Hedonic Prices from Sequential Bargaining

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(2009 NZAE Quality-Assured Paper, resubmitted 14 July 2009)

Keywords: housing demand; hedonics and valuation**;** residential markets.

JEL Codes: D00 – General Microeconomics; R20- General Household Analysis; R21 - Housing Demand

Abstract

A property's selling price is described as the result of sequential bargaining between a buyer and a seller in an environment of asymmetric information. Hedonic housing prices are estimated based upon 17,333 records of New Zealand residential properties sold during the years 2006 and 2007.

I. Introduction

The demand for housing is commonly described as arising from a potential buyer's desire to maximize utility over desirable housing characteristics (e.g. Palmquist, 1984). This approach follows the hedonic pricing model of Rosen (1974) for differentiated products. This paper describes how hedonic prices may instead arise from a sequential type of bargaining between the buyer and the seller of a housing unit. Estimates of hedonic prices for some housing characteristics are then derived using 2006-2007 data on New Zealand residential properties.

II. The Model

The model is a version of a two-period game with asymmetric information (see e.g. Gibbons, 1992). In the first period, the seller offers a property selling price, p_1 that the buyer decides either to accept or reject. If the offer is accepted, the game ends. If the offer is rejected, the seller makes a second-period offer, p_2, which again the buyer either accepts or rejects. The game ends after a decision on p_2 is made.

The buyer derives a benefit from the property, b that depends upon the property's characteristics. There is a one-period discount factor, δ, so that any second-period payoffs in either the selling price or the benefit is to be discounted by δ. Information is asymmetric in that the benefit is known to the buyer but not to the seller. All that the seller knows is that b is randomly distributed according to some probability distribution. For simplicity, the distribution is assumed to be uniform with a range of from between a minimum value of 0 and a maximum of b_h.

A possible equilibrium that results in a property being sold is that the seller makes a first-period offer which the buyer rejects, after which the seller makes a second-period offer which the buyer accepts. For such an equilibrium, there is an optimal first-period offer p_1* made by seller. Corresponding to this offer is an optimal critical benefit to the buyer, b_1*, for which p_1* will be accepted if the benefit of the property is anywhere higher, and for which p_1* will be rejected if the benefit is anywhere lower. Finally there is an optimal second-period offer p_2*, that the buyer will accept. These solutions are found by analysing the strategies and the payoffs below.

First, the critical benefit to the buyer can be derived as $b_1 = (p_1\text{-}\delta p_2) / (1\text{-}\delta)$. The reason is as follows. If the first-period offer were accepted, the buyer's payoff will be $(b - p_1)$. If it were rejected and the second-period offer were accepted, it will instead be $\delta(b - p_2)$. If both offers were rejected, the buyer's payoff will be 0. From these it follows that the first-period offer will be accepted if b were to be greater than the maximum of either p_1 or $(p_1\text{-}\delta p_2) / (1\text{-}\delta)$. Suppose that the higher of these two were b_1. If b_1 were p_1, then the buyer is better off by rejecting both offers, with the result that the equilibrium of the game is uninteresting. If instead b_1 were $(p_1\text{-}\delta p_2) / (1\text{-}\delta)$, then the first-period offer is rejected and the second period offer is accepted. Thus if the game were to proceed to the second period and the second-period offer were to be accepted, b_1 must be necessarily equal to $(p_1\text{-}\delta p_2) / (1\text{-}\delta)$.

Second, the solution for the second-period offer can be derived as $p_2 = b_1/2$. This is because having had the first offer rejected, the seller forms an updated belief concerning the range of the buyer's benefits. This range is now thought of as between 0 and b_1. For a uniform distribution, the conditional probability that the buyer will accept the second-period offer is thus $(b_1 - p_2) / b_1$, an area corresponding to the range between p_2 and b_1. The conditional probability that the buyer will reject the offer is p_2 / b_1. The seller's goal is thus to choose p_2 so as to maximize the expected value function: $\{((b_1 - p_2) / b_1)\ p_2 + (p_2 / b_1)\ 0\}$. The solution to this problem is $p_2 = b_1/2$.

Finally, the solution for the first-period offer p_1 is obtained by assuming that the seller shall have formed all beliefs early on in the game. The seller knows that the probability is $(b_h - b_1) / b_h$ that the buyer will accept the first-period offer and, also, that the critical benefit to the buyer is $b_1 = (p_1 - \delta p_2) / (1-\delta)$. Armed with this foresight, the seller's problem is thus to choose p_1 in order to maximize the following expected payoff from every possible contingency: $\{((b_h - b_1) / b_h)\ p_1 + (\delta\ (b_1 - p_2) / b_h)\ p_2 + \delta\ (p_2 / b_h)\ 0\}$. In their reduced form, the resulting solutions for p_2*, b_1* and p_1* are therefore:

(1) $p_2^* = (2-\delta)\ b_h / 2(4-3\delta)$

(2) $b_1^* = (2-\delta)\ b_h / (4-3\delta)$

(3) $p_1^* = (2-\delta)^2\ b_h / 2(4-3\delta)$

The solution for p_2* indicates the main testable proposition of the model: that if a property were successfully sold, the selling price will in general be a positive function of the buyer's benefit. The solution for b_1* indicates that the buyer forms an optimal benefit and it is on this basis that the first-period offer (the solution for p_1*) is rejected.

The solutions in (1) to (3) can be generalized if the assumed probability distribution is not uniform. If the underlying distribution continues to be bounded by a minimum value of 0 and a maximum value of b_h, the solutions can each be shown as continuing to be a positive function of δ and b_h. If instead the underlying distribution were to be unbounded from either side, an additional assumption is required regarding what the seller is supposed to know. This additional assumption is that the seller must know the probability of the benefit falling within the range of 0 and b_h. This probability can then be used as a weight to obtain closed-form solutions that are similar to those in (1) to (3).

III. Empirical Implementation

Econometrically, the benefit of a property can be estimated by valuing the impact of favourable housing characteristics upon the property's selling price. Such an investigation was made possible by the records of Land Information New Zealand (LINZ) concerning 17,333 residential properties sold between July 1, 2006 and August 20, 2007. To control for market appreciation, four dummy variables were created to represent the quarterly lag at which the properties were sold. The first, for a one-quarter lag, was for sales dates between September 1, 2006 and November 30, 2006. The fourth, for a four-quarter lag, was for sales dates between June 1, 2007 and August 20, 2007. Thus, the base dates for gauging market appreciation were properties sold between July 1, 2006 and August 31, 2006, and these accounted for 878 of the observations.

Table 1. Summary statistics and regression coefficients of housing characteristics upon property selling prices as the dependent variable. Column (1) shows the coefficients from an ordinary least squares regression. Column (2) shows those from a fixed-effects linear regression where the groups are the twelve regional areas. Column (3) shows those from a random-effects regression. Numbers in parentheses are t-statistics.

Variable	Mean	Standard Deviation	Least Squares (1)	Fixed Effects (2)	Random Effects (3)
Property selling price (in dollars)…………………………..	389816.40	356262.80	. -----	. -----	. -----
Land area (in square meters)……………………………….	115.72	1139.43	34.57	24.81	28.36
			(9.63)	(6.42)	(7.83)
Number of units on the same property……………………..	1.15	1.79	753.58	802.23	631.35
			(1.28)	(1.51)	(1.08)
Parking units available…………………………………….	1.47	4.29	-196.73	575.69	-145.99
			-(0.56)	(1.80)	-(0.41)
Building condition (1=good. 0 if average, fair or poor.)…..	0.48	0.50	16835.76	12341.23	15483.84
			(6.54)	(5.19)	(6.03)
Building area (in square meters)…………………………..	145.86	198.36	719.66	747.32	725.93
			(21.67)	(24.72)	(21.92)
Levelled location rather than sloped (1=yes)……………...	0.56	0.50	-35284.95	3615.80	-33482.90
			-(14.45)	(1.55)	-(13.73)
Some view available of landscape or water (1=yes)………	0.06	0.24	194014.20	162341.60	191780.30
			(41.40)	(37.82)	(41.04)
Living area (in square meters) …………………………….	119.43	50.83	1174.45	1054.81	1163.82
			(27.94)	(27.40)	(27.75)
Deck available (1=yes)…………………………………….	0.48	0.50	-132.15	2486.35	973.56
			-(0.05)	(1.10)	(0.40)
Large improvements. e.g. swimming pool. (1=yes)………	0.02	0.16	38042.10	50731.80	38522.75
			(5.29)	(7.77)	(5.38)
Roofed garage (1=yes)…………………………………….	0.57	0.88	-444.70	-747.83	138.42
			-(0.28)	-(0.51)	(0.09)
Sold first quarter (1=yes)………………………………….	0.28	0.45	-----	8928.55	2818.11
				(1.76)	(0.53)
Sold second quarter (1=yes)………………………………	0.30	0.46	-----	20619.97	14158.01
				(4.07)	(2.68)
Sold third quarter (1=yes)…………………………………	0.27	0.45	-----	25854.97	27914.65
				(5.06)	(5.23)
Sold fourth quarter (1=yes)………………………………..	0.09	0.29	-----	22655.82	48414.04
				(3.72)	(7.75)
Constant of the regression…………………………………	-----	-----	121810.80	93574.18	104573.10
			(35.49)	(16.80)	(18.01)

Estimates for the benefit are shown in Table 1. The dependent variable is the property's selling price in New Zealand dollars. The first-column results are from an ordinary-least squares regression that does not consider the market-appreciation dummy variables. The second and third regressions are from fixed and random-effects linear-regressions that consider them. These additional ones were necessary because the observations were grouped according to twelve territorial areas spread across New Zealand. The fixed effects regression assumed that the group-specific residual was constant within each territorial area.

The average selling price of a residential property was found to be NZ$389,816, and this price had a standard deviation of NZ$356,263. One of the most important influences upon it was market appreciation. This ranged from between a one-quarter effect of NZ$8,929 (2.3% of the average selling price) to a four-quarter effect of NZ$48,414 (12.4% of the selling price). Also statistically significant was the size of the property, measured either in land area, in building area, or in living area. For instance, an additional square meter of living space was estimated to convey a price effect of between NZ$1054 to NZ$1174.

Building condition was also highly valued. A top ranking of "good" by inspectors (as opposed to average, fair or poor) conveyed a price effect of between NZ$12,341 to $16,835. A large improvement such as a swimming pool, a glass house or a tennis court also added anywhere between NZ$38,042 to NZ$50,730 to the selling price. Having either a landscape or water view was estimated to increase the price by between NZ$162,341 to NZ$194,014.

Of some surprise was the negative and statistically-significant effect of a property being built on land that was levelled rather than sloped. The theoretical expectation was that levelled properties would have been the ones favoured. Also of some surprise was the statistical insignificance of having access to parking, to a roofed garage or a deck, or to the lack of privacy from having units located on the same property.

IV. Concluding Remarks

These findings can be regarded as adding to the literature on uncovering the hedonic benefits of housing characteristics. Nonetheless, the model is not derived from utility-maximization. Its testable proposition arises from the much more common experience of haggling in property markets. The model also adds to other theories of property decision-making such as to one where buyers or tenants are instead interested in minimizing their search and moving costs (see eg. Victorio 2007). One area for future research is the inclusion in the regressions of demographic variables to help explain why some hedonics matter more than others.

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