bade, Cheung, *et al.* (2018) investigate if Christian churches have any price effects on surrounding properties. This study contributes to a narrow literature regarding places of worship, which touches several issues regarding valuation of urban amenities, as well as the effects of historical and cultural heritage. They use a dataset of about 183,000 sales between 2010 and 2016. The dataset also includes 143 Christian churches and 64 marae.

Preliminary results show that houses with a church within a 200 metre radius are sold with a discount of 6.4 per cent. A 400 metre radius generates a discount of 2.6 per cent, and at one kilometre the discount is 1.4 per cent.

5. Concluding remarks

New Zealand is a spatially unique landscape where urban and environmental amenities shape the urban configuration of each city and determine land-use regulations. Hedonic models supply information to make appropriate decisions regarding the provision of those amenities and to design more effective zoning and land-use regulations. Those models then contribute to informing planners on how individuals value amenities and developers on how to design development projects that preserve profit-maximization behaviour (Heal, 2001; Anderson and West, 2006). Planners and policymakers may use those models to inform the ongoing discussions about the direction and typology of growth that is sought for any city.

This paper reviews hedonic pricing models in the broader economic literature, the application of these models in New Zealand, and briefly describes three pieces of Auckland Council research. Its purpose is to inform the council's decision-making process about economic valuation of urban and environmental amenities. This paper then summarises those applications in terms of their research questions, methods and data, and contributions. Researchers and policymakers will find this paper useful to locate their own works within the context of existing literature.

Since the seminal works of Rosen (1974), Goodman (1978) and Ridker and Henning (1967), hedonic models have evolved to become the standard way economists deal with the complexities of the housing market (Malpezzi, 2002). The hedonic model uses behaviour observed in housing markets to value not only housing features but also environmental and urban amenities. The popularity of the hedonic model is reflected in its numerous applications world-wide, particularly due to the relatively minimal data requirements and straightforward empirical implementation (Taylor, 2003).

Even though the theoretical and empirical literature on hedonic models is vast, the basic setup of decomposing the housing price into its attributes and their contributions remains the same. The main insight derived from the estimates is the value of a (marginal) change in an environmental or urban amenities that accrues to a population of residents in any area (Taylor, 2003). Many details still require careful consideration for the setup of datasets and econometric estimates, for this some comprehensive reviews may be found in Taylor (2003), Malpezzi (2008) and Mendelsohn and Olmstead (2009). There is also scope for more cutting-edge and methodological applications in New Zealand such as semiparametric, nonparametric or Bayesian approaches, applications to commercial real estate and the interactions with residential markets, matching sales transaction with households' characteristics, and welfare estimations based on the estimates of marginal prices.

Environmental amenities are not traded in conventional markets and no price may be ascribed in order to infer an economic value. But this does not imply that individuals have no (positive or negative) attitudes toward those amenities, or changes in their quantity or quality. As every policy proposal should be thoroughly assessed and decisions be taken based on sound evidence, hedonic models (and in general other non-market valuation techniques) are an essential tool in decision-making, becoming foundations for rigorous cost-benefit analysis.

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