THE INFLUENCE OF LOT POSITION ON HOUSE PRICE

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ABSTRACT

This study aims to understand and quantify the influence that residential lot position has on house price in Auckland City, New Zealand. The empirical results show that price effects largely depend on whether the lot accesses an arterial or local road. With an inside lot fronting a local road as the default condition, the study finds corner lots facing arterial roads are most heavily discounted, while rear lots off arterial roads are on par with sought-after inside lots on quiet streets. These findings reflect homebuyers' willingness-to-pay for refuge from the air and noise pollution generated by vehicles travelling on arterial roads.

Keywords: House prices, infill development, noise pollution, air pollution, housing markets, hedonic pricing model.

INTRODUCTION

Within housing markets, the classic real estate motto "location, location, location" is often associated with location decisions at the regional or city level. Little research has investigated the small-scale relationship between house prices and location in terms of lot position. With an increasing number of progressive local and regional governments promoting sustainable development by adopting Smart Growth [1] principles, the predominant suburban pattern of inside and corner residential lots will likely evolve into a mixture of inside, corner and rear lots, with the latter largely being created through subdivision and infill development.

One such progressive government is the Auckland Regional Council, which promotes land use 'intensification' and creation of high quality, compact urban environments. In its 1999 publication, *Auckland Regional Growth Strategy: 2050,* the Auckland Regional Growth Forum outlined its Growth Concept. Its proposed intensification aims to largely constrain growth to existing urban limits and focuses on increasing densities around town centres and major transportation routes. Mixed-use developments are to be lauded, while single-use, greenfield development discouraged. Although less emphasis is placed on

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[1] For discussions on Smart Growth see Downs (2005) and Song (2005).

general suburban infill development, it is a proposed method of increasing density (Auckland Regional Growth Forum, 1999).

In the context of Auckland's Growth Concept, the authors use Auckland City as a case study to determine if lot position, namely rear lot position, has any significant influence on house price.

LITERATURE

Little empirical research has been conducted on the relationship between lot position and house prices. However, it is evident from the literature that lot position price effects largely relate to the lot type's inherent level of exposure to externalities, namely noise and air pollution from vehicular traffic. Two studies have specifically focused on price influences of lot position, but only in regards to corner lots. Guntermann (1979) provided the first empirical evidence on the 'corner lot effect'. The study found that corner property values are affected negatively if the house is on a heavily travelled main thoroughfare. Otherwise, there is no significant price difference with inside lots. In a follow-up study by Larsen and Peterson (1987), the researchers found corner lot locations have no significant impact on house price. However, the hedonic model employed did not control for differences in road traffic.

Additional studies have included variables for corner lot position and traffic levels, although these were not the focus. For instance, Sirmans et al (1997) found corner lot position to have no significant impact on prices. However, houses fronting an arterial road were found to be negatively impacted. Although no empirical study has been published on the link between traffic noise and house price in New Zealand, an Australian case study found that for each additional 1 dB(A) of noise pollution house price declines by 1 percent (Renew, 1996). Several other international studies have also found that noise from high traffic roads negatively impact house prices including Li and Brown (1980), Nelson (1982), Asabere (1990), Hughes and Sirmans (1992), Palmquist (1992), Lake et al (1998), Wilhelmsson (2000) and Matthews and Turnbull (2007). In addition to traffic noise, Lake et al (1998) found that the visual impact of arterial roads also negatively influence house prices in Glasgow, Scotland.

Traffic is also a major source of air pollutants in urban areas. In Europe, for example, exhaust from motor vehicle traffic is considered to contribute more than 50% of PM_{10}, or airborne particulate matter of 10 micrometers or less (Fillinger et al, 1999). Ridker and Henning (1967) employed one of the earliest hedonic house price models to estimate the negative impact of air pollution on property value, with many subsequent studies largely corroborating Ridker and Henning's findings. A meta-analysis of 37 such studies on air pollution and house prices found that the marginal willingness-to-pay for a reduction in air pollution was quite consistent across housing markets (Smith and Huang, 1995).

Underlying this property research evidence, several epidemiological studies have found that living near an arterial road significantly increases health risks. The most comprehensive report on this subject in New Zealand was commissioned by the Ministry of Transport which concluded that vehicle-sourced air pollution contributes to hundreds of deaths per year, with densely populated urban areas such as Auckland at highest risk (Fisher et al, 2002). There are also many international studies that connect vehicle-sourced air pollution to health problems. A recent German study found that adults living near busy roads had increased non-allergic respiratory symptoms (Heinrich et al, 2005), and older adults living within 50 metres of a major road were found to have significantly increased risk of death due to cardiopulmonary causes in two European cities (Gehring et al, 2006). While in the United States, a study of U.S. veterans found that residing near a major road increased risk of respiratory disease (Garshick et al, 2003). Along with older adults, children also appear to be more vulnerable to the ill effects of vehicle-sourced air pollution. A study in the San Fransisco Bay area found that children living near busy roads or attending schools fronting a busy road are more prone to respiratory problems (Kim et al, 2004). Lastly, some of the toxic air pollutants from motor vehicles are linked to cancer. For example, the toxin benzene, which is released into the air through vehicle emissions, causes leukaemia (McCubbin and Delucchi, 1999).

In summary, no empirical research has been conducted to-date that specifically investigates the impact of rear lot position on house price. The literature identifies confounding factors of vehicle-sourced noise and air pollution that influence phenomenon such as the 'corner lot effect'. Given that rear lots are located a distance away from the road, houses on these lots may prove to be somewhat sheltered from the road's ill health effects.

DATA AND EMPIRICAL METHODOLOGY

The main source of data for this study is bulk sales transaction data purchased from Quotable Value covering all detached residential sales in Auckland City during the years 1997 and 1998. These years were selected because they are the last full years that data on lot position was collected for Auckland City. Transactions were excluded from analysis if they were suspected to include data entry errors. Specifically, houses were removed if the floor area was less than 60 square meters or over 360 square meters, if lot size was below 200 square meters or over 3,000 square meters, or had any missing data for any of the variables of interest. Also transactions were deleted that had leasehold rather than freehold interests, were classified as being other than a standard residential dwelling (detached house on its own separate land plot) or were deemed not to reflect an arm's length transaction. In total, 7,919 house sales transactions were analyzed.

Hedonic specification
An hedonic model was developed to answer the research question, does lot position influence house prices? An equation was designed with the following specification:

Let P(**X**) = P(**S, E, N, T, L**) be a house price function that regresses housing characteristics on house price. This function includes structural characteristics, **S** (floor area, site area, vintage, etc); externalities, **E** (water views and surrounding improvements); neighbourhood characteristics, **N** (median household income, ethnicity, etc); temporal, **T** (semi-annual period when transaction occurred); and location, **L** (lot position and suburb where the house is located).

Parameters of hedonic equations are frequently estimated by using a semi-logarithmic functional form to conform to rules of parametric tests. This specification regresses the natural log of gross sales price on a linear combination of housing characteristics. The semi-log functional form is given by

$$\mathbf{P} = e^{\mathbf{X}b+e}, \qquad\qquad (1)$$

where P is the sales price, net of chattels, X is a vector of housing characteristics, b is the vector of unknown hedonic coefficients, and e is the residual. Taking natural logs of Equation (1) yields the transformed equation:

$$\mathbf{Z} = \ln \mathbf{P} = \mathbf{X}b+e, \qquad\qquad (2)$$

The empirical hedonic specification used here is

$$
\begin{aligned}
\ln(P_i) = \quad & b_0 + b_1(\text{Floor\_Area}) + b_2(\text{Floor\_Area2}) + b_3(\text{Site\_Area}) + b_4(\text{Carparks}) + \\
& b_5(\text{Ext\_Wall\_Good}) + b_6(\text{Ext\_Wall\_Poor}) + b_7(\text{Int\_Good}) + b_8(\text{Int\_Poor}) + \\
& b_9(\text{Monolithic\_Clad, etc}) + b_{10\text{-}17}(\text{D1980, etc}) + b_{18}(\text{LScape\_Good}) + \\
& b_{19}(\text{LScape\_Poor}) + b_{20}(\text{Deck}) + b_{21}(\text{Steep}) + b_{22\text{-}26}(\text{Rear\_Arterial, etc}) + \\
& b_{27\text{-}29}(\text{Water\_Slight, etc}) + b_{30}(\text{Neighbours\_Good}) + b_{31}(\text{Neighbours \_Poor}) + \\
& b_{32}(\text{HH\_Income}) + b_{33}(\text{Perc\_MP}) + b_{34}(\text{Perc\_Polynesian}) + \\
& b_{35\text{-}37}(\text{S1997\_Q12, etc}) + b_{38\text{-}137}(\text{au514000, etc}) + e
\end{aligned}
\qquad (3)
$$

where:

P_i	=	net sales price of the *i*th house;	
Floor_Area	=	total building floor area in square metres;	
Floor_Area2	=	floor area squared;	
Site_Area	=	area of the land plot in square metres;	
Carparks	=	number of off-street car parks;	
Ext_Wall_Good	=	dummy variable for whether the house's exterior walls were coded by the valuer as being in 'Good' condition with the default category being 'Average' condition;	
Ext_Wall_Fair_Poor	=	dummy variable for whether the house's exterior walls were coded by the valuer as being in 'Fair' or 'Poor' condition;	
Int_Good	=	dummy variable for whether the house's interior fixtures and finishes were coded by the valuer as being in 'Good' condition with the default category being	

		'Average' condition;
Int_Poor	=	dummy variable for whether the house's interior fixtures and finishes were coded by the valuer as being in 'Poor' condition;
Monolithic_clad		dummy variable for whether the house's exterior walls are entirely monolithic-clad (stucco, EIFS, etc) with the default category being cladding other than monolithic;
D1980, D1970, etc	=	set of dummy variables corresponding to the vintage (decade) in which the house was built with the default category being the latest vintage (1990s);
LScape_Good	=	dummy variable for whether the land plot's landscaping was coded by the valuer as being in 'Good' condition with the default category being 'Average' condition;
LScape_Poor	=	dummy variable for whether the land plot's landscaping was coded by the valuer as being in 'Poor' condition
Deck	=	dummy variable for whether the house has an outside deck or not; default category is <u>no</u> deck;
Steep	=	dummy variable for whether the house's land plot is steeply sloped or not; default category is <u>not</u> steep (land plot was coded by the valuer as being either 'Level' or having an 'Easy to Moderate' fall or rise);
Rear_Arterial	=	dummy variable for whether the house features a rear lot position and is located on an 'arterial road' (Road Class 1 as defined by Land Information New Zealand (LINZ)) or 'minor arterial road' (Road Class 2); default category is an <u>inside</u> lot position on a 'collector' or 'local' road, classes 3 and 4 respectively;
Corner_Arterial	=	dummy variable for whether the house features a corner lot position and is on an arterial or minor arterial road;
Inside_Arterial	=	dummy variable for whether the house features an inside lot position and is on an arterial or minor arterial road;
Rear_Local	=	dummy variable for whether the house features a rear lot position and is on a collector or local road;
Corner_Local	=	dummy variable for whether the house features a corner lot position and is on a collector or local road;
Water_Slight	=	dummy variable for whether the house features a slight water view from the main living room with the default category being no water view.
Water_Moderate	=	dummy variable for whether the house features a moderate water view from the main living room;
Water_Wide	=	dummy variable for whether the house features a wide water view from the main living room;

Neighbours_Good	=	dummy variable for whether the house's immediate surroundings (namely neighbouring improvements) were coded as being 'Good' quality with the default category being 'Average' quality;
Neighbours_Poor	=	dummy variable for whether the house's immediate surroundings were coded as being 'Poor' quality
HH_Income	=	median household income of the property's meshblock[2] based on the 1996 NZ Census;
Perc_MP	=	percentage of meshblock's working-age population in managerial and professional occupations based on the 2001 NZ Census;
Perc_Polynesian	=	percentage of meshblock's population that is of Polynesian ethnicity ('NZ Maori' and 'Pacific Islander' minorities[3]) based on the 1996 NZ Census;
S1997_Q12, etc	=	set of dummy variables corresponding to the semi-annual period in which the house was sold with the default category being quarters 3 and 4 of 1998;
au514000, etc	=	set of dummy variables corresponding to the house's 2006 Area Unit[4] (proxy for suburb);
e	=	random error.

Selection of study area

The authors initially considered analysing sales across Auckland Region as a whole, but after closer examination determined that Auckland City, the region's most established and densely urbanised territorial authority, offers a more ideal case study for investigating residential infill development. Figure 1 contains a box plot of house vintage against lot position (inside or corner lots versus rear lots). Auckland City differs substantially from the balance of the region in terms of infill development patterns. Although both lot position categories feature the full range of vintages, inside and corner lots in Auckland City primarily contain earlier vintage homes while rear lots tend to have recent vintage homes. As the city's population grew, the standard quarter acre lot was subdivided for new, infill housing. In fact, the upper quartile of inside/corner lots aligns with the lower quartile of rear lots at the 1950 vintage. As for recent vintage houses located on inside and corner lots, this likely involved relocation or demolition of the older home to make room for a new dwelling. In contrast to Auckland City, there is a considerable amount of vintage overlap between lot positions in the region's other cities and districts. This suggests a somewhat different development pattern. In absence of data on the subdivision of land plots, the authors speculate that greenfield residential

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[2] Meshblocks are the smallest census geography (enumeration units) employed by Statistics New Zealand. In dense urbanised areas meshblocks are individual city blocks.
[3] Maori and Pacific Islanders were combined into one ethnic category based on Johnston et al (2005) who found that, particularly in Auckland, these two ethnic groups tend to share residential space and together experience residential segregation.
[4] Area Units are the second smallest enumeration units employed by Statistics New Zealand. In urbanised areas the target size for an Area Unit is 3,000 to 5,000 people.

subdivisions in these outlying areas tended to incorporate rear lots in their original design. Given that the research focus is on infill development, Auckland City in isolation is deemed the most appropriate study area.

Figure 1: Box plot of house vintages against lot position in Auckland city and the balance of the Auckland region
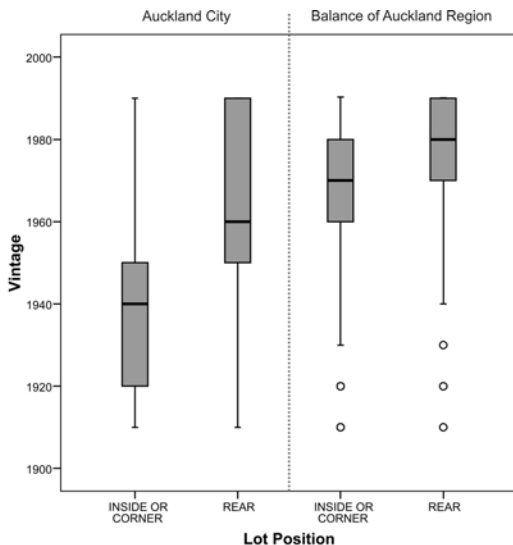
The authors anticipated that versus inside lots, rear and corner lot positions will significantly influence house price; however according to the literature, this impact is likely dependent on the type of road the lot accesses. Specifically, it is assumed that rear lots will be discounted due to such lots' inherent lack of visibility from the street. In a study on the price effects of alleyways, Guttery (2002) suggested that some homeowners find such alternatives to the conventional front-entry driveway unattractive since they may increase the possibility of being a victim of criminal assault. In addition, rear lots sometimes have cumbersome access via a lengthy, narrow right-of-way. As for corner lots, they are expected to achieve a price premium when fronting quiet, low-volume roads thanks to the added visibility and potential 'curb appeal'. However, these benefits are expected to be outweighed by the negative effects of additional exposure to street noise and air pollution when corner lots front arterial roads.

Table 1 provides a frequency table of analysed sales by road classification and lot position. The vast majority (75 percent) of properties are inside lots accessing low-traffic, collector or local roads. This category is followed by a set of three with similar

numbers (between 7 and 9 percent): rear and corner lots on collector roads and inside lots on arterial roads. The rarest of combinations are rear lots accessing arterial roads, only 137 observations (1.7 percent), and corner lots on busy roads, which account for 66 observations (0.8 percent). Figure 2 illustrates the three lot types (inside, corner and rear) in a parcel map of an Auckland suburb. In this excerpt, Balmoral and Sandringham Roads are the only two arterials with the remainder being local and collector roads.

Table 1: Frequency table of analysed properties by road classification and lot position

Road Class	Lot Position	Count	Percent
Local	Inside	5,909	74.6%
	Rear	688	8.7%
	Corner	529	6.7%
Arterial	Inside	590	7.5%
	Rear	137	1.7%
	Corner	66	0.8%
	Total	7,919	100%

Figure 2: Excerpt Auckland city parcel map illustrating lot position types

EMPIRICAL RESULTS

Table 2 provides the hedonic equation's unstandardized coefficients, the standard error estimates and an indication of each coefficient's significance level. The chosen specification fits the data well, with a coefficient of determination (R^2) equal to .844.

Table 2: Hedonic equation results

Variable	B	Std. Error	t		Variable	B	Std. Error	t	
(Constant)	12.092	.029	422.101	**	LScape_Good	.046	.007	6.693	**
Floor_Area	2.68E-03	1.58E-04	16.928	**	LScape_Poor	-.018	.010	-1.842	
Floor_Area2	-1.51E-06	3.59E-07	-4.210	**	Steep	-.055	.008	-6.696	**
Site_Sqm	2.63E-04	9.25E-06	28.495	**	Rear_Arterial	.024	.018	1.384	
Carparks	.019	.003	5.779	**	Corner_Arterial	-.069	.024	-2.862	**
Int_Good	.061	.008	8.108	**	Inside_Arterial	-.030	.009	-3.390	**
Int_Poor	-.051	.009	-5.561	**	Rear_Local	-.030	.009	-3.356	**
Ext_Wall_Good	.029	.006	5.118	**	Corner_Local	-.003	.009	-0.342	
Ext_Wall_Fair_Poor	-.064	.012	-5.206	**	Water_Slight	.055	.011	5.212	**
Deck	.027	.005	5.295	**	Water_Moderate	.155	.012	13.343	**
Monolithic_clad	.057	.010	5.505	**	Water_Wide	.332	.016	21.388	**
D1980	-.121	.015	-8.169	**	Neighbours_Good	.075	.008	9.026	**
D1970	-.167	.015	-11.106	**	Neighbours_Poor	-.016	.011	-1.524	
D1960	-.154	.013	-11.761	**	HH_Income	1.30E-06	1.92E-07	6.740	**
D1950	-.112	.013	-8.536	**	Perc_MP	.176	.030	5.937	**
D1940	-.115	.014	-8.217	**	Perc_Polynesian	-.207	.021	-9.828	**
D1930	-.062	.014	-4.278	**	S1997_Q12	.070	.006	11.749	**
D1920	-.042	.013	-3.140	**	S1997_Q34	.062	.006	10.115	**
D1910_and_earlier	-.007	.014	-0.500		S1998_Q12	.018	.007	2.715	**

Notes: Area Unit dummy variables are omitted from table; Dependent Variable = Natural log of net sales price;
R^2 = .844; Standard Error of the Estimate = .187; N = 7,919.
** Indicates significance at .01 level, using a two-tailed test.
* Indicates significance at .05 level.

These quantitative results are largely as anticipated with nearly all variables significant at the .01 level and in the expected direction. Specifically, the estimated coefficients for the series of vintages indicate a nonlinear, quadratic 'vintage effect' with earliest vintage houses, namely character villas and bungalows, being on par with the new homes while houses belonging to the 1960s and 1970s vintages are sharply discounted. This nonlinear relationship corroborates prior research on vintage effect by Rehm, Filippova and Stone (2006). Other structural control variables also meet expectations including the floor area, site area and number of car parks, the set of variables accounting for interior and exterior condition, the featuring of an outside deck, the contour of the site, and quality of landscaping. The dummy variable controlling for differences in wall cladding material corroborate research by Rehm (2009) who observed that, prior to the media coverage on the country's leaky building problems, monolithic-clad dwellings commanded price premiums over alternative cladding types. The present data confirms this to be the case.

As anticipated, properties that feature appreciable water views attract price premiums. This corroborates recent work by Filippova (2009) and Bourassa et al (2005). The variable controlling for ethnic composition differences across neighbourhoods also matches expectations, with house price negatively correlated with concentrations of Polynesian ethnicity. Similar price effects are found throughout the literature including Bajari and Kahn (2005), Adair et al (2000) and Kiela and Zabelb (1996). Other notable findings include the series of semi-annual dummy variables that control for differences in date of sale. These meet expectations and reflect the slumping housing market and subsequent decline in property values brought on by the 1997-98 New Zealand recession.

As for the dummy variables representing the combinations of lot position and road class, the results were largely as anticipated. However, with an inside lot on a quiet local road as the default condition, the variable Rear_Arterial is statistically insignificant. In other words, 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. To the contrary, inside and corner lots fronting arterial roads are subject to price reductions. In particular, corner lots fronting a busy road are the most heavily discounted at 6.5 percent of mean house price. This percentage price effect is derived through transforming the variable's estimated coefficient by taking its antilog and subtracting one (for the interpretation of dummy variable coefficients within semi-log equations, see Halvorsen and Palmquist, 1980). This heavy discounting is rational, given that these corner properties are generally more exposed to traffic noise and air pollution. However, the more sheltered inside lots facing busy roads are subject to much smaller discount of 2.6 percent. As for lots accessing collector and local roads, corner lots are on par with inside lots while rear lots are also subject to a slight discount of 2.3 percent.

Table 2: Comparative price effects between lot positions

		Inside Arterial	Corner Local	Corner Arterial	Rear Local	Rear Arterial
		Comparative Lot Position				
Reference Lot Position	Inside Local	-2.6%	-0.1%	-6.5%	-2.3%	-0.9%
	Inside Arterial		2.5%	-4.0%	0.3%	1.7%
	Corner Local			-6.5%	-2.3%	-0.8%
	Corner Arterial				4.2%	5.7%
	Rear Local					1.5%

Table 2 presents the varying price effects between the combinations of lot position and street type. Compared with the listed reference lot positions, the price effects range from effectively nil for corner lots compared with inside lots on local streets to a discount of 6.5 percent for corner arterial lots compared with inside and corner lots on local streets. The estimated discount for a rear lot position versus an inside or corner position fronting a local street is 2.3 percent. Perhaps the most intriguing statistic contained in Table 2 is the 5.7 percent price premium commanded by rear versus corner lots fronting arterial roads. Therefore, the authors reason that if the discount for the inherent disadvantages of rear lot positions (access via a right-of-way, lack of curb appeal, etc) is combined with the rear lot premium over corner arterial lots, the result would be an estimate of the value for shelter from the negative features of a busy road, namely noise and air pollution. Based on this analysis, the value of shelter from arterial roads is equivalent to 8 percent of mean house price.

CONCLUSION

This study helps understand how lot position influences house prices. Of particular interest is the price difference between common inside lots and rear lots, which are largely produced through the process of infill development. Such development will likely become widespread, given that 'intensification' is one of the strategies for Auckland Region to achieve its Smart Growth objectives.

The slight discount of rear lots on quiet, local streets is as anticipated given the lack of 'curb appeal' and the sometimes cumbersome access to rear lots via a narrow right-of-way. However, the hedonic model suggests that rear lots accessing arterial roads are surprisingly on par with the sought-after inside lots on quiet streets. The authors believe this is because these houses are partially sheltered from the negative amenity of these busy streets, namely road noise and vehicle-sourced air pollution. In other words, rear lots are discounted if on a quiet street but effectively given a premium if accessing an arterial road.

Perhaps the main limitation to the study is its timeframe (1997-1999). Further research can expand on this study using more recent data, if available. Based on increased traffic flows along Auckland's roads over the past decade, it is likely that lot position price effects are now more acute.

These findings can be directly applied to improving computer-assisted mass appraisal models used by city councils and their consultants in assessing property values for taxation purposes. This study can also be applied to improve residential valuations. Lastly, the findings also indicate that homebuyers are willing-to-pay an inferred premium of 8 percent of mean house price for refuge from the air and noise pollution associated with arterial roads.

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