The Composition of Hedonic Pricing Models

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Abstract

A house is made up of many characteristics, all of which may affect its value. Hedonic regression analysis is typically used to estimate the marginal contribution of these individual characteristics. This study provides a review of recent studies that have used hedonic modeling to estimate house prices. The findings indicate that slanted versus flat roof, sprinkler system, garden bath, separate shower stall, double oven and gated community positively affect selling price while not having attic space, living in an earthquake zone, proximity to a hog farm, proximity to a landfill, proximity to high voltage lines, corporate-owned properties, percentage of Blacks or Hispanics in an area and properties that require flood insurance negatively affect selling price.

Introduction

Home is defined as the social unit formed by a family residing together. A house, on the other hand, is a bundle of characteristics such as size, quality and location. For a number of reasons, valuing a house is difficult. Being a physical asset, each house has its own specific location. Also, a house is a long-term durable good with a long life, which means that houses with substantially different ages can exist at the same time in the same market. Each house has its own unique set of characteristics that affect value. In addition, certain housing characteristics may be valued differently across different geographical areas. For example, a garage may have a greater value in a colder climate whereas a swimming pool may have a greater value in a warmer climate.

In addition to the problem of the presence of different characteristics across houses, homebuyers possess unique utility functions causing them to value characteristics differently. For example, one homebuyer may place a greater value on hardwood floors than another buyer. Thus a certain house with a given set of characteristics may be valued differently by different buyers.

All these factors suggest that housing is not a homogeneous good. Different bundles of characteristics make valuation difficult. The fact that buyers may value individual characteristics differently further complicates the process. Nonetheless, a substantial body of historical research has attempted to explain the value of housing by valuing its individual components. The typical method used to do this is the hedonic pricing model, because it allows the total housing expenditure to be broken down into the

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values of the individual components. One caveat in using hedonic pricing models is that the results are location-specific and are difficult to generalize across different geographic locations. Because of this, hedonic pricing models are generally used to gain insight into the workings of a particular market. On the other hand, comparing studies across areas may at least establish those characteristics that are consistently valued (either positively or negatively) by homebuyers.

Comparing studies that use hedonic models is complicated by the fact that studies define and measure variables differently. For example, one study may measure bedrooms as simply the number of bedrooms whereas another study may use binary variables (a dummy variable if the house has one bedroom, a second dummy variable if the house has two bedrooms, etc.) The comparability of previous hedonic pricing studies is also complicated and/or limited because of different empirical specifications. Typically, hedonic pricing equations have been estimated using linear or semi-logarithmic models.

Even with its problems, however, hedonic modeling can be (and has been) useful in addressing a number of issues in housing valuation. It has been used in valuing not only the obvious components such as square footage, bathrooms, etc. but has also been useful in measuring the effect of other issues such as school quality, proximity to a landfill or high voltage lines, and the effect of non-market financing.

Malpezzi, Ozanne and Thibodeau (1980) compare housing to a bundle of groceries in that some bundles are bigger than others and contain different items. Housing is a bundle of bedrooms, bathrooms, and other amenities and the particular bundle of a house distinguishes it from other houses. However, unlike groceries, the price of individual features cannot be directly observed. The usefulness of hedonic modeling is to price these individual features by using multiple regression analysis on a pooled sample of many dwellings. As these authors point out, using this model assumes that consumers derive utility (and therefore value) from various housing characteristics and that the value of this utility can be priced. In housing consumption, consumers will pursue maximization of utility within their budget constraint.

The hedonic model generally takes this form:

$$\text{Price} = f(\text{Physical Characteristics, Other Factors}).$$

This says that the price of the house is a function of its physical characteristics (square footage, bathrooms, age, location, various amenities, etc.) and other factors such as school quality and external factors. The regression estimates give the implicit prices of each variable or characteristic. A complication is that these values are not likely to be the same for all price ranges of houses. For example, the value added of a bedroom might be greater for a $500,000 house than for a $100,000 house. For this reason, the hedonic pricing model is often estimated in semi-log form with the natural log of price used as the dependent variable. Then the coefficient estimates allow one to calculate the percentage change in price for a one-unit change in the given variable.

The remainder of the paper reviews recent studies that have estimated hedonic pricing models. After a brief discussion of the early history of hedonic models, the review covers primarily studies that have been published over the last decade. Approximately 125 studies were examined from a number of different journals including the *Journal of Real Estate Research*, *Journal of Real Estate Finance and Economics*, *Real Estate Economics*, *Journal of Urban Economics*, *Land Economics* and *The Appraisal Journal*. The major objectives are to determine variables that are consistently significant in explaining price, compare the coefficients of some variables by geographic location, and examine the relationship between house price and time-on-the-market.

The Theoretical Development of Hedonic Pricing Models

In his 2003 paper, Malpezzi presents an excellent review of the theoretical development behind hedonic pricing models. As he points out, the hedonic model is a way to estimate the value of individual characteristics of the house. Hedonic equations have also been used to measure the effect of various factors of special interest on house prices.

Hedonic models are typically estimated as single-stage equations. That is, the model simply estimates the effect of characteristics on price and does not examine the structural parameters of the individual characteristics. Hedonic models also are estimated various ways regarding the dependent variable, the house price. Price may be specified as an absolute amount (unlogged) or as a logged variable. The most typical model structure historically has been the semi-log form, with the price specified in natural logs and regressed against unlogged independent variables. This allows for variation in characteristic prices across different price ranges within the sample.

Theoretical Underpinnings of the Hedonic Model

As Malpezzi (2003) discusses, the hedonic model arises because of a heterogeneous housing stock and heterogeneous consumers. Not only does each house contain different housing characteristics, but those characteristics may be valued differently by different consumers.

Econometrics has always faced the problem of identification (*i.e.*, distinguishing between supply and demand). In the typical supply and demand model, the price of the good is exogenous and the consumer, being a price-taker, decides how much to consume based on the price. In a nonlinear hedonic model where the price varies with the quantity, the consumer chooses both a quantity and price.

Specification Problems

Due to the difficulty in the practical application of hedonic models, the functional form of the model and the variables included in the model can often seem ad hoc.

This can be traced back to the original papers of Lancaster (1966) and Rosen (1974) that present models of housing characteristics but do not specifically identify what those are. In practical application, the dependent variable in the model is usually a recent selling price, standing as a proxy for the value of the house. Using the observed price is generally thought to better minimize bias as compared to other measures such as an owner's self-assessment.

There is almost a limitless number of independent variables that can be included in the model. The high correlation of some of these variables with each other can create estimation problems even if all the variables are not included in the model. For example, a location variable may appear to be highly significant in the model but may actually be reflecting something else, such as school quality. Because of this, interpretation of the individual coefficients can be more difficult.

Studies have wrestled with the problem of correct functional form. Follain and Malpezzi (1980) found that the semi-log specification has some advantages over the linear form. Some of these are: (1) it allows for variation in the dollar value of each characteristic; (2) the coefficients can be easily interpreted as the percentage change in the price given a one-unit change in the characteristic; and (3) the semi-log model helps minimize the problem of heteroscedasticity.

The Early History of Hedonic Models

Identifying the "father" of hedonic modeling is not easy. In his review, Malpezzi (2003) points out that a study by Court (1939) is often cited as the beginning of hedonic models, although this study actually developed a hedonic price index for automobiles and not for housing. As Goodman (1998) discusses, although popularized by Griliches (1958) in his work on the demand for fertilizer, the term "hedonic" dates back to the 1939 Court article and that Court is generally cited in most articles. Goodman argues that, as a hedonic price analysis, Court's work stands up quite well under contemporary standards. Court, as an economist for the Automobile Manufacturers' Association from 1930 to 1940, recognized that a single variable could not explain automobile demand. His hedonic model to explain price included three variables: dry weight, wheelbase and horsepower. His modeling would be considered modern in that he used a semi-log form, accounted for cars that actually sold and estimated the models over different time periods.

A 1999 study by Colwell and Dillmore, however, points out that it is highly unlikely that Court is the original source of hedonics. Seventeen years prior to the Court study a monograph by Haas (1922a) at the University of Minnesota applied a hedonic model to estimate the value of farmland. Also, a 1926 study by Wallace examined the value of farmland in Iowa. Colwell and Dillmore connect Court to Haas (and Wallace) this way: Court developed his idea for a hedonic model from discussions with the chief of the Bureau of Labor Statistics who probably knew of the work by Wallace and maybe the work by Haas.

Later studies important to hedonic modeling are Lancaster (1966) who provided a microeconomic foundation for estimating the value of utility-generating characteristics

(with a natural application to housing) and Rosen (1974) who focused on characteristics with less emphasis on utility and more on price determination. Rosen's work provided the basic foundation for nonlinear hedonic pricing models.

The Relationship between Selling Price and Time-on-the-Market

Typically, a seller's goal is to sell the house at the highest possible price in the shortest possible time. These two objectives are generally reconciled with the setting of the listing price. A listing price that is too high may have the effect of both lengthening the selling time and limiting the pool of potential buyers. Setting the listing price too low may minimize the selling time but may also result in a selling price lower than what otherwise could be attained.

Since selling price and time-on-the-market tend to be interactive variables, some studies have estimated simultaneous or two-stage models to capture the effect. Specifying such models for selling price and time-on-the-market is difficult since they tend to be very similar. This section discusses some recent studies that have followed this procedure.

When time-on-the-market is included and statistically significant in the selling price equation, it is generally negative. This indicates that a longer selling time results in a lower selling price. When selling price is included in a time-on-the-market estimation, the results are much less clear. In some cases, a higher selling price leads to a longer selling time whereas in others, a higher selling price results in a shorter selling time.

The following are some recent studies that have examined the relationship between selling price and time-on-the-market. Jud, Seaks and Winkler (1996) examine the impact of brokers, brokerage firms and marketing strategy on time-on-the-market using a duration model. They find duration dependence to be positive, indicating that the probability of selling the property increases with time-on-the-market. Their results show that higher listing prices result in a longer time-on-the-market whereas reducing the listing price decreases time-on-the-market. The results also show that atypical homes have a longer time-on-the-market.

A 1996 study by Forgey, Rutherford, and Springer estimates a two-stage least squares model of house prices and time-on-the-market. Their results show that housing liquidity depends on market participants' search effort, which is determined by market conditions, physical characteristics of the property, the size of the brokerage firm and listing price. They find that houses with higher liquidity sell for higher prices and that selling prices increase with sellers' search effort.

In testing real estate agents' comments, Haag, Rutherford and Thomson (2000) estimate Ordinary Least Squares (OLS) models for selling price and time-on-the-market. They find that time-on-the-market has a significant negative effect on selling price. Their time-on-the-market equation includes list price, which is shown to be not significant. They find that motivated sellers accept lower selling prices but have a

longer selling time and that updated properties produce a higher selling price and a shorter selling time. However, they find that some other improvements such as new paint and roof work decrease price and increase time-on-the-market.

In examining exclusive agency and exclusive right to sale contracts, Rutherford, Springer and Yavas (2001) estimate a simultaneous equations model for selling price and time-on-the-market. The first stage regresses time-on-the-market against various factors and the second stage regresses selling price against a similar set of factors. The results show a positive relationship between selling price and selling time and that exclusive agency listings and builder-owned listings have a shorter selling time than exclusive right to sale listings and owner-held properties. However, exclusive agency listings are associated with lower selling prices while builder-owned properties have higher selling prices. Another 2001 study by Johnson, Salter, Zumpano and Anderson examines the effect of artificial stucco on house prices and selling time. They first use a probit model to relate the presence of artificial siding to explanatory variables. Next, they estimate the selling price using typical explanatory variables with artificial stucco included. Then, they use duration modeling to measure the effect of artificial stucco on selling time. Their results suggest that properties with artificial stucco sell at a premium although the selling time is longer.

Knight (2002) uses a maximum-likelihood probit model and information on price changes during a home's marketing period to examine the selling price and time-on-the-market relationship. He finds that it is expensive to overprice the house initially. Homes that had large percentage adjustments in listing price not only had longer selling times but also ultimately sold at lower average selling prices. A 2003 study by Anglin, Rutherford and Springer also examines the importance of setting the initial listing price and the marketability of the property. The paper measures the degree of overpricing as the percentage difference between the actual listing price and the expected listing price. Their theoretical models shows that there is no direct tradeoff between selling price and selling time but that market conditions affect how the expected selling price and the expected selling time vary jointly based on the initial listing price. They find that increases in the listing price increase time-on-the-market. Their results also show the importance of changing marketing conditions on selling time.

These studies illustrate the difficulty in specifying the relationship between selling price and time-on-the-market. Because of this, most studies involving hedonic pricing models have chosen to ignore these problems by estimating a simpler OLS model, although time-on-the-market is sometimes included as an explanatory variable.

Review of Recent Hedonic Pricing Model Studies

This section discusses some studies published over the last decade that have used hedonic modeling. Approximately 125 were examined.

The Top Twenty Characteristics

Exhibit 1 shows the top twenty characteristics that have been used to specify hedonic pricing equations. The exhibit shows the total number of times a characteristic has been used and the number of times its estimated coefficient has been positive, negative, or not significant. As seen, age shows up most frequently in hedonic models and typically has the expected negative sign although it is seen to be positive and not significant in some studies. Square footage is the next most used characteristic and typically has the expected positive effect on selling price. Other characteristics that appear frequently are garage, fireplace and lot size. Each typically has the expected positive effect. Garage never has a negative sign but it has been not significant in a number of studies. Fireplace shows up negative in only a few studies and lot size never shows up negative.

Other characteristics that show up frequently are bedrooms, bathrooms, swimming pool and basement. Bedrooms show up negative in some studies but bathrooms almost never do. A swimming pool never has a negative effect on selling price although it has been not significant in some studies. Basement is usually positive but it has been shown to be negative or not significant in some studies.

Time-on-the-market shows up in eighteen studies and shows to be not significant most often. When it is significant, it is negative to positive eight to one. This tends to support the argument that the longer a house is on the market, the more willing the seller is to concede on the selling price. The opposing theory is that the longer a house in on the market, the more likely the seller is to find the one buyer willing to pay a higher price.

Other characteristics that have been commonly used to specify selling price include distance variables, brick exterior, the number of stories and a time trend. Brick exterior is consistently positive but the other variables have different signs. This could be at least partially a function of the method of specification.

Typical Characteristics by Category

Exhibit 2 shows the top five characteristics by eight categories. The most common structural characteristics are lot size, square feet, age, number of bathrooms and number of bedrooms. All characteristics except age typically have the expected positive sign.

Internal features that appear most frequently are full bathrooms, half bathrooms, fireplace, air-conditioning, hardwood floors and basement. These characteristics rarely have negative coefficients although they sometimes do appear not significant.

External features used most frequently in explaining selling price are garage/garage spaces, deck, pool, porch and carport. None of these characteristics had negative coefficients except carport. One study reported a negative sign on carport.

Exhibit 1
The Twenty Characteristics Appearing Most Often in Hedonic Pricing Model Studies

Variable*	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Lot Size	52	45	0	7
Ln Lot Size	12	9	0	3
Square Feet	69	62	4	3
Ln Square Feet	12	12	0	0
Brick	13	9	0	4
Age	78	7	63	8
# Stories	13	4	7	2
# Of Bathrooms	40	34	1	5
# Rooms	14	10	1	3
Bedrooms	40	21	9	10
Full Baths	37	31	1	5
Fireplace	57	43	3	11
Air-Conditioning	37	34	1	2
Basement	21	15	1	5
Garage Spaces	61	48	0	13
Deck	12	10	0	2
Pool	31	27	0	4
Distance	15	5	5	5
Time On Market	18	1	8	9
Time Trend	13	2	3	8

Note: Although some of these variables are the same and just measured differently, they are presented separately so readers can see how they are typically measured.

Characteristics provided by the natural environment consistently have a positive effect on selling price. These include lake front or view, ocean view and a "good view."

Environmental characteristics created by neighborhood or location include location, crime, distance, golf course and trees. Location is generally measured as a neighborhood identifier, zip code, etc. and typically has a positive effect on price. Crime is usually measured as the crime rate for a given area and typically has a negative effect on price. Distance is typically measured as distance from the city center and the estimated coefficient has been both positive and negative. Golf course is usually measured as being on or near a golf course and, as expected, consistently has a positive effect on selling price. Trees usually mean a wooded lot versus an open lot and is also seen to consistently have a positive effect on price.

Environmental characteristics resulting from public services include the school district, percentage minority in school district and access to a public sewer. In general, the

Exhibit 2
The Top Five Characteristics by Category from Hedonic Pricing Model Studies

Category	Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
1	Construction & Structure				
	Lot size	52	45	0	7
	Sq ft	69	62	4	3
	Age	78	7	63	8
	# of bathrooms	40	34	1	5
	Bedrooms	40	21	9	10
2	House Internal Features				
	Full baths	37	31	1	5
	Half baths	7	6	0	1
	Fireplace	57	43	3	11
	Air-conditioning	37	34	1	2
	Hardwood floors	7	5	0	2
	Basement	21	15	1	5
3	House External Amenities				
	Garage spaces	61	48	0	13
	Deck	12	10	0	2
	Pool	31	27	0	4
	Porch	9	5	0	4
	Carport	4	1	1	2
	Garage	4	3	0	1
4	Environmental—Natural				
	Lake view	5	5	0	0
	Lake front	5	5	0	0
	Oceanview	4	4	0	0
	"Good view"	4	3	0	1
5	Environmental—Neighborhood & Location				
	Location	9	7	2	0
	Crime	7	1	4	2
	Distance	15	5	5	5
	Golf course	9	9	0	0
	Trees	6	6	0	0

Exhibit 2 (continued)
The Top Five Characteristics by Category from Hedonic Pricing Model Studies

Category	Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
6	Environmental-Public Service				
	School district	10	3	7	0
	% School district minority	7	0	5	2
	Public sewer	2	1	1	0
7	Marketing, Occupancy & Selling Factors				
	Assessors quality	6	5	0	1
	Assessed condition	8	7	0	1
	Vacant	10	0	9	1
	Owner-occupied	6	4	0	2
	Time on market	18	1	8	9
	Trend	13	2	3	8
8	Financial Issues				
	FHA Fin	3	0	3	0
	VA Fin	3	0	3	0
	Foreclosure	5	0	5	0
	Favorable financing	3	0	0	3
	Property tax	3	0	1	2

consistent significance of the school district variable indicates that perceived school quality has a significant effect on house prices. An increasing minority population in schools has a consistent negative effect on selling price.

Marketing, occupancy and selling characteristics include the assessor's judgment of quality, the assessed condition of the house, whether the house is vacant at the time of sale, whether the house is owner-occupied, the time-on-the-market and a time trend. Measures of quality and condition have a positive effect on price. Being owner-occupied also has a positive effect. Being vacant and for sale is not good for the selling price. Generally, time-on-the-market has a negative effect and the time trend variables have been not significant.

The last category, financial issues, includes types of financing (FHA, VA, favorable), whether a house is in foreclosure and property taxes. Studies show that houses with FHA or VA financing sold for less than houses with conventional financing. Being in foreclosure also has a negative effect on price. Studies on property taxes are mixed. One study shows a negative effect while two studies show property taxes are not significant.

All Characteristics by Category

Exhibit 3 presents a comprehensive list of the characteristics that have appeared in hedonic models. As seen, a large of number of diverse variables has been used to define selling price. This section discusses some interesting variables that have not been previously discussed. For example, structural characteristics such as roof type, having a sprinkler system or not having attic space affect selling price. Interior amenities such as having a garden bath, a separate shower stall and a double oven in the kitchen have a consistent positive effect on price. On the other hand, having a fence has not been shown to affect price.

Natural environmental characteristics related to earthquake magnitude or earthquake zones have a negative effect on selling price while living in a gated community has a positive effect. One study, examining the effect of proximity to a hog farm found that selling price decreases as the manure index increases.

Interesting neighborhood characteristics include proximity to a metro station, distance to a landfill and proximity to a religious building. Prices are shown to not be higher for houses closer to a metro station. Likewise, selling prices increase with distance from a landfill. Being located close to a religious building has been shown to both increase and decrease price.

One study shows that being located in proximity to high voltage power lines reduces selling price while the percentage of gifted students in the school increases price.

Studies have shown that houses that are corporate owned have lower selling prices. Studies also show that selling prices decrease as the percentage of Blacks or Hispanics in the area increases.

Exhibit 3
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel A: Category 1—Construction and Structure Variables				
Lot Size	52	45	0	7
Ln Lot Size	12	9	0	3
Acreage	1	1	0	0
Ln Frontage Feet	1	1	0	0
Small Lot	1	0	0	1
Large Lot	1	1	0	0
Plot Size In Meters	1	1	0	0
Plot Depth In Meters	1	1	0	0
Square Feet	69	62	4	3
Ln Square Feet	12	12	0	0
Square Feet Squared	1	0	1	0
Living Area	6	6	0	0
Ln Living Area	2	0	2	0
Other Area	2	2	0	0
Square Feet of Foundation	1	1	0	0
Net Area (improvements)	2	2	0	0
Year Built	4	2	1	1
Ln Year Built	2	2	0	0
Age	78	7	63	8
Age Squared	8	8	0	0
Ln Age	8	0	6	2
New Construction	2	1	0	1
New House	1	0	1	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel A: Category 1—Construction and Structure Variables (continued)				
Stucco	3	1	1	1
Brick	13	9	0	4
Vinyl	7	4	0	3
Frame	8	1	6	1
Synthetic Stucco	2	2	0	0
Siding	2	2	0	0
Brick Home Exterior	2	1	0	1
Painted Exterior Wall	1	0	1	0
Stone/Brick Exterior	1	1	0	0
Roof Type	8	6	0	2
Composite, Wood Shingle or Buildup roof	1	0	0	1
Tile Roof	1	0	0	1
No Attic	3	0	2	1
Attic	2	1	0	1
High Ceilings	1	0	0	1
Two-Story	6	4	1	1
2.5 Stories	1	1	0	0
3 Or More Floors	1	0	0	1
# Stories In Building	13	4	7	2
Split Level	4	2	1	1
Dummy For Colonial Style Home	7	2	1	4
Ranch Style	2	1	0	1
Sprinkler system	2	2	0	0
Holes In Floor	1	0	1	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel A: Category 1—Construction and Structure Variables (continued)				
Low Quality Home	1	0	1	0
High Quality (Design and Materials)	3	2	0	1
Dummy For Renovated Property	2	2	0	0
Outlier	1	0	1	0
Updated	2	2	0	0
New Paint	1	0	1	0
Amps for Remodeling	1	1	0	0
Fixer Upper	1	0	1	0
Slab Foundation	2	0	1	1
Pier and Beam Foundation	1	1	0	0
Asphalt Road	1	0	1	0
Lake Water	3	0	2	1
Cape Cod	1	0	0	1
Panel B: Category 2—Internal House Features				
# Rooms	14	10	1	3
# Bedrooms and Bathrooms	1	1	0	0
Bedrooms	40	21	9	10
Ln Bedrooms	4	4	0	0
# of Bathrooms	40	34	1	5
One Bedroom	1	0	1	0
2 Bedrooms	1	0	1	0
3 Bedrooms	1	1	0	0
4 Bedrooms	2	2	0	0
Five or More Bedrooms	2	2	0	0
Master Bedroom Traffic Free	1	1	0	0
Ln (# of Baths)	2	2	0	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel B: Category 2—Internal House Features (continued)				
Full Baths	37	31	1	5
Ln Full Bathroom	2	2	0	0
Third Baths	4	4	0	0
Half Baths	7	6	0	1
1.5 Baths	1	1	0	0
Two baths	2	2	0	0
2.5 Baths	1	1	0	0
3 or More Baths	1	1	0	0
Sauna	1	1	0	0
Garden Bath	3	3	0	0
Shower Separate	2	2	0	0
Ceramic Tub	1	1	0	0
Tile Bath	1	1	0	0
Dining Area	4	3	0	1
Ln Dining Area	2	2	0	0
Dining Rooms	2	1	0	1
Ln Kitchen Area	2	2	0	0
Kitchen Wallpaper	1	0	0	1
Double Oven	2	2	0	0
Microwave	1	0	0	1
Disposal	1	0	0	1
Refrigerator	1	0	0	1
Fireplace	57	43	3	11
Air-Conditioning	37	34	1	2
Central Air	1	1	0	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel B: Category 2—Internal House Features (continued)				
No Air-Conditioning	2	0	2	0
Window AC	4	1	3	0
Forced Air Heat	5	5	0	0
Electric Heat	1	1	0	0
Gas Heating System	4	1	3	0
Oil Heat	1	0	0	1
Central Heating	6	5	0	1
Heat	1	1	0	0
Water Heat/Heat Pump	1	1	0	0
Ceiling Fan	1	1	0	0
Basement	21	15	1	5
Dummy for No Basement	6	0	3	3
Basement Finished	4	2	0	2
Recroom in Basement	1	1	0	0
Hardwood floors	7	5	0	2
Carpet	3	3	0	0
New Carpet	1	0	0	1
Tile	1	1	0	0
Molding	1	0	0	1
Cable TV	1	0	1	0
Skylights	1	0	0	1
Wet Bar	4	3	0	1
Family Room/ Main Floor	1	1	0	0
Panel	2	0	0	2
Wood paneling	1	0	0	1

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel C: Category 3—External House Features				
Garage Spaces	61	48	0	13
One Car garage Space	1	1	0	0
2 or More Car Garage Spaces	1	1	0	0
Carport	4	1	1	2
Garage	4	3	0	1
No Garage	2	0	1	1
Detached Garage	3	3	0	0
Deck	12	10	0	2
Pool	31	27	0	4
Tennis Court	1	0	0	1
Separate Shop Space	1	1	0	0
Storage	1	1	0	0
Porch	9	5	0	4
Covered Porch Area	1	1	0	0
Landscaping	3	3	0	0
Fence	2	0	0	2
Gated Community	1	1	0	0
Panel D: Category 4—Natural and Environmental Characteristics				
"Good View"	4	3	0	1
Lake View	5	5	0	0
Lake/River View	2	1	0	1
Lake Front	5	5	0	0
Ocean Front	2	2	0	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel D: Category 4—Natural and Environmental Characteristics (continued)				
Ocean View	4	4	0	0
Oceanview1	1	1	0	0
Oceanview2	1	1	0	0
Oceanview3	1	1	0	0
Oceanview4	1	1	0	0
Distance to Nearest Beach	1	0	1	0
Width of Nearest Beach	1	1	0	0
Mountain View	2	0	0	0
Bay Front	1	1	0	0
Next to Stream	2	1	0	1
Groundwater Contamination in Neighborhood	1	0	0	1
Oil Spill on Waterfront Lot	1	0	1	0
Oil Spill on Interior Lot	1	0	1	0
Magnitude of Largest Earthquake	2	0	2	0
Special Studies Zone for Earthquake	1	0	1	0
Flood Plain	1	0	1	0
Riparian Buffer Width in Trees	1	0	0	1
Soil Type	1	1	0	0
Airport Noise	1	0	1	0
Air Quality	1	0	0	1
Air Pollution	1	0	0	1
Ln Manure Index	1	0	1	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel E: Category 5—Environmental Neighborhood and Locational Factors				
Location	9	7	2	0
Good Location	1	0	0	1
Golf Course	9	9	0	0
Located on Alley Way	3	0	1	2
On 2-Way Street	1	1	0	0
Busy Street	2	0	0	2
Interstate	3	0	3	0
Arterial Road	1	0	0	1
High Traffic Area	3	0	2	1
In City	1	1	0	0
Close	3	0	0	3
Distance	15	5	5	5
Distance Squared	2	1	1	0
Travel Time to Work	1	0	1	0
Hwy Time to CBD	4	2	2	0
Distance from Waste	4	2	1	1
Distance to School	1	1	0	0
Distance to Landfill	1	1	0	0
Metro Within 1/4 Mile	1	0	1	0
1/2 Mile to Hwy Interchange	1	0	0	1
1/2 to 1 Mile to Hwy Interchange	1	0	0	1
1–2 Miles to Interchange	1	1	0	0
2–3 Miles to Interchange	1	1	0	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel E: Category 5—Environmental Neighborhood and Locational Factors (continued)				
1/4 Mile to Metro Station	1	0	1	0
1/4 to 1/2 Mile to Station	1	0	0	1
1/2 to 1 Mile to Station	1	0	0	1
1–2 Miles to Station	1	1	0	0
2–3 Miles to Station	1	1	0	0
Railroads	1	0	1	0
Train Station	1	1	0	0
Stream	1	0	0	1
Bay	1	1	0	0
Crime	7	1	4	2
Bad Crime Level	1	0	0	1
Murder Rate	1	0	1	
Correctional Facility	1	0	0	
Abandoned Bldgs in Area	1	0	1	
# Houses in Neighborhood Boarded Up	1	0	1	
Neighborhood Density	4	1	1	
Neighborhood Noise	1	0	0	
Noise Control Level	1	0	1	0
Bad Trash in Area	1	0	0	1
Neighborhood Odor Bad	1	0	0	1
Trees	6	6	0	0
R1 Zoning	2	2	0	0
R2 Zoning	2	2	0	0
R3 Zoning	2	0	0	2

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel E: Category 5—Environmental Neighborhood and Locational Factors (continued)				
Lot Density	1	1	0	0
Lot Density	1	1	0	0
Baptist	1	0	1	0
Catholic	1	0	1	0
Church of Jesus Christ of Latter Day Saints	1	1	0	0
Distance to Group Home	1	0	1	0
Panel F: Category 6—Public Service Amenities				
School District	10	3	7	0
In Local School District	1	0	0	1
School Quality	1	1	0	0
If Public Elem. School OK	1	0	0	1
Improvements in Elem School	0	0	0	0
Private School	1	0	1	0
% School District Minority	7	0	5	2
Special Education	1	0	0	1
% of Gifted Students	1	1	0	0
% Change in School Enrollment	1	0	1	0
% of School Age Children	1	0	0	1
Rate of Turnover in Student Pop Each Year	1	1	0	0
Average Attendance per Student	1	0	1	0
% High School	3	1	0	2
Avg Math Score	1	1	0	0
Avg Reading Score	1	1	0	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel F: Category 6—Public Service Amenities (continued)				
Pass Rate for Elementary School Test	2	1	0	1
Dollar Expenditures per Student for Instruction	1	0	0	1
Dollar Expenditures per Student for Administration	1	0	0	1
Dollar Expenditures per student for operation	1	0	0	1
Dollar Expenditures per student for staff	1	0	0	1
Support Dollar Expenditures per Student	1	0	0	1
Free Lunch in School	1	0	1	0
Public Sewer	2	1	1	0
Public Assistance	1	0	0	1
Exterminator Service	1	0	1	0
Power Lines	1	0	1	0
Commercial Activities	1	0	0	1
Adequate Shopping Area	1	1	0	0
Public Transportation OK	1	0	1	0
Ln Quality of Public Service	1	1	0	0
Commute Time	1	0	0	1
Drugs	1	0	0	1
Deed Restrictions	1	1	0	0
Panel G: Category 7—Marketing, Occupancy and Selling Factors				
Assessors Quality	6	5	0	1
Assessed Condition	8	7	0	1
Quality1	1	0	1	0
Quality2	1	0	1	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel G: Category 7—Marketing, Occupancy and Selling Factors (continued)				
Condition1	1	0	1	0
Condition2	1	0	1	0
Condition3	1	1	0	0
Condition4	1	1	0	0
Average condition	1	1	0	0
Good Condition	5	4	0	1
Dollar Repairs at Closing	1	0	0	1
Owner-Occupied	6	4	0	2
Non-Owner Occupied	1	0	1	0
Tenant	1	0	1	0
% Renters	2	1	1	0
Occupied Units	1	0	1	0
Previously Occupied Dummy	1	0	0	1
Vacant	10	0	9	1
% Vacant	4	0	1	3
DOM X Vacant	1		0	0
Avg Income in Area	2	1	0	1
Median Income	3	0	1	2
Median Household Income	3	1	0	2
Two Income	1	0	1	0
Household Income	2	1	1	0
% Blue Collar	3	0	2	1
% Poverty	1	0	1	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel G: Category 7—Marketing, Occupancy and Selling Factors (continued)				
Unemployment Rate	4	0	0	4
Proximity to Employment	1	0	0	1
Manufacturing Employment Density	1	0	1	0
Retail Employment Density	1	0	1	0
Real Estate Agent is Used (Dummy)	1	0	0	1
Exclusive Agency	1	0	1	0
Exclusive Agency Sell by Owner	1	1	0	0
Listing Contract Period	3	2	0	1
Contract Expiration Days	2	1	0	1
# of Days from Contract to Closing	2	0	0	2
Listing Brokerage Firm	3	1	1	1
Buyer's Broker	1	0	0	1
Buyer Agent	1	0	0	1
Listed in Fall	1	0	1	0
Listed in Spring	1	0	1	0
Listed in Summer	1	0	1	0
Offer Open 1 Day or Less	1	1	0	0
First Time Homebuyer	1	0	0	1
New Resident in Area	1	0	0	1
Seller Eager	1	0	1	0
Motivated Seller	1	0	0	1
Motivated	1	0	1	0
Buyer must sell house	1	0	0	1

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel G: Category 8—Marketing, Occupancy and Selling Factors (continued)				
Seller Relocated	1	0	1	0
Corporate Owned	2	0	2	0
Corporate Sale	1	0	1	0
Intra-Family Sale	1	0	1	0
Bank Sale	1	0	1	0
Estate Sale	1	0	1	0
Time on Market	18	1	8	9
Total Days on Market	4	0	2	2
Ln TOM	5	1	2	2
Date of Sale (Time)	1	1	0	0
Time Trend	13	2	3	8
Time Trend Squared	1	0	0	1
Sale Year	1	1	0	0
Year Dummy	1	0	1	0
Continuous Month-of Sale Variable	1	1	0	0
Cash Sale	4	0	4	0
Good Buy	1	0	1	0
Builder Owned	1	1	0	0
CPI for Fuel	1	1	0	0
% Asian	1	0	1	0
% Black	4	0	3	1
% Hispanic	2	0	2	0
% Black or Hispanic	1	0	1	0
% White	1	1	0	0

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel G: Category 8—Marketing, Occupancy and Selling Factors (continued)				
Population % > 62	1	1	0	0
Historic Façade Easement	1	0	1	0
Federal Historic District	1	1	0	0
Distant Moves	1	1	0	0
Employer Pays Moving	1	1	0	0
New Household	1	0	1	0
No Experience	1	0	1	0
Family Size	1	0	0	1
Age of Buyer	1	1	0	0
Population Change	1	0	0	1
Population Density	1	0	1	0
Points Paid by Seller in $	1	1	0	0
Closing Cost Paid by Seller in $	2	0	0	2
Perceived Risk	1	0	1	0
# of Media Articles	1	1	0	0
Panel H: Category 8—Financing Issues				
Mortgage Rate	2	1	1	0
Conventional Financing	1	0	1	0
FHA Financing	3	0	3	0
VA Financing	3	0	3	0
Owner Financing	1	0	1	0
Other Financing	2	0	0	2

Exhibit 3 (continued)
Characteristics by Category from Previous Studies

Variable	Appearances	# Times Positive	# Times Negative	# Times Not Significant
Panel H: Category 8—Financing Issues (continued)				
Foreclosure	5	0	5	0
Financing Premium	1	1	0	0
Favorable Financing	3	0	0	3
Seller Pays Closing Costs	1	0	0	1
Flood Insurance	1	0	1	0
Selling Bonus	1	0	0	1
# Days in Rental Process	1	1	0	0
Property Tax	3	0	1	2
Superfund	1	1	0	0
Eminent Domain Purchase	1	1	0	0

Studies measuring financing characteristics show that owner financed homes sell for less. Also, houses that require flood insurance sell for less.

Comparing Coefficient Estimates by Geographical Area

Exhibit 4 shows coefficient estimates for selected characteristics by geographical area. The coefficients are from studies that used semi-log models and were consistent in their measurement of the characteristics.

As can be seen, estimations are somewhat consistent across areas. For example, the coefficients for square feet do not have a great deal of variation across regions. They are normally in the 0.0004 to 0.0007 range. Square footage seems to have the greatest effect on price in the Southwest where, on average, each additional square foot adds about 0.05% to value. The lowest average effect seems to be in the Midwest. The coefficients for the Southeast and West seem to average in the 0.045% range. Remember that this coefficient is measuring the percentage change in price with each additional square foot. Likewise, the coefficients for lot size are somewhat consistent across geographical regions.

Age consistently has a negative effect on selling price. There is some variation in the coefficient estimates but there does not seem to be a discernable pattern of differences across regions. The average effect of age on value seems to be about 1% or less.

Bathrooms generally have a significant effect on selling price. Studies discussed here that have included the number of bathrooms tend to be limited to Northeast and Southwest data. The bathroom coefficient for the Northeast falls in the 0.13 – 0.18 range indicating that each additional bathroom adds 13% to 18% to the price of the house. The coefficients for the Southwest have a wider variation ranging from 0.015 to 0.18. The average effect on price is in the 10% to 12% range.

As with bathrooms, studies included here that have estimated the effect of bedrooms are limited to the Northeast and Southwest. The effect of an additional bedroom seems to be somewhat greater in the Northeast than in the Southwest.

A number of studies have included fireplace in hedonic models. The presence of a fireplace consistently has a significant positive effect on selling price. Casual observation shows that a fireplace generally affects selling price by a range from 6% to 12% and this effect is consistent across regions, except for the West. The estimated coefficients for the studies from the West seem to be, on average, less than for studies from other areas.

Central air-conditioning generally is significant and has a positive effect on price. Several studies from the Northeast produce models where air-conditioning is significant with an average effect on price in the 7% range with coefficients ranging from 4% to 9%. Several studies from the Midwest also show air-conditioning to be important with the effect in a higher range from 6% to 13%. Although fewer in number, studies from the Southeast and West show air-conditioning to be important

Exhibit 4
Coefficient Estimates from Hedonic Pricing Models for Selected Characteristics by Geographical Area

Region	Square Feet	Lot Size	Age	Bathrooms	Bedrooms	Fireplace	AC	TOM	Basement	Pool	Garage Spaces	School District
Northeast	x	0.0000132	−0.00294	0.127	0.157	0.143	0.048	0.00	x	0.037	0.070	
		−0.004	0.13	0.06		0.040	0.0		0.058		0.230	
			−0.010			0.033	0.070	0.00		0.056	0.113	
							0.090	0.099			0.060	
							0.090				0.113	
							0.050				0.079	
							0.131				0.121	
Southeast	0.00035	0.0000021	−0.009	0.099	x	0.127	0.129	−0.0002	1.120	0.098	0.063	−0.128
	0.00042	0.0000029	−0.005			0.133	0.101	−0.0001		0.090	0.070	−0.086
	0.00040		−0.012			0.067		−0.0220		0.048	0.067	
	0.00070		−0.019			0.145		−0.0002		0.077	0.055	
	0.00040					0.037		−0.0003			0.100	
											0.143	
Midwest	0.00015	0.0000044	−0.017	x	x	0.078	0.129	0.00	0.158	0.060	0.106	−0.030
	0.00040	0.0000070				0.110	0.099		0.120	0.059	0.120	
						0.085	0.060		0.121		0.096	
						0.078	0.075		0.050		0.106	
						0.045	0.070				0.036	
							0.129					
Southwest	0.00040	0.0000070	−0.012	0.161	0.022	0.128	0.16	−0.0003	x	0.134	0.072	x
	0.00060	0.00020	−0.015	0.015	0.035	0.067	0.15			0.104	0.057	
	0.00040		−0.0002	0.044	0.31	0.120	0.26			0.128	0.074	
	0.00070		−0.008	0.18		0.146				0.097	0.107	
						0.011				0.093		
										0.083		
										0.104		

Exhibit 4 (continued)

Coefficient Estimates from Hedonic Pricing Models for Selected Characteristics by Geographical Area

Region	Square Feet	Lot Size	Age	Bathrooms	Bedrooms	Fireplace	AC	TOM	Basement	Pool	Garage Spaces	School District
West	0.00050	0.000017	−0.006	x	x	0.054	0.007	x	0.143	0.134	0.045	0.054
	0.00060	0.00001	−0.003			0.106	0.048		0.059	0.046	0.024	−0.184
	0.00030	0.0000014	−0.020			0.053				0.058	0.039	0.148
	0.00040		−0.0032			0.024				0.090	0.014	−0.020
										0.085	0.025	
											0.051	
											0.170	
											0.080	
											0.138	
Coeff.[a]	0.0003	0.015 (in acres)	−0.050 (binary variables for age)	0.216 (full baths)	0.041	0.113	0.117	−0.015	−0.087	0.076 (inground pool)	0.121	x
				0.139 (half baths)								

Note:
[a]Estimates from Sirmans and Macpherson (2003).

with the effect on selling price in the 12% and 3% range, respectively. The effect on price in the Southwest is in the 15% to 19% range.

Basement is seen to have a significant positive effect on selling price. A study from the Southeast shows that a basement adds about 12% to value. Several studies from the Midwest show that a basement affects value in the 12% to 16% range. A couple of studies from the West show a basement adds from 6% to 14% to house price.

Swimming pool is an often-included characteristic in hedonic models. It is generally positive and significant. In the Northeast, a pool adds 4% to 6% to value. In the Southeast, the effect is in the 5% to 10% range. The effect in the Midwest is similar to the effect in the Northeast with the average effect on value about 6%. A pool seems to affect price the most in the Southwest, where studies show the effect to be between 8% and 13%. A pool is also important in the West but the effect on value is less consistent than other areas. In the West, the average effect on value ranges from 5% to 13%.

Garage is generally specified in pricing models as the number of garage spaces. This characteristic is included often and has a significant positive effect on selling price. In the Northeast, most studies show that each garage space adds between 6% and 12% to value. Garage spaces are priced similarly in the Southeast with the value added between 6% and 14% of selling price. In the Midwest, the effect on value is between 4% and 12% while the effect in the Southwest is between 6% and 11%. Garage space seems to add the least to value in the West where a number of studies show a 1% to 5% addition to value.

Some studies have attempted to examine the importance of schools by including some school identifier. The typical measure is to identify the home's school district. These measures consistently show perceived school quality to be important. The estimated coefficients are sometimes positive and sometimes negative depending on perceptions. Overall, the effect on price seems to range between 3% and 18%.

The results from the recent study by Sirmans and Macpherson (2003) examining the value of housing characteristics are given at the bottom of Exhibit 4. In general, these results are consistent with the results from previous studies.

Conclusion

This study was made up of several parts: the early history of hedonic modeling was discussed, the relationship between selling price and time-on-the-market was discussed and recent studies using hedonic modeling were reviewed. Although Court (1939) is often viewed as the father of hedonic modeling, earlier hedonic studies that examined the value of farmland date back to Haas (1922a,b) and Wallace (1926). Later studies developed the microeconomic foundation for estimating the value of utility-generating characteristics (Lancaster, 1966) and for nonlinear hedonic pricing (Rosen, 1974).

Selling price and time-on-the-market were seen to be interactive making specification of these variables in a simultaneous framework difficult. Time-on-the-market was seen to be generally negative when estimated in a selling price equation. This implies that a longer selling time results in a lower selling price. When selling price is included in a time-on-the-market equation, the results are less clear. Some models show that houses with higher selling prices sell faster while other studies show that houses with higher selling prices have longer selling times. Studies were discussed that show listing price as a major factor in time-on-the-market.

Using the recent literature, the characteristics that are most frequently included in hedonic pricing models were identified. These include lot size, square feet, age, the number of stories, the number of bathrooms, the number of rooms, the number of bedrooms, fireplace, central air-conditioning, basement, garage, deck, pool, brick exterior, distance to CBD, time-on-the-market and a time trend. These variables generally have the expected signs although in some instances they are not significant. Due to the large number of variables, categories were created and the top five characteristics from each category were identified. The categories and characteristics are: *structural features*: lot size, square feet, age, number of bathrooms and number of bedrooms; *internal features*: full baths, half baths, fireplace, air-conditioning, hardwood floors and basement; *external features*: garage spaces, deck, pool, porch, carport and garage; *natural environmental features*: lake view, lake front, ocean view and good view; *neighborhood and location*: location, crime, distance, golf course and trees; *public services*: school district, percentage of school district minority and public sewer; *marketing, occupancy and selling factors*: assessor's quality, assessed condition, vacant, owner-occupied, time-on-the-market and time trend; and *financing issues*: FHA financing, VA financing, foreclosure, favorable financing and property taxes. Most of the characteristics have a positive effect on selling price. Those characteristics that have had a negative effect on price include age, crime, percentage of school district minorities and vacancy.

Some other interesting variables that are seen to affect selling price were discussed. Those that have a positive effect include slanted versus flat roof, sprinkler system, garden bath, separate shower stall, double oven and gated community. Some other characteristics that have a negative effect on selling price include not having attic space, living in an earthquake zone, proximity to a hog farm, proximity to a landfill, proximity to high voltage lines, corporate-owned properties, percentage of Blacks or Hispanics in an area and properties that require flood insurance.

Estimated coefficients for selected characteristics were compared across geographical regions. The results from the recent Sirmans and Macpherson (2003) paper entitled "The Value of Housing Characteristics" were compared to these results and found to be consistent. Some major conclusions were:

- The effect of square footage on selling price does not have a great deal of variation across regions. The greatest effect was in the Southwest and the lowest average effect is in the Midwest;

- The effect of lot size is also somewhat consistent across regions;
- Age is consistently negative and the effect on price seems to be consistent across regions;
- For studies primarily from the Northeast and Southwest, each additional bathroom seems to affect selling price in the 10% to 12% range;
- For studies limited to the Northeast and Southwest, the effect of bedrooms on price seems to greater in the Northeast than in the Southwest;
- Fireplace has a positive effect on selling price in the 6% to 12% range and seems to be consistent across regions, except for the West;
- Central air-conditioning is consistently important in all regions with the greatest price effect in the Southwest;
- Basement adds significant value to selling price in most studies in the 12% to 16% range;
- Swimming pool is a consistently significant characteristic with the effect on price being the greatest in the Southwest and Southeast;
- The value of a garage is consistent across regions in the 6% to 12% range; and
- Perceived school quality consistently has a significant effect on selling price.

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