Structural Change in the Demand for Housing Services and Policy Implications

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Abstract

This research paper estimates the demand for housing services across the United States and studies public policy implications based on estimation results. More specifically, the research paper examines the price and income elasticity of demand in the United States and tests for structural change in the demand for housing services between two different time periods. The empirical analysis on 33 Metropolitan Statistical Areas in 2005 and 2011 suggests that the demand for housing services is inelastic with respect to price per unit of housing services, and the income elasticity of demand has a relatively larger magnitude than the price elasticity of demand. In addition, there is a structural change in the demand for housing services between 2005 and 2011. Finally, the parameters estimated from the housing demand model are used to perform a preliminary policy analysis of households' response to a housing allowance program. The estimated housing demand equation allows the assessment of the impact of housing allowance programs on the price of housing services and thus, may help policy makers to ensure adequate housing stock in an area.

I. Introduction

Recently, a dynamic shift in the housing market has led to a shortage in housing inventory. According to the Standard & Poor's Case-Shiller Index, home prices rose 13.6 percent nationwide over the course of 2013, varying from a slight decline in New York to a surge of 27.1 percent in Las Vegas (Isidore 2013). These changes counter the fall in the U.S housing demand after the housing bubble burst in 2007 and the subsequent rapid depreciation in home values. Housing demand provides incentives for suppliers to change production, and understanding these incentives can help policy makers to respond to any inadequacies in the market process in either over or under providing housing services. This research project will provide an empirical analysis of the demand for housing services for owner-occupied housing that incorporates the simultaneous selection of housing structural and neighborhood characteristics. The objective of the study is to estimate the price elasticity and the income elasticity of demand for housing services, test for structural change, and consider policy analysis. The study will be based on Zabel's (2004) model of housing demand estimation because of the shared objective and feasibility of replication. In his paper, Zabel performs research on 38 Metropolitan Statistical Areas[1] (MSAs) in the years 1993 and 2001 (Zabel 2004). This paper adopts the same selection method, using data from 33 MSAs in 2005 and 2011. In addition, this paper extends his work to a new model that takes into account *additional* housing structural and neighborhood features.

This study tests the following hypotheses:

1. The demand for housing services is inelastic with respect to price.
2. The income elasticity of demand has a relatively larger magnitude than the price elasticity of demand.
3. There is a structural change in the parameters of some or all of the variables attributed to the quantity demanded for housing services in 2005 and 2011.

[1] The U.S. Office of Management and Budget defines MSA as an area that contains a core urban area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core measured by commuting ties.

The research concludes with a policy analysis using the estimated parameters from the housing demand equation. The next sections of the research project will first present a literature review, followed by two sections on the empirical model and empirical approach. The next sections will present the data used in the analysis, as well as discuss the empirical process and findings. The following section will provide details about policy implications. The conclusion section will highlight the important findings and some of the limitations of this research project.

II. Literature Review

The literature includes different approaches to estimate the demand for housing. However, the literature does not have a clear definition of housing demand. Rothenberg made an effort to classify the literature on housing demands into four categories (Rothenberg et al. 1991). These four categories are the demand for individual housing attributes, the demand for the spatial allocation of households, the demand for owner occupancy versus renting (tenure choice), and the demand for housing services. This, however, does not imply that each previous research focuses solely on one of these categories. Rather, Rothenberg’s categories often encompass one another in one research project in an attempt to estimate the housing demand. The research topic determines the main category of the literature and the appropriate combination of different variables from other categories. The determination of this combination of variables is based on different theoretical models and estimation strategies.

Among researchers who study the demand for individual housing attributes, Kain and Quigley (1975) estimate the demand for twenty-one separate housing attributes and the effect of racial discrimination in the housing market on Black household consumption. Their empirical analysis uses a pooled sample of owner-occupied and rental households in the St. Louis housing market to provide a comprehensive overview of households’ choices of various housing attributes. Their findings also confirm their hypothesis that Black householders face systematic restrictions in the housing supply available to them. In another study, Harrison and Rubinfeld (1978) estimate the demand for clean air as one individual housing attribute. Their analysis uses a four-step procedure to show that the marginal air pollution damages share a positive relationship with the level of air pollution and household income.

The second category of research focuses on the demand for spatial allocation of households. Alonso (1964) and Wheaton (1977) estimate the demand for housing based on the spatial allocation of the households using the bid-rent gradient theory. Alonso defines a "bid-rent function" as the set of amounts that households would bid for land at alternative distances from a city center while achieving a given level of utility. In this model, households' choices of a location and an amount of land depend on the tradeoff between cheaper rents and a longer commute to work as one moves further from the city center, assuming that all employments are fixed at the center of the city (Straszheim 1975).

Among all the literature on the demand for housing, Alonso and Wheaton's approach suffers from the most criticism because, though theoretically rigorous, it makes some restrictive assumptions in order to empirically estimate price and income effects for residential housing. Spatial variation in observed prices around the city center for any housing attribute must be collapsed to single dimension "rent gradient" (Straszheim 1973). This requirement is the major limitation of Alonso's model because it can be argued that households regard housing services as multidimensional, with some of their attributes directly associated with particular characteristics of the capital stock, such as neighborhood characteristics and public services (Straszheim 1975). Critics also use the multidimensional aspect of housing services to criticize other approaches to estimate income elasticity. One of these approaches can be found in Hansen, Formby and Smith's (1998) study. In their research, Hansen, Formby and Smith estimate the income elasticity of demand for housing using a Lorenz curve[2] and associated concentration functions[3]. The Lorenz curve approach allows income elasticity to vary in an unrestricted manner over the entire range of income[4]. However, similar to Alonso's approach, the Lorenz curve approach introduces omitted variable bias in the estimation of income elasticity because a method for incorporating non-income determinants of demand had yet to be developed. These determinants include housing price, demographic characteristics and tenure choice.

Follain and Jimenez (1985) examine the theoretical foundation and critique past econometrics techniques used to estimate the demand for both housing structural and locational

[2] The Lorenz curve indicates the cumulative proportion of income received by cumulative proportions of households when households are ordered by income (Hansen 1998)

[3] Cifarelli and Regazzini (1987) defined the concentration function of a probability measure P with respect to another one, say P_o extending the classical notion of the Lorenz-Gini curve. By the concentration function, the discrepancy between two measures defined on the same probability space is studied, comparing the different concentrations of probability determined by the measures.

[4] Traditional literature uses log-linear demand function, in which the elasticity is restricted to be constant or to increase with income (Hansen 1998)

characteristics. They emphasize the importance of this type of analysis because it provides insights about the tradeoff that consumers are willing to make between physical and locational characteristics. Understanding this tradeoff furthers the understanding of the dynamics of the housing market and the shift in housing structures over time and place. Furthermore, it was noted that this shift alters the composition of the housing characteristics in a community and eventually affects the distribution of wealth in an economy (Ngai 1995).

Other researchers consider the fact that there are both consumption and investment aspects to the housing purchase. These two aspects are the motives for tenure choice. The Heckman approach[5] is widely used by many researchers to incorporate these aspects in determining tenure choice. Goodman (1988) formulates the owner-renter price ratios and value-rent ratios to study the consumption and investment components of the housing demand. Haurin and Lee (1989) adopt a similar approach to estimate a structural model of the demand for owner-occupied housing. Their model takes into account factors influencing tenure choice as well as loan-to-value ratio, which reflects a tradeoff between mortgage interest rate and household size. The research also shows that if one of these components can be changed, then the housing demand equation can be modified. Therefore, policy makers can determine the appropriate mortgage interest rate and the loan-to-value ratios to ensure adequate supply of the housing stock in a particular area.

Recent work shows that a proper method to achieve this objective is to model housing demand as a continuous quantity that represents the flow of housing services. It is important to distinguish the demand for housing services and the demand for individual structural and locational characteristics. The flow of housing services is quantified as an abstract unit determined by all factors attributed to the market value of the house. On the other hand, different housing attributes only refer to a specific set of housing characteristics. As Follain and Jimenez indicate, the study of the demand for housing attributes implies certain important policy analyses, but it does not allow the estimation of price and income elasticity.

[5] The Heckman approach refers to a two-step selection model and involves estimating the probability of owning, constructing a selection term from the probit regressors and coefficients, and including this selection term in an OLS regression restricted to a sample of owners (Rapaport 1997).

Housing services demand estimation has always included household structure as a major determinant. However, research in the past two decades has been extended to incorporate the impact of neighborhood effects on the demand for housing services. Rapaport (1997) constructs a housing demand model which demonstrates a household's simultaneous choice of community, tenure and the quantity of housing services consumed. Her paper addresses the limitation that housing demand literature in the past has not factored community choice into the utility maximization problem. Rapaport's empirical analysis of housing in five counties near Tampa, Florida concludes that incorporating community choice substantially increases the estimated price elasticity of demand for owner-occupied housing, and thus has a great impact on housing demand. In another study, Ioannides and Zabel (2003) extend the conventional housing demand equation to a new model that focuses specifically on neighborhood effects. In this study, the authors apply Manski's concepts of endogenous social effect and contextual effect[6] to an empirical analysis consisting of data from 100 MSAs and affirm the presence of both effects in the housing demand model. Given the significant impact of neighborhood characteristics, it is important to incorporate these vectors of variables into the demand for housing services equation.

In Zabel's (2004) model, both household structural and neighborhood characteristics jointly affect the demand for housing services. This expansion to include both components eliminates the limitation of Alonso's approach and at the same time, takes into account spatial allocation of household as one of the neighborhood characteristics. However, Zabel's model does not include the tenure choice factor. Considering this factor in the housing demand equation would require the incorporation of property tax rate, inflation rate and mortgage financing variables. This would add to the complexity of the model and therefore, this research project will not consider tenure choice in the housing demand equation.

[6] Manski defines the endogenous social effect as the propensity of an individual to behave in some way that varies with the behavior of the group, and the contextual effect as the propensity of an individual to behave in some way that varies with the exogenous characteristics of the group (Manski 1993). In the housing demand context, the endogenous social effect expresses the case in which individuals who view their neighbors' decision to maintain, renovate, repair or make additions to their houses will strive to keep up by making similar decisions and hence, increases their own housing consumption. The contextual effect arises when owners view their neighbor's characteristics, e.g. income, as a signal of their future housing consumption and thus alter their own consumption accordingly (Ioannides and Zabel 2003).

Given the shared objectives and the feasibility of replicating methods, this research paper will extend Zabel's model. This paper will incorporate *additional* housing structural and neighborhood characteristics variables in two different time periods. The objective of the paper is to verify the three hypotheses stated in the introduction. In addition, this paper will study public policy implications using the estimated housing demand equation. While the term "housing services" is used in this context to refer demand for a flow of housing services, this paper will frequently refer to the demand for or elasticity of demand for "housing," with this latter term actually referring to the flow of housing services.

III. Empirical Model

The conceptual model described in this section is based on Zabel's (2004) approach. The approach uses the standard consumer's utility maximization model to derive the log-log housing demand equation. This model is based on the assumption that given a specific budget constraint, individuals will try to maximize their utility function. In the housing context, let individual *i*'s utility function depend on non-housing composite consumption C_i, housing services H_i, and own demographic characteristics that might affect preferences z_i so that the utility function can be mathematically described as the following:

$$U_i = U(C_i, H_i, z_i) \tag{1}$$

Assume that the price of C_i is a unit and there is no price associated with z_i so that an individual chooses to allocate income, y_i, between C_i and H_i , so the budget constrain is:

$$C_i + (p * H_i) = y_i \tag{2}$$

where p is the price of a unit of housing services.

Theoretically, the utility function in equation (1) is maximized subject to the budget constraint in equation (2) to obtain a demand function for housing services such that the quantity demanded for housing services is explained in terms of the price per unit of housing services, household income, and owner demographic characteristics. Such demand expressions are commonly modeled as log-log housing demand equations. The mathematical expression for this relationship is demonstrated in the following equation:

$$ln(H_i) = \beta_o + \beta_1 . ln(p) + \beta_2 \, ln(y_i) + \sum_{j=1}^{n} \lambda_{ij} \, z_{ij} + \gamma_i \tag{3}$$

where γ_i represents household unobservable tastes for housing services. From equation (3), the price elasticity of demand $\widehat{\beta_1}$ and the income elasticity of demand $\widehat{\beta_2}$ will be estimated. The estimated parameters $\widehat{\beta_1}$ and $\widehat{\beta_2}$ will allow the test of the four hypotheses stated in the objective of this research paper.

IV. Empirical approach

Given the above traditional framework for demand, the empirical approach is described as the following. The first step is to estimate a separate hedonic regression for each MSAs. The second step is to construct the housing price indices using the estimated parameters from the hedonic regression equations. The construction of the housing price index then allows the construction of the housing services quantity. At this point, housing demand regressions are run for both 2005 and 2011 using two different specifications - Model 1 uses current income as the regressor and Model 2 uses permanent income as the regressor. Finally, a Chow test is performed to test for structural change between the housing demand in 2005 and 2011.

The first and second steps are performed because it is important to find exogenous variation in *p* to limit bias of the coefficients in the OLS model. The first consideration is the potential problem of simultaneous causality bias in equation (3). The OLS estimation assumes that the independent variables are uncorrelated with the error term. An explanatory variable that is determined simultaneously with the independent variable is generally correlated with the error term, which leads to bias and inconsistency in the OLS model (Wooldridge 2013). In equation (3), income y_i and owner demographic characteristics that might affect preferences z_i are exogenous variables. The problem of simultaneity of housing demand and the housing price arises because price and quantity of housing services are jointly determined by the interaction between demand and supply. Therefore, price is endogenous in the model. In order to solve this problem, it is necessary to express *p* in terms of exogenous variables before estimating the demand for housing services. If this condition is satisfied, then the value of *p* is more likely to be uncorrelated with the error term and thus, remove bias of the estimated coefficients in the OLS model.

Given the need to construct an exogenous value for price per unit of housing services (*p*), the first estimation stage is to use the hedonic price model[7] to assess the relationship between separate housing characteristics and the unit market value. In the hedonic price model, the marginal willingness to pay for a particular housing characteristic is equal to the corresponding estimated parameter. Rosen (1974) outlines the theory for the estimation of demand and supply function that determines the hedonic price model. However, economic theory provides little evidence regarding the specification of the functional form of the dependence of price on quality (Gencay and Yang 1996). Thus, researchers have identified three econometric estimation techniques: the ordinary least square (OLS) regression, the Box-Cox, and the Wooldridge transformation. Out of the three techniques, the Box-Cox transformation is the most popular because of its flexibility in the model specification, and thus, the technique results in a better fit of the data (Rasmussen 1990). For convenience, however, this research project adopts the OLS regression to estimate the hedonic price equation. The major assumptions of the hedonic price model are (Chin and Chau 2002):

1. There is no market segmentation as there is mobility among locations and no price discrimination.

2. Irrelevant independent variables[8] might be included, which may result in unbiased and consistent but inefficient estimation.

3. Markets operate under perfect competition as no individual can affect the price of the properties.

4. Buyers have perfect information about attributes of the housing product and price.
5. There are no interrelationships between the implicit prices of attributes.

Under these assumptions, the hedonic price model can be used to draw a relationship between the market value of the house and all the characteristics attributed to this market value. Research has always focused on the structural features of the house. However, research in the past two decades recognizes that neighborhood characteristics are also significant determinants

[7] Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them (Rosen 1974). Major contributions to the hedonic price model include Lancaster (1966) and Rosen (1974).

[8] Irrelevant independent variables are variables included in the model even though they have no partial effect on the independent variable in the population. Inclusion of irrelevant independent variable in multiple regression analysis can have undesirable effects on the variances of the OLS estimators (Wooldridge 2013).

of the house price (Kiel and Zabel 1996). Thus, the model used in this research incorporates both sets of characteristics in the hedonic price equation. In this model, assume the data includes information from more than one housing market, say *J > 1* markets:

$$\ln(P_{hj}) = \alpha_{0j} + \alpha_{1j} * \ln(s_{hj}) + \alpha_{2j} * \ln(n_{hj}) + \varepsilon_{hj} \qquad j = 1, \dots . J \qquad (4)$$

P_{hj} is the market value of house *h* in market j, s_{hj} indicates the structural characteristics of house *h* in market j and n_{hj}indicates the neighborhood characteristics of house *h* in market *j*.

The second consideration is the construction of the value of p using the estimation results from the hedonic regression and ensuring that there is adequate variation in *p*. Price variation needs to be present to be able to properly identify the parameters. Ohsfeldt and Smith (1988) point out that the unbiasedness of structural parameter estimates is strongly affected by the magnitude of the exogenous variation in the system. In this paper, adequate price variation arises from the assumption that there is one price of housing services per MSA. The details of this assumption are implied by equation (5). Under the context of one price per MSA, price differentials arise because of local factors that influence the desirability of living in one market over another, and possibly because of differences in the supply and demand for housing across MSAs.

In order to construct *p* using the results from the hedonic regression, a constant quality house price index can be calculated. Zabel (1999) shows that even if the desired index does not require neighborhood characteristics to be held constant, it is still necessary to include neighborhood characteristics in the underlying house price regressions for the estimators of house price indices to be unbiased. It is possible to obtain an unbiased index by adding the effect of neighborhood characteristics on house price changes. Following this argument, the constant quality price index is constructed through the evaluation of the hedonic equation for each market at constant levels of *s* and *n*. These constant levels are calculated as the average value of *s* and *n*. The ratio of house prices in market *j* to a fixed market (say *j = 1*) demonstrates the relative price of housing in market *j*:

$$p_j = \frac{e^{(\alpha_{oj} + \alpha_{1j} \ln(\bar{s}) + \alpha_{2j} \ln(\bar{n}))}}{e^{(\alpha_{o1} + \alpha_{11} \ln(\bar{s}) + \alpha_{21} \ln(\bar{n}))}} \qquad (5)$$

Note that *s* and *n* are evaluated at constant level $\bar{s}$ and $\bar{n}$. This equation permits the construction of one price per housing market. More specifically, these constant levels are computed as the average value of the structural and neighborhood variables. Note that $p_1 = 1$. The index will be normalized by multiplying by 100 so that $p_1 = 100$.

The next step is to estimate the quantity of housing services H_i. H_i is equal to the value of these services divided by the price per unit of services. Since the value of a house is the present discounted value of the stream of services provided by that house, the annualized value of these services is $r * P_i$, where r is the user cost of housing and P_i is the market value of unit i. The quantity of housing services is $H(s_i, n_i)$ and is now explicitly expressed as a function of different amounts of structure s_i and neighborhood characteristics n_i. The notation for the market value of unit i, given the corresponding value of housing services $H(s_i, n_i)$ is $P(s_i, n_i)$. The following equation demonstrates the relationship between $H(s_i, n_i)$ and p:

$$H(s_i, n_i) = \frac{r * P(s_i, n_i)}{p} \qquad (6)$$

where p is the price of a unit of housing services.

Substituting P_{hj} from equation (4) and p_j from equation (5) into equation (6) yields the following expression of the quantity of housing services for a house h:

$$H(s_i, n_i) = \frac{r.P(s_i,n_i)}{p} = \frac{r.e^{(\alpha_{0j} + \alpha_{1j} * \ln(s_h) + \alpha_{2j} * \ln(n_h))}}{\frac{e^{(\alpha_{oj} + \alpha_{1j}\, ln(\bar{s}) + \alpha_{2j}\, ln(\bar{n}))}}{e^{(\alpha_{o1} + \alpha_{11}\, ln(\bar{s}) + \alpha_{21}\, ln(\bar{n}))}}}$$

$$= r * e^{(\alpha_{o1} + \alpha_{11}\, ln(s_h) + \alpha_{21}\, ln(n_h) + (\alpha_{1j} - \alpha_{11}) * (\ln(s_h) - ln(\bar{s})) + (\alpha_{2j} - \alpha_{21}) * (\ln(n_h) - ln(\bar{n})))} \qquad (7)$$

Equation (7) reflects the deviation of the coefficients for s_h and n_h in market j from those in the base market. This deviation is captured by the difference between the coefficient α_{1j} in market j and the coefficient α_{11}in the based market 1. Similarly, equation (7) also reflects the deviation in the amounts of s_h and n_h embodied in house h as compared to the standard package $\bar{s}$ and $\bar{n}$. The deviation is captured by the difference between $ln(s_h)$ and $ln\,\bar{s}$ and between $ln(n_h)$ and $ln(\bar{n})$.

Going back to equation (6), taking the natural log of (6) gives:

$$\ln[H(s_i, n_i)] = \ln(r) + \ln[P(s_i, n_i)] - \ln(p) \qquad (8)$$

Note that in the housing demand equation, the term *r* will be subsumed in the constant term. The constancy of r is based on the assumption that the user cost *r* is fixed across MSAs and a change in *r* does not affect the variation of the housing services quantity in terms of the market value of the house and thus will be ignored in the construction of the housing services term. Given the estimated p value, the relationship between $H(s_i, n_i)$ and p demonstrated in equation (6) will allow the construction of $H(s_i, n_i)$. At this point, the demand equation for housing services can be estimated. The next section of the paper will revisit the steps to estimate the demand equation as well as present the selection of variables from different data sources used for the analysis in 2005 and 2011.

V. Data

Data sources and data manipulation

For the hedonic regression, the selection of the independent variables is based on previous research on the hedonic regressions and Fannie Mae's Uniform Residential Appraisal Report (URAR). The URAR provides a concise list of the most important housing structural features used to establish fair market value[9] for sellers and purchasers. This list consists of three categories: foundation, exterior description and interior description. In this research project, the selected housing structural variables include the number of full bathrooms, the number of full bedrooms and the age of the unit and its square, as well as dummy variables indicating the presence of central air conditioner, open cracks, fireplace, garage, outside water leaks and porch.

The hedonic regression also incorporates neighborhood characteristics. Neighborhood variables include demographic and other neighborhood characteristics. Data on actual demographic neighborhood characteristics are unavailable. Therefore, owner characteristics can be used as proxy for socioeconomic characteristics of neighbor because they are highly correlated (Kiel and Zabel 1998). These variables include the age of householder, current household income and dummy variables for high school graduate, married, male and Black. In addition, following Zabel's (2004) argument, length of tenure and its square is also incorporated to capture the overvaluation of house prices by owners. For the analysis in 2005, other

[9] Fair market value is the price that property would sell for on the open market. It is the price that would be agreed on between a willing buyer and a willing seller, with neither being required to act, and both having reasonable knowledge of the relevant facts (IRS Publication 561).

neighborhood characteristics include dummy variables for whether or not there is serious neighborhood crime in the past 12 months and if public transportation is available. This paper compares the structural change in housing demand in 2005 and 2011. Ideally, this paper would study the effect of crime and public transportation on housing demand in both periods. However, because of data unavailability, a number of neighborhood variables are eliminated from the AHS in 2011. Aside from demographic variables, the only common neighborhood variable available in both years is the householder's rating of the neighborhood. This variable will serve as proxy for crime and public transportation, as well as other neighborhood characteristics. To justify this, the correlation statistics between the homeowner's rating, crime and public transportation variable will be computed. In addition, it is possible that this variable takes into account other unobservable neighborhood characteristics. As the structural test is one of the main focus of this research paper, only the result of the analysis using the homeowner's rating variable for 2005 and 2011 is reported. The justification of the use of crime and public transportation variables and the result of the housing demand equation that incorporates these two variables in 2005 is provided in the appendix.

The study uses data for owner-occupied housing from the Public-Use Microdata in the American Housing Survey (AHS), provided by the U.S. Department of Housing and Urban Development. The study uses the national version of the AHS for 2005 and 2011. The raw data consists of 128 MSAs with 26,493 observations in 2005. The first data manipulation step is selecting the variables of interest and omitting observations that have missing data on any of these variables. The missing data are denoted as -9 if the data are not reported, -8 if the interviewee refuses to provide the information, -7 if the interviewee does not know about the requested information and -6 if the question if not applicable. This data omission process reduces the number of observations to 10,075. The second step is choosing MSAs that have at least 100 observations. The purpose of choosing 100 observations per MSA is to reduce the variance in the estimated parameters in each hedonic regression, and ensure the inclusion of enough MSAs to increase the unbiasedness of the housing demand equation. This selection process reduces the number of MSAs to 33 with the corresponding observations of 6,883 in 2005. In 2011, the AHS combines the metropolitan and national data into a file consisting of 128 MSAs with 186,448 observations. This combination requires an additional step of extracting the data from the national version before applying the first data manipulation step, which reduces the raw data file to 33 MSAs with 7,764 observations. The list of these MSAs with the corresponding geographical code PMSA is given in Table 1.

Table 1: List of MSAs with PMSA code and number of observations in 2005 and 2011

	PMSA Code	**MSA**	**2005**	**2011**
1	360	Anaheim-Santa Ana-Garden Grove, CA	N/A	179
2	520	Atlanta, GA	N/A	143
3	720	Baltimore, MD	165	146
4	875	Bergen-Passaic, NJ	125	109
5	1120	Boston, MA	216	222
6	1600	Chicago, IL	485	455
7	1680	Cleveland, OH	162	148
8	1920	Dallas, TX	170	180
9	2160	Detroit, MI	488	491
10	2680	Fort Lauderdale-Hollywood, FL	129	N/A
11	2800	Fort Worth-Arlington, TX	108	121
12	3360	Houston, TX	197	211
13	3760	Kansas City, MO-KS	113	117
14	4480	Los Angeles-Long Beach, CA	505	1341
15	5000	Miami-Hialeah, FL	151	155
16	5080	Milwaukee, IL	104	114
17	5120	Minneapolis – Saint Paul, MN	212	202
18	5380	Nassau-Suffolk, NY	251	225
19	5600	New York City, NY	453	487
20	5640	Newark, NJ	133	147
21	5720	Norfolk-Virginia Beach, VA-NC	120	129
22	5775	Oakland, CA	176	168
23	6160	Philadelphia, PA-NJ	506	562
24	6200	Phoenix, AZ	236	240
25	6280	Pittsburg, PA	151	147
26	6780	Riverside-San Bernardino, CA	147	131
27	6920	Sacramento, CA	102	N/A
28	7040	Saint Louis, MO-IL	150	131
29	7240	San Antonio, TX	114	100
30	7320	San Diego, MO-IL	179	163
31	7360	San Francisco, CA	134	117
32	7400	San Jose, CA	116	115
33	7600	Seattle, WA	159	151
34	8280	Tampa-Saint Petersburg – Clearwater, FL	161	152
35	8840	Washington, DC-MD-VA	264	265
Total			6883	7764

The definition and the description of all variables in the hedonic and demand regression is given in Table 2. This information is obtained from the Codebook for the American Housing Survey: Public Use File: 1997-2011 version 2.1. The document was revised in March 2013.

Table 2: Variable Definitions in the Hedonic and Demand Regressions		
Variable	**Definition**	**Description**
VALUE	Current market value of unit in dollars	The information is collected for all owner-occupied units, but is not collected for renter-occupied units. For owner-occupied units, value represents the respondent's estimate of the property's sale price (house and lot) if it were for sale.
LnVALUE	Log of VALUE	
HOUSESER	Housing services per unit	
LnHOUSESER	Log of HOUSESER	
HPRICE	Hedonic price in dollars	
LnHPRICE	Log of HPRICE	
AIRSYS	Dummy variable, 1 if there is a central air conditioner	A "central system" is a central installation which air-conditions the entire housing unit. In an apartment building, a central system may cool all apartments in the building, each apartment may have its own central system, or there may be several systems that provide central air conditioning for a group of apartments. A central installation with individual room controls is a central air-conditioning system.
BATHS	Number of full bathrooms in unit	Bathrooms: A unit has a full bathroom if it has a room with a flush toilet, bathtub or shower, a sink, and hot and cold piped water in the structure for the exclusive use of the occupants of the unit.
BEDRMS	Number of bedrooms in unit	Bedrooms: The number of bedrooms in a housing unit is the count of rooms used mainly for sleeping, even if also used for other purposes. Rooms reserved for sleeping, such as guest rooms, even though used infrequently, are counted as bedrooms.
AGEUNIT	Number of years since the year the unit was built to the year 2005	
AGEUNITSQ	Square of *AGEUNIT*	
CRACKS	Dummy variable, 1 if there is an open crack wider than a dime	
FPLWK	Dummy variable, 1 if there is a useable fireplace	
GARAGE	Dummy variable, 1 if garage or carport is included with unit	

Table 2: Variable Definitions in the Hedonic and Demand Regressions		
Variable	**Definition**	**Description**
LEAK	Dummy variable, 1 if there is any outside water leaks in last months	
PORCH	Dummy variable, 1 if there is porch/deck/balcony/patio	A porch, deck, or balcony must be attached to the unit, not only to the building. It can be open or enclosed. It must measure at least 4 by 4 feet. An enclosed porch used for year-round living and reported as a room is not reported as a porch to avoid double counting.
METRO	Dummy variable, 1 if the unit locates in the central of an MSA	
CRIME	Dummy variable, 1 if there is serious neighborhood crime in last 12 months	This category refers to all forms of street and neighborhood crime, such as petty theft, assaults against the person, burglary, or any related activities that the respondent judges to be a crime.
PUBTRAN	Dummy variable, 1 if there is public transportation available	
HOWN	Dummy variable, 1 if the householder is satisfied with the neighborhood	Rating of neighborhood as place to live neighborhood on a scale of 1 to 10
PER	Number of persons in household	
HHAGE	Age of householder	The classification refers to the age reported for the householder as of that person's last birthday.
HHAGESQ	Square of *HHAGE*	
HHAGECUB	Cube of *HHAGE*	
HHGRAD	Dummy variable, 1 if householder graduates from high school	
HHMAR	Dummy variable, 1 if householder is married	
HHBLACK	Dummy variable, 1 if household is Black	
HHMALE	Dummy variable, 1 if householder is a male	
HHMOV	Years that household have resided in the house	
HHMOVSQ	Square of *HHMOV*	
HINC	Household income in dollars	The household income recode is the sum of the wage & salary income of all household members age 14+ and all other reported income.
LnHINC	Log of *HINC*	
PINC	Household permanent income in dollars	
LnPINC	Log of *PINC*	

The next data manipulation process is described as the following: For the dummy variables *AIRSYS*, *CRACKS*, *FPLWK*, *GARAGE*, *LEAK* and *PORCH*, the raw data denotes 1 for any houses that have these characteristics and 2 if they do not. The value of 2 is recoded to 0 in the data set. The raw data does not provide the variable *AGEUNIT* but does provide data on the year the unit was built, which is denoted as *BUILT* in the AHS code book. *AGEUNIT* is then calculated by taking difference between 2005 (or 2011) and *BUILT*. *HOWN* shows the householder's rating of the neighborhood. More specifically, 0 denotes no neighborhood, and 1 to 10 denotes the householder's rating with 10 for best and 1 for worst. Observations with value of 0 are omitted, while 0 denotes below average rating and 1 denotes above average ratings. In specific, all values ranging from 1 to 5 is recoded to 0 and all values ranging from 6 to 10 is recoded to 1. For *HHGRAD*, the raw data has a series of number that represent the education level of householders. The values of these number range from 31 to 47. Any value less than 39 indicates that the person is not a high school graduate. For example, 33 indicates that the person has the highest education level of either 5th or 6th grade; 38 indicates that the person has the highest education level of 12th grade. Any value greater than or equal to 39 indicates that the person is a high school graduate. For example, 43 indicates that the person has an associated degree in college through an academic program; 47 indicates that the person has a doctorate degree. This research project adopts high school as the compared education level. For this purpose, the values within the range 31 and 38 are recoded to 0 to indicate that the person is not a high school graduate. Likewise, any values within the range 39 to 47 are recoded to 1 indicate that the person is a high school graduate.

For *HHMAR*, the raw data also has a series of numbers that represent the marital status of the householder. In specific, the raw data denotes 1 if the interviewee is married with spouse present; 2 if married with spouse absent, 3 if widowed, 4 if divorced, 5 if separated, 6 if never married. The values 1, 2 and 5 in the raw data are recoded to 1 to indicate that the person is married and the values 3, 4 and 6 is recoded to 0 to indicate that the person is not married. For *HHRACE*, the raw data has a series of numbers ranging from 1 to 21 to represent the race of the householder. For example, 1 denotes if the person is White only; 2 denotes if the person is Black only; 10 denotes if the person has mixed races of Black and American Indian or Alaska Native; 16 denotes if the person has a mixed races of White, Black and Asian. The construction of the Black-only dummy variables requires the recoding of the value 2 to 1 to indicate that the person is Black only, and the value of 1 as well as all values ranging from 3 to 21 to 0 to indicate that the person is not Black only. For *HHMALE*, the raw data denotes 1 for male and 2 for female. The value of 2 is recoded to 0 in the data set. For *HHMOV*, the data does not provide the information on the years that household have resided in the house, but provides data on the year householder moved in, which is denoted as *HHMOVE* in the AHS code book. Similar to the process of data manipulation applied to *AGEUNIT*, *HHMOV* is obtained by subtracting the data on *HHMOVE* from the number 2005 and 2011. For *HINC*, all observations that have negative or $0 current household income are omitted from the analysis. This omission of data is due to the later logarithmic transformation in the hedonic price and housing demand regression.

Descriptive Statistics

Table 3 provides descriptive statistics of all variables used in the analysis in 2005. There are 6,883 observations in the analysis in 2005. The respondent's estimate of the property's sale price if it were for sale (*VALUE*) ranges from $1 to $1,540,794. On average, the respondents estimate their property's sale price (*VALUE*) to be $357,809. The corresponding standard deviation of $345,102.54 is relatively large. This indicates that the respondents' estimates of the property's sale price (*VALUE*) are not concentrated around the mean value. Current household income (*HINC*) ranges from $1 to $878,728. Out of 6883 observations, there are 42 observations that have the value of *VALUE* smaller than $1,000. On average, current household income (*HINC*) is $84,144.87 and permanent household income (*PINC*) is $62,015.81. After the construction of the hedonic price using Baltimore as the comparison MSA, the price per unit of housing services (*HPRICE*) ranges from $34 to $371. On average, the price per unit of housing services (*HPRICE*) is $66.847. From the generated hedonic price, the quantity of housing services (*HOUSESER*) is calculated with the range of value between 0.0067 and 35,715.89. On average, the quantity of housing services (*HOUSESER*) is 2,923.46 units. As indicated in the conceptual model, the quantity of housing services (*HOUSESER*) is measured in an arbitrary unit that reflects both structural and neighborhood characteristics of a house.

Table 3: Descriptive statistics of all variables used in the model with 6883 observations in 2005						
Variable	**Minimum**	**Maximum**	**Mean**	**Median**	**Mode**	**Standard Deviation**
VALUE	1	1,540,794	357,809	250,000	-	345,102.54
HPRICE	34	371	122.46	-	-	66.85
HOUSESER	0.0067	35,715.89	2,923.46	-	-	2,535.55
AIRSYS	0	1	-	1	1	0.47
BATHS	0	7	-	2	2	0.71
BEDRMS	0	8	-	3	3	0.94
AGEUNIT	0	86	46.82	-	-	22.48
CRACKS	0	1	-	0	0	0.18
FPLWK	0	1	-	0	0	0.50
GARAGE	0	1	-	1	1	0.42
LEAK	0	1	-	0	0	0.32
PORCH	0	1	-	1	1	0.30
HOWN	0	1	-	1	1	0.26
PER	1	13	-	1	2	1.52
HHAGE	16	92	52.83	-	-	16.05
HHGRAD	0	1	-	1	1	0.33
HHMAR	0	1	-	1	1	0.48
HHBLACK	0	1	-	0	0	0.32
HHMALE	0	1	-	1	1	0.49
HHMOV	0	86	15.13	-	-	14.16
HINC	1	878,728	84,144.87	-	-	81,798.50
PINC	4,394.67	101,110.23	62,015.81	-	-	25,482.56

Table 4 provides descriptive statistics of all variables used in the analysis for year 2011. For 2011, the range for the respondent's estimate of the property' sale price (*VALUE*) increases to $4,414,135. However, the average property's sale price (*VALUE*) reduces to $343,091. This implies that compared to 2005, there is a significant increase in at least a few property's sale price across the U.S while the majority of property's value decreases. The range of current household income increases to $1,497,552. On average, current household income also increases to $93,139 and permanent household income increases to $67,813. The quantity of housing services increases to 2,927.84 units.

Table 4: Descriptive statistics of all variables used in the model with 7763 observations in 2011

Variable	**Minimum**	**Maximum**	**Mean**	**Median**	**Mode**	**Standard Deviation**
VALUE	2	4,414,135	343,091	250,000	-	352,174.5169
HPRICE	41	285	118.80	-	-	57.01
HOUSESER	0	51,382	2,927.84	-	-	2,630.36
AIRSYS	0	1	-	1	1	0.47
BATHS	0	8	-	2	2	0.77
BEDRMS	0	8	-	3	3	0.94
AGEUNIT	0	92	51.50	-	-	23.79
CRACKS	0	1	-	0	0	0.20
FPLWK	0	1	-	0	0	0.50
GARAGE	0	1	-	1	1	0.39
LEAK	0	1	-	0	0	0.34
PORCH	0	1	-	1	1	0.32
HOWN	0	1	-	1	1	0.28
PER	1	14	-	2	2	1.53
HHAGE	18	93	55.19	-	-	15.60
HHGRAD	0	1	-	1	1	0.30
HHMAR	0	1	-	1	1	0.49
HHBLACK	0	1	-	0	0	0.32
HHMALE	0	1	-	1	1	0.50
HHMOV	0	87	17.04	-	-	14.43
HINC	9	1,497,552	93,139.08	-	-	90,397.40
PINC	6,393.06	109,377.37	67,812.68	-	-	27,821.71

In comparing the two years, a typical house in 2005 and 2011 has 2 bathrooms and 3 bedrooms with 2 people in the household. The values of the mode for categorical variables indicate that most houses in the sample have a central air conditioning, a garage, a porch and do not have open cracks, a useable fireplace or outside water leaks in last months. By the year 2005, the houses in the sample were 47 years old on average. By the year 2011, the houses in the sample were 51 years old on average. Most householders in the sample are satisfied with living in the neighborhood. Most householders in the sample are male, married and are high school graduates.

An examination of pairwise correlation statistics among the independent variables in the hedonic regression is used to test for possible multicollinearity among these variables. In order to fully investigate correlation in this case, it is necessary to create 33 matrices that demonstrate pairwise correlation among the independent variables. As an example, Appendix Table 3 provides the result of the pairwise correlation for Baltimore in 2005. Overall, there is not a significant high correlation between the independent variables. The pair of independent variables that has the highest pairwise correlation is *HHAGE* and *HHMOV*. This result accords with the expectation because the age of householders is likely to be associated with owner tenure in current home. The older the householder gets, the longer the householder is likely to have resided in the house or vice versa. The pair of independent variables that has the second highest pairwise correlation value is *AIRSYS* and *AGEUNIT* with the value of -0.504. This result is also expected because as the age of a house increases, the less likely that the house has a central air conditioner.

Appendix Table 4 provides the result of pairwise correlation for Phoenix in 2011. In the case of Phoenix, *HHAGE* and *HHMOV* also show the highest pairwise correlation with the value of 0.513. However, the correlation coefficient between *AIRSYS* and *AGEUNIT* is only 0.001, which is not high. *HHAGE* and *HHMOV* consistently have the highest pairwise correlation values across MSAs. These value are, however, not significantly high. The correlation between *AIRSYS* and *AGEUNIT* varies depending on MSA. The pairwise correlations between all other independent variables are consistently not high, therefore the hedonic regression model does not suffer from severe correlation in general.

Table 5 and 6 provide the correlation statistics for the demand regression equation. Among the variables used in the housing demand equation, *HHAGE* and *HHMOV* also have the highest correlation value (0.667 for 2005 and 0.655 for 2011). The pair of independent variables that has the second highest pairwise correlation coefficient is *PER* and *HHMAR* (0.474 for 2005 and 0.468 for 2011). This result matches the expectation because the larger the size of the household, the more likely that the householder is married. The correlation value of other pairs of independent variables do not imply high correlation. Similar to the hedonic regression model, the variables in the demand regression model does not suffer from severe correlation. In the next section, details about empirical process and findings will be discussed.

Table 5: Pairwise correlation statistics for variables used in the demand equation regression in 2005

	HPRICE	*HINC*	*PER*	*HHAGE*	*HHGRAD*	*HHMAR*	*HHBLACK*	*HHMALE*	*HHMOV*
HPRICE	1	0.118**	0.036**	0.033**	0.0128	0.031**	-0.0420	-0.0144	0.030*
HINC	0.118**	1	0.200**	-0.1900	0.186**	0.243**	-0.1090	0.135**	-0.1720
PER	0.036**	0.200**	1	-0.3500	-0.0840	0.474**	0.0150	0.144**	-0.2410
HHAGE	0.033**	-0.1900	-0.3500	1	-0.1350	-0.1490	0.0135	-0.0610	0.667**
HHGRAD	0.0128	0.186**	-0.0840	-0.1350	1	0.041**	-0.0490	0.0223	-0.1050
HHMAR	0.031**	0.243**	0.474**	-0.1490	0.041**	1	-0.1170	0.336**	-0.1080
HHBLACK	-0.0420	-0.1090	0.0150	0.0135	-0.0490	-0.1170	1	-0.0880	0.034**
HHMALE	-0.0144	0.135**	0.144**	-0.0610	0.0223	0.336**	-0.0880	1	-0.0360
HHMOV	0.030*	-0.1720	-0.2410	0.667**	-0.1050	-0.1080	0.034**	-0.0360	1

Note: *. Correlation is significant at the 5% level (2-tailed).
**. Correlation is significant at the 1% level (2-tailed).

Table 6: Pairwise correlation statistics for variables used in the demand equation regression in 2011

	HPRICE	*HINC*	*PER*	*HHAGE*	*HHGRAD*	*HHMAR*	*HHBLACK*	*HHMALE*	*HHMOV*
HPRICE	1	0.147**	0.060**	0.031**	0.0101	0.045**	-0.0200	-0.0240	0.047**
HINC	0.147**	1	0.185**	-0.2000	0.175**	0.263**	-0.1080	0.113**	-0.1840
PER	0.060**	0.185**	1	-0.3440	-0.0970	0.468**	-0.0167	0.125**	-0.2210
HHAGE	0.031**	-0.2000	-0.3440	1	-0.1100	-0.1670	0.027*	-0.0710	0.655**
HHGRAD	0.0101	0.175**	-0.0970	-0.1100	1	0.0047	-0.0083	-0.0064	-0.0780
HHMAR	0.045**	0.263**	0.468**	-0.1670	0.0047	1	-0.1260	0.299**	-0.1340
HHBLACK	-0.0200	-0.1080	-0.0167	0.027*	-0.0083	-0.1260	1	-0.1070	0.052**
HHMALE	-0.0240	0.113**	0.125**	-0.0710	-0.0064	0.299**	-0.1070	1	-0.0700
HHMOV	0.047**	-0.1840	-0.2210	0.655**	-0.0780	-0.1340	0.052**	-0.0700	1

Note: *. Correlation is significant at the 5% level (2-tailed).
**. Correlation is significant at the 1% level (2-tailed).

Empirical Process and Findings

Empirical Process

A separate hedonic equation is estimated for each MSA prior to estimating the housing demand equation. For the hedonic equations, the dependent variable is the market value of the housing unit. The independent variables are the housing structural characteristics and neighborhood characteristics. The result of the coefficients generated from the hedonic regression equation is then used to construct the price index. Certain prediction about the relationship between the market value of a house and certain structural and neighborhood characteristics can be made based on past research and common observations. More specifically, it is expected there is a positive relationship between the market value of a house and the following variables: number of full bathrooms, number of full bedrooms, central air conditioner, fireplace, garage, porch, homeowner's rating of the neighborhood, percent of high school graduates, and current household income. On the other hand, a negative relationship is expected between the market value of a house and the following variables: the age of a unit, open cracks, outside water leaks, and Black. The relationships between the market value of a house and the age of householder, owner tenure in current home, married and male remains ambiguous.

After the construction of the hedonic price index and housing services, the log-log housing demand equation for the MSAs is estimated. For this equation, the dependent variable is the quantity of housing services. The independent variables consist of the hedonic price, current household income, owner demographic characteristics that might affect preferences including household sizes, owner tenure in current home and its square and dummy variables indicating married, graduated from high school and Black. Among these variables, the variables of interest are the hedonic price and current household income. The rest are control variables. Quantity of housing services is expected to have a positive relationship current household income, high school graduate, number of person in the household, married and a negative relationship with the hedonic price, owner tenure in current home and Black. The result of the estimated parameters from the housing demand equation will allow the testing of the hypotheses stated in the introduction.

Apart from the housing model that incorporates current household income, a second housing model that incorporates permanent household income is constructed. According to Olsen

(1987), it is standard practice to use permanent rather than current household income in the housing demand because households are likely to make the decision on the quantity demanded for housing services based on permanent rather than current household income. Permanent household income elasticity is expected to be higher than current household income elasticity because quantity demanded for housing services is more responsive to a change in permanent rather than current household income. Permanent household income is defined as the predicted value from the regression of the log of current household income on age and its square and dummy variables indicate if the householder is a male, a high school graduate, Black, married and whether or not the unit lies in the central city of MSA (Zabel 2004). The MSA dummy variable is included to capture differences in the cost-of-living across MSAs.

Finally, the presence of a structural break in the housing demand equation between 2005 and 2011 is tested using the Chow test. The result of this test will provide insights about the impact of the 2007 recession on the structural housing demand.

Hedonic Regression Results and Price Index Construction

Summary information on the hedonic regressions for 33 MSAs in 2005 and 2011 are provided in Table 7. Among these variables, the values of the coefficients for *GARAGE*, *PORCH* and *HHGRAD* have the widest range in 2005. The value of the coefficient for *GARAGE* ranges from -1.315 to 1.009. The value of the coefficient for *PORCH* ranges from -0.636 to 1.175, and the value of the coefficient for *HHGRAD* ranges from -0.569 to 1.777. These suggest that the impact of the presence of a garage, a porch and educational level on the market value of a house varies significantly across MSAs in 2005. In 2011, apart from *GARAGE* and *HHGRAD*, the value of the coefficient for *AIRSYS* also has a wide range from -0.282 to 1.075. These suggest that the impact of the presence of a garage, a central air-conditioner and educational level on the market value of a house varies significantly across MSAs in 2011. The weighted mean values of the coefficient for *HHAGE* (0.004 in 2005 and 0.002 in 2011) and *AGEUNIT* (-0.005 in 2005 and -0.007 in 2011) are relatively small compared to the weighted mean values of the coefficients for other variables used in the hedonic regression. This suggests that overall, the age of the householder and the age of the house imposes the least impact on the market value of the house. Detailed regression results may be found in Appendix Tables 5 and 6.

Table 7: Summary of Coefficients from Hedonic Regressions for 2005 and 2011								
	Summary of 2005 Coefficients				Summary of 2011 Coefficients			
Variable	Min	Max	Weighted Mean	Median	Min	Max	Weighted Mean	Median
AIRSYS	-0.775	1.325	0.160	0.116	-0.282	1.075	0.170	0.172
BATHS	-0.177	0.406	0.148	0.170	-0.075	0.471	0.200	0.206
BEDRMS	-0.039	0.676	0.162	0.140	-0.034	0.333	0.132	0.121
AGEUNIT	-0.050	0.027	-0.005	-0.005	-0.037	0.028	-0.007	-0.013
AGEUNITSQ	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
CRACKS	-0.626	1.129	0.025	0.066	-0.910	0.581	-0.088	-0.026
FPLWK	0.042	0.590	0.276	0.274	-0.113	0.795	0.253	0.225
GARAGE	-1.315	1.009	0.195	0.193	-0.191	1.114	0.169	0.126
LEAK	-0.657	0.435	-0.019	0.009	-0.381	0.374	-0.013	-0.010
PORCH	-0.636	1.175	0.137	0.103	-0.622	0.926	-0.017	-0.019
HOWN	-0.390	0.842	0.196	0.162	-0.176	0.939	0.257	0.239
HHAGE	-0.008	0.030	0.004	0.003	-0.012	0.021	0.002	0.003
HHGRAD	-0.569	1.777	0.165	0.154	-0.731	0.833	0.155	0.143
HHMAR	-0.627	0.262	-0.008	0.028	-0.212	0.300	-0.003	-0.017
HHBLACK	-1.254	0.350	-0.228	-0.135	-0.638	0.321	-0.203	-0.203
HHMALE	-0.251	0.160	-0.017	-0.015	-0.197	0.214	-0.004	0.000
HHMOV	-0.041	0.024	-0.006	-0.005	-0.023	0.119	0.006	0.003
HHMOVSQ	0.000	0.001	0.000	0.000	-0.001	0.001	0.000	0.000
LnHINC	-0.031	0.661	0.176	0.117	0.013	0.336	0.145	0.144
INTERCEPT	4.614	11.972	8.837	8.631	5.310	11.058	9.121	9.262

The coefficients generated from the hedonic regression allows the construction of the price per unit of housing services. At this point, the relationship between housing structural and neighborhood variables and current market value of the unit can be studied. Table 8 provides information about the expected sign of the variables with respect to *VALUE* and the associated number of MSAs that have the results matching the expected sign.

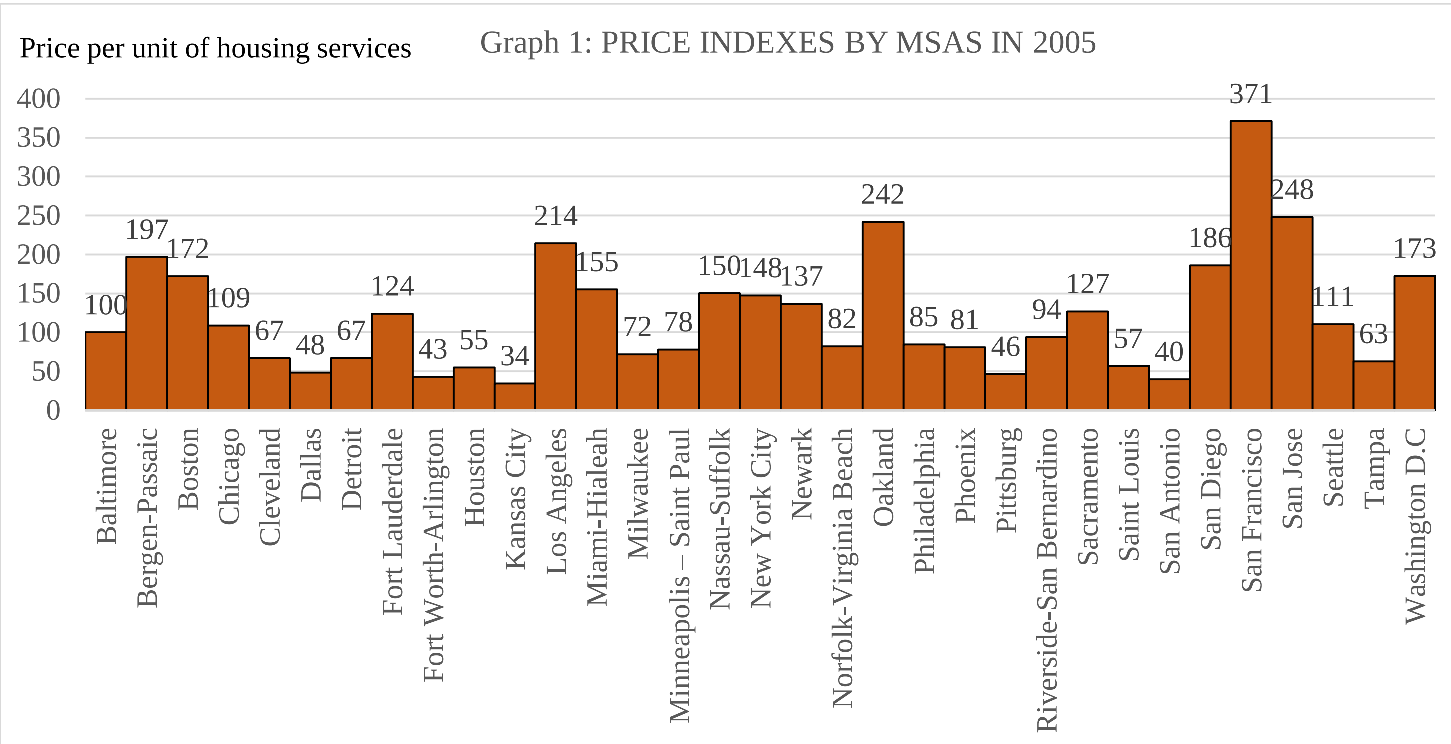
Table 8: Expected sign of the hedonic regression and the associated number of MSAs that have result matching the expected sign in 2005 and 2011			
Variables	**Expected sign**	**2005**	**2011**
AIRSYS	Positive	25	23
BATHS	Positive	29	31
BEDRMS	Positive	32	32
AGEUNIT	Negative	24	24
CRACKS	Negative	14	19
FPLWK	Positive	33	30
GARAGE	Positive	26	25
LEAK	Negative	16	18
PORCH	Positive	22	13
HOWN	Positive	29	30
HHAGE	Ambiguous	N/A	N/A
HHGRAD	Positive	25	26
HHMAR	Ambiguous	N/A	N/A
HHBLACK	Negative	24	29
HHMALE	Ambiguous	N/A	N/A
HHMOV	Negative	20	14
HINC	Positive	30	33

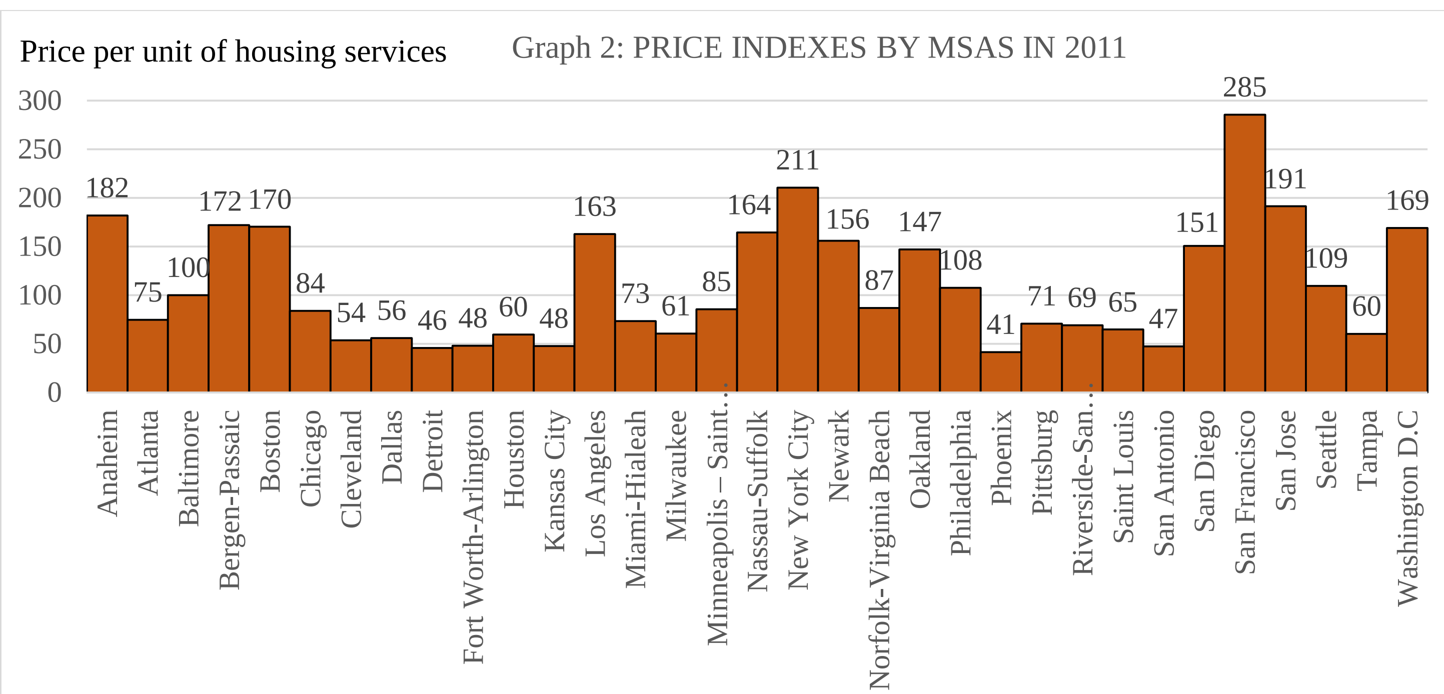
Overall the hedonic regressions show a positive relationship between *VALUE* and *AIRSYS, BATHS, BEDRMS, FPLWK, GARAGE, CRACKS, LEAK, PORCH, HOWN, HHGRAD* and *LnHINC*. Among these variables, notice that neighborhoods that have more high school graduates and higher current household income increase property values. The signs for the coefficients of *CRACKS* and *LEAK* do not match the prediction. The results are, however, not statistically significant. The hedonic regression shows that there is negative relationship between *VALUE* and *AGEUNIT*, *HHMALE*, *HHMOV,* and *HHBLACK*. In general, the results also match the expectation. Neighborhoods that have predominantly Black householders and transient population have a negative impact on property values. As expected, neighborhoods with satisfied residents increase property values. An interesting result is the sign the coefficient for *HHMALE*. This implies that neighborhoods that have male householders decreases property value. The result, however, is not statistically significant.

The result for the coefficients *BEDRMS* and *BATHS* are consistently significant across MSAs in both 2005 and 2011. The results show that bedroom and bathroom are the two most important housing structural characteristics and have a positive impact on the market value of the house. The magnitude of the coefficients for *BEDRMS* fluctuates across MSAs. For example, an increase of one bedroom increases the market value of the house in Houston in 2005 by 13.93 percent on average, ceteris paribus. On the other hand, an increase of one bedroom increases the market value of the house in Detroit by 25.5 percent on average, ceteris paribus. In 2011, an increase of one bathroom increases the market value of the house in New York City by 18.5 percent on average, ceteris paribus. In addition to *BEDRMS* and *BATHS*, the positive sign of *LnHINC* is also consistently significant across MSAs. This implies that neighborhoods that have higher current household income are likely to increase the values of the houses lying within that neighborhood. For example, a one percent increase in current household income of a neighborhood increases the market value of a house in Seattle in 2005 by 0.4585 percent on average, ceteris paribus. In 2011, a one percent increase in current household income of a neighborhood increases the market value of a house in Philadelphia by 0.0955 percent on average, ceteris paribus. Similar to the case of *BEDRMS*, the coefficient for *LnHINC* fluctuates across MSAs. This suggests that a one percent increase in current household income of a neighborhood increases property values at different rates across MSAs.

Among the dummy variables, *FPLWK* has parameters that are consistently significant across MSAs. The effect of a change in *FPWLK* on the value of a house varies among MSAs. For example, in Los Angeles, houses with useable fireplaces have property values that are 15.57% higher in 2005 and 29.71% in 2011 than those do not. Likewise, the difference in property values relative to the presence of a fireplace decreases from 21.55% in 2005 to 20.89% in San Antonio. The coefficients of the demographic variables explain the effect of different demographic characteristics on property values across MSAs. In Pittsburg in 2005, houses with Black householders have property values that are 26.94% lower than those with householders associated with other races. In 2011, this value decrease to 7.86%. Houses with householders who are high school graduates have property values that are 61.06% higher than those with householders associated with lower education levels in Minneapolis – Saint Paul in 2005, and this difference decreases to 21.56% in 2011. The difference in property values associated with different educational levels increases from 63.41% in 2005 to 83.31% in 2011 in Baltimore.

From the hedonic regression, a price index is then constructed for each MSA. Graph 1 and 2 provide the results for each constructed price index that is associated with each MSA in 2005 and 2011 respectively.





From Graph 1 and 2, the price per unit of housing services in San Francisco is observed to be the highest. In 2005, this value is 371 and in 2011, this value decreases to 285. The MSAs that have the lowest value of price per unit of housing services are Kansas City (with the value of 34) in 2005 and Phoenix (with the value of 41) in 2011. Overall, there is a decrease in the price per unit of housing services across MSAs from 2005 to 2011. However, the change in the price per unit of housing services varies among MSAs. In some areas including San Diego, New York City and Los Angeles, price per unit of housing services decreases significantly. On the other hand, in other MSAs such as Newark, Philadelphia and Saint Louis, price per unit of housing services rises significantly. This change in price implies a change in housing services demand between these two periods. The test for this structural change will be provided later in the paper.

Constructions of Permanent Income

As indicated in Empirical Process, permanent household income is calculated as the predicted value from the regression of the log of current household income on the age of the householder and its square and dummy variables indicates if the householder is a male, a high school graduate, Black, married and whether or not the unit lies in the central city of MSA. These results are provided in Table 9.

Table 9: Regression result used to construct		
Variable	**2005**	**2011**
HHAGE	0.0513 (0.0047)	0.0271 (0.0043)
HHAGESQ	-0.0006 (0.0000)	-0.0004 (0.0000)
METRO	-0.1000 (0.0254)	-0.0231 (0.0221)
HHGRAD	0.6014 (0.0377)	0.6620 (0.0363)
HHMAR	0.4304 (0.0273)	0.5573 (0.0237)
HHBLACK	-0.3277 (0.0393)	-0.3119 (0.0338)
HHMALE	0.1614 (0.0261)	0.1037 (0.0225)
INTERCEPT	9.2497 (0.1280)	9.7842 (0.1235)
Observations	6882	7763
R^2	0.2178	0.2267
Note: Standard errors are in parentheses.		

The regression result in Table 9 demonstrates a positive relationship between current household income and high school graduate, married and male. On the other hand, household income shares a negative relationship with central metro status and Black. A positive sign on *HHAGE* and a negative sign on *HHAGE* suggests that *HHAGE* has a diminishing effect on *LnHINC*. Using the following formula to calculate the turning point x^* for *HHAGE* in 2005 to obtain:

$$x^* = \left| \frac{\widehat{\beta_{HHAGE}}}{2 * \widehat{\beta_{HHAGESQ}}} \right| = 42.75$$

The value of x^* means that for householders who are younger than 43 years old, age has a positive impact on current household income. For householders who are older than 43 years old, age has a negative impact on current household income. For a householder with an average age of 52.83, current household income is predicted to decrease by 1.0896 percent on average, ceteris paribus.

Among other control variables, the coefficient value of *HHGRAD* is 0.6014. This suggests that the current household income difference between householders with high school graduate degree and householders with lower education level is 60.14% on average, ceteris paribus. In 2011, this difference increases to 66.20%. A negative value of -0.3277 associated with *HHBLACK* in 2005 indicates that Black householders have current household income 32.77% lower that householders associated with other races. In 2011, this difference decreases to 31.19%. As indicated, permanent household income is constructed as the predicted value of this regression. Table 10 shows the result of the demand regression which takes into account both current and permanent household income for 33 MSAs in 2005 and 2011.

Initial Housing Services Demand Regression Results

Table 10 below provides the initial results for the housing demand regressions. Model 1 refers to the estimation of housing demand when current income is the variable used for income, and Model 2 refers the estimation of housing demand when permanent income is used as the regressor for income.

Table 10: Regression result of the housing demand equation

Variable	**2005**		**2011**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
LnHOUSESER				
LnHPRICE	-0.1194*** (0.0215)	-0.0778*** (0.0221)	-0.0775*** (0.0166)	-0.0298 (0.0171)
LnHINC	0.2355*** (0.0108)	-	0.2188*** (0.0088)	-
LnPHINC	-	0.4232*** (0.0696)	-	0.2869*** (0.0927)
PER	0.0203* (0.0092)	0.0323*** (0.0095)	-0.0052 (0.0068)	0.0075 (0.0071)
HHAGE	0.0054*** (0.0010)	0.0090*** (0.0015)	0.0038*** (0.0008)	0.0056*** (0.0016)
HHGRAD	0.3205*** (0.0365)	0.2065*** (0.0586)	0.2793*** (0.0304)	0.2463*** (0.0705)
HHMAR	0.0968*** (0.0288)	-0.0094 (0.0438)	0.1357*** (0.0216)	0.0753 (0.0582)
HHBLACK	-0.3757*** (0.0367)	-0.3114*** (0.0442)	-0.3318*** (0.0274)	-0.3119*** (0.0399)
HHMALE	-0.0033 (0.0246)	-0.0314 (0.0279)	-0.0119 (0.0183)	-0.0157 (0.0215)
HHMOV	-0.0055* (0.0026)	-0.0086*** (0.0028)	0.0054** (0.0020)	0.0035 (0.0022)
HHMOVSQ	0.0001 (0.0000)	0.0001* (0.0001)	-0.0001* (0.0000)	-0.0001 (0.0000)
INTERCEPT	5.1029 (0.1579)	2.8363 (0.7522)	5.1199 (0.1247)	4.1011 (1.0033)
Observations	6882	6882	7763	7763
R^2	0.1276	0.0728	0.1537	0.08
Note: Standard errors are in parentheses. *, **, *** indicate significant				

There are 6,882 observations in the regression**.** Model 1 incorporates current household income and Model 2 incorporates permanent household income. The R^2 value of 0.1276 for Model 1 indicates that 12.76 percent of the variation in log of housing services is explained by log of the hedonic price, log of current household income, household size, age of householder, owner tenure in current home and dummy variables that indicates if householder is a high school graduate, male, Black and married. The R^2 value in Model 2 is lower compared to Model 1 (0.0728 versus 0.1276). The R^2 value for both models in 2011 is higher than 2005. Similarly, the R^2 value for Model 2 is lower compared to Model 1 (0.08 versus 0.1537). This suggests that the incorporation of current household income improves the fitness of the housing demand regression equation rather than that of permanent household income. The variables of interest in the housing demand regression are *LnHPRICE* and *LnHINC* for Model 1 and *LnHPRICE* and *LnPHINC* for Model 2. The control variables are *PER*, *HHAGE, HHGRAD, HHMAR*, *HHBLACK*, *HHMALE, HHMOV*. The signs of all coefficients in both models accord the expectation. The negative value of *LnHPRICE* suggests that an increase in the price per unit of housing decreases the quantity demanded for housing services demanded. A positive sign of *LnHINC* and *LnPHINC* also matches the prediction that the income elasticity of demand for housing is a normal good. As current (and permanent) household income increases, households demand for more unit of housing services. Similar to the results of the hedonic regression for each 33 MSAs, the signs of the coefficients of the controlled variables *HHAGE, HHGRAD, HHMAR*, *HHBLACK* and *HHMOV* match the expectations. An interesting result is the negative relationship between *HHMALE* and *LnHOUSESER*. This suggests that male householders are likely to demand less quantity of housing services than female householders.

The value of the coefficient *LnHPRICE* in Model 1 in 2005 is -0.1194. This means that a one percent increase in the price per unit of housing services decreases the quantity demanded for housing services by 0.1194 percent on average, ceteris paribus. Compared to the value of -0.0778 in Model 2, the price elasticity in Model 1 is higher. This confirms the conjecture that quantity demanded for housing services is more responsive to a change in permanent rather than current household income. Compared to 2005, the demand for housing services in 2011 is more inelastic with respect to price for both models. In addition, all values of the coefficients *LnHPRICE* in both models in 2005 and 2011 are smaller than 1. The result confirms the first hypothesis that the demand for housing services is inelastic with respect to price. In other words, the change in quantity demanded for housing services is proportionately less than the change in the price per unit of housing services.

The value of the coefficient *LnHINC* in Model 1 in 2005 is 0.2355. This indicates that a one percent increase in current household income increases the quantity demanded for housing services by 0.2355 percent on average, ceteris paribus. The value of the coefficient *LnPHINC* in Model 2 is 0.4232. This indicates that a one percent increase in permanent household income increases the quantity demanded for housing services by 0.4232 percent on average, ceteris paribus. The value of the coefficient *LnHINC* in 2011 is 0.2188; and the value of the coefficient *LnPHINC* is 0.2869. These values indicate that compared to 2005, the demand for housing services in 2011 is more inelastic with respect to current household income and permanent household income. This result confirms the second hypothesis that the income elasticity of demand has a relatively larger magnitude than the price elasticity of demand. As expected, the permanent income elasticity is higher than the current income elasticity. The results for both variables of interest are significant at 0.5% significance level.

The interpretation of the control variables also provides insights about the impact of some demographic characteristics on the demand for housing services. In Model 1 in 2005, the coefficient value for *PER* is 0.0203. This indicates that an increase of one person in a household increases the quantity of housing services demanded by 2.03% on average, ceteris paribus. In Model 2 in 2005, the coefficient value for *PER* increases to 0.0323. This means that a change of one person per household imposes a greater impact on the quantity demanded for housing services in Model 2 compared to Model 1. The coefficient value for *HHMAR* in Model 1 in 2005 is 0.0968. This suggests that householders who are married have a quantity of housing services that are 9.68% higher than those who are not on average, ceteris paribus. In Model 2 in 2005, the coefficient of *HHMAR* has a negative value -0.0094. This means that householders who are married have a quantity of housing services that are 0.94% lower than those who are not. This interesting result suggests that when permanent household income is factored into the demand for housing services equation, marriage status has a much less significant impact on the quantity demanded for housing services compared to the case of current household income. The similar pattern can be observed in 2011 as the coefficient value of *HHMAR* is 0.1357 in Model 1 and 0.0753 in Model 2.

In Model 1 in 2005, the coefficient value for *HHMOV* is -0.0055 and *HHMOVSQ* is 0.0001. Calculating the turning point x^* yields:

$$x^* = \left|\frac{\widehat{\beta_{HHMOV}}}{2 * \widehat{\beta_{HHMOVSQ}}}\right| = 27.5$$

The value of x^* is interpreted as when householders move in fewer than 28 years, the number of years moved in has a negative impact on the quantity for housing services. After 28 years, the negative relationship turns into a positive relationship. With the average moved in years of 14, the quantity for housing services decreases by 0.29% on average, ceteris paribus. In Model 2, an average moved years of 14 decreases the quantity for housing services by 0.6% on average, ceteris paribus. In Model 1 in 2011, the sign of the coefficient for *HHMOV* and *HHMOVSQ* reverses compared to the result in 2005. The value of x^* is 27 suggests that when householders move in fewer than 27 years, the number of years moved in has a positive impact on the quantity of housing services. After 27 years, the positive relationship between the two variables change into a negative relationship. With the average of moved in year of 18, the quantity for housing services increases by 0.2% on average, ceteris paribus. In Model 2 in 2011, this value changes to 0.01%.

Testing and Correcting for Heteroscedasticity

The Breusch-Pagan test is used to investigate heteroscedasticity. The result chi-squared value from the test is 1231.44 for Model 1 and 79.57 for Model 2 for the analysis in 2005. The chi-squared value for Model 1 is 282.22 and 19.85 for Model 2 for the analysis in 2011. The p-values in both models for both years are sufficiently smaller than the 0.5% significance level. Thus, the null hypothesis of homoscedasticity is rejected. The conclusion is that the expected value of the squared of the residuals in the housing demand equation is related to at least one of the independent variables. In other words, the OLS estimator of the housing demand equation is not the best linear unbiased estimator. The problem of heteroscedasticity is then corrected by computing the robust standard errors. Table 11 provides the values of these robust standard errors for both models. Note, while heteroscedasticity is detected, the effects on the statistical significance of any coefficient is minimal.

Table 11: Regression result of the housing demand equation for 33 MSAs with robust standard errors				
Variable	**2005**		**2011**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
LnHOUSESER				
LnHPRICE	-0.1194*** (0.0188)	-0.0779*** (0.0185)	-0.0775*** (0.0181)	-0.0298 (0.0188)
LnHINC	0.2355*** (0.0265)	-	0.2188*** (0.011)	-
LnPHINC	-	0.4232*** (0.0877)	-	0.2869*** (0.0980)
PER	0.0203* (0.0086)	0.0323*** (0.0090)	-0.0052 (0.0065)	0.0075 (0.0068)
HHAGE	0.0054*** (0.0011)	0.0090*** (0.0018)	0.0038*** (0.0326)	0.0056*** (0.0017)
HHGRAD	0.3205*** (0.0440)	0.2065*** (0.0708)	0.2793*** (0.0326)	0.2463*** (0.0742)
HHMAR	0.0968*** (0.0292)	-0.0094 (0.048)	0.1357*** (0.0222)	0.0753 (0.0612)
HHBLACK	-0.3757*** (0.0351)	-0.3114*** (0.044)	-0.3318*** (0.0284)	-0.3119*** (0.0413)
HHMALE	-0.0033 (0.0274)	-0.0314 (0.032)	-0.0119 (0.018)	-0.0157 (0.0213)
HHMOV	-0.0055* (0.0025)	-0.0086*** (0.0029)	0.0054** (0.0022)	0.0035 (0.0025)
HHMOVSQ	0.0001 (0.0000)	0.0001* (0.0001)	-0.0001* (0.0000)	-0.0001 (0.0000)
INTERCEPT	5.1029 (0.2823)	2.8369 (0.9381)	5.1199 (0.1523)	4.1011 (1.0563)
Observations	6882	6882	7763	7763
R^2	0.1276	0.0728	0.1472	0.08
Note: Standard errors are in parentheses. *, **, *** indicate significant at the 5%, 1% and 0.5% significance levels respectively.				

Finally, the Chow test is used to test the structural break in the housing demand equation in both periods. The first step of the Chow test is running the housing demand regression that incorporates both data sets in 2005 and 2011 and collecting the residual sum of squares from the regression. The second step is running a separate housing demand regression for both periods and collecting the residual sum of squares resulted from each regression. The values of the residual sum of squares and the corresponding degrees of freedom from each regression allow the construction of the Chow statistic. The Chow statistic is 3.4046 for Model 1 and 3.6130 for Model 2. These values are greater than the F critical value of 2.3221 at the 1% significance level. Thus, the null hypothesis of stable parameters in both periods is rejected. In other words, there is a structural break in the estimated parameters used in the housing demand equation between 2005 and 2011. This structural break suggests there is a change in market reaction to a change in the price per unit of housing services as well as a change in the exogenous variables such as current household income from 2005 to 2011.

One concern is that the R^2 values for both models are relatively low in both years. In 2005, R^2 value is 0.1276 for Model 1 and 0.0728 for Model 2. In 2011, R^2 value is 0.1567 for Model 1 and 0.08 for Model 2. These values align with Zabel's R^2 results (0.18 for Model 1 and 0.10 for Model 2) in 2001. The results suggest that the OLS model does not explain the data very well. Possible explanations for the low R^2 value are the choice of functional forms and the possible case of non-linear budget constraints. This possibility is due to the heterogeneous feature of the housing product and the fact that the prices associated with different housing attributes vary jointly in a nonlinear way.

VI. Policy implications

Important public policy implications can be addressed using the estimated coefficients of the housing demand equation. One of the applications of the housing demand model is measuring households' response to various types of housing allowance programs. This particular application requires the use of comparative statics method, which analyzes how price and quantity react to a change in exogenous variable (Perloff 2010). In this analysis, current household income is the exogenous variable. If the amount of housing allowances is understood as an increase in current household income, then given a targeted income level and price and income elasticity of housing demand, policymakers can estimate the change in price and quantity demanded for housing services.

The theoretical framework of comparative statics is described as the following. Suppose the demand function is

$$Q_d = D(P, \theta) \tag{9}$$

and the supply function is

$$Q_s = S(P, \omega) \tag{10}$$

where Q_d and Q_s denote quantity demanded and quantity supplied respectively; P denotes price; θ and ω denote the exogenous variables that affect the change in demand and supply, respectively. In this case, θ represents current household income.

Under the market equilibrium condition, equilibrium price can be determined by equating the demand and supply equation. As the exogenous variable changes, P changes so that the equation continues to hold. Therefore, we can express P as an implicit function of θ and ω and so:

$$D(P(\theta, \omega), \theta) = S(P(\theta, \omega), \omega) \tag{11}$$

Taking the total derivative from both sides of the equation with respect to θ yields:

$$\frac{\partial D}{\partial P} * \frac{\partial P}{\partial \theta} + \frac{\partial D}{\partial \theta} = \frac{\partial S}{\partial P} * \frac{\partial P}{\partial \theta} \tag{12}$$

In order to measure the change in price with respect to the change in current household income, it is necessary to express equation (12) in terms of $\frac{\partial P}{\partial \theta}$. The mathematical steps to achieve this objective are demonstrated as the following:

$$\left(\frac{\partial D}{\partial P} - \frac{\partial S}{\partial P}\right) * \frac{\partial P}{\partial \theta} = -\frac{\partial D}{\partial \theta} \tag{13}$$

$$\frac{\partial P}{\partial \theta} = \frac{-\frac{\partial D}{\partial \theta}}{\frac{\partial D}{\partial P} - \frac{\partial S}{\partial P}} = \frac{-\frac{\partial D}{\partial \theta} * \frac{\theta}{\theta}}{\left(\frac{\partial D}{\partial P} - \frac{\partial S}{\partial P}\right) * \frac{P}{P} * \frac{Q}{Q}} = \frac{-\frac{\partial D}{\partial \theta} * \frac{\theta}{\theta}}{\left(\frac{\partial D}{\partial P} * \frac{P}{Q} - \frac{\partial S}{\partial P} * \frac{P}{Q}\right) * \frac{Q}{P}} = \frac{-\frac{\partial D}{\partial \theta} * \frac{\theta}{\theta} * \frac{P}{Q}}{\frac{\partial D}{\partial P} * \frac{P}{Q} - \frac{\partial S}{\partial P} * \frac{P}{Q}} \tag{14}$$

$$\frac{\partial P}{\partial \theta} = -\frac{\varepsilon_\theta * \frac{P}{\theta}}{\varepsilon_D - \eta_S} \tag{15}$$

where ε_D, η_S and ε_θ denote the price elasticity of demand, price elasticity of supply and income elasticity of demand respectively.

From the estimated housing demand equation, $\varepsilon_D = -0.1194$ in 2005 and $\varepsilon_D = -0.0775$ in 2011; $\varepsilon_\theta = 0.2355$ in 2005 and $\varepsilon_\theta = 0.2188$ in 2011. Hedberg and Krainer (2012) estimate supply elasticity with respect to price to be in the range of 0.02 to 0.06 from the aggregated housing supply function in 2010. These estimates are in line with Mayer and Somerville's (2000) result of 0.02 in their analysis in 1994. Taking $\eta_S = 0.04$, which is the middle value of the range 0.02 and 0.06, $\varepsilon_D = -0.1194$ and $\varepsilon_\theta = 0.2355$ and plugging in equation (19) yields:

$$\frac{\partial P}{\partial \theta} = -\frac{0.2355 * \frac{P}{\theta}}{-0.1194 - 0.04} \tag{16}$$

Suppose in a predicted time period, the price per unit of housing services is determined to be 122.46 units (note that this value reflects the price per unit of housing services that incorporates both structural and neighborhood characteristics), and the current household income to be $84,144.87 (these values are the mean of the price per unit of housing services and current household income in 2005), then:

$$\frac{\partial P}{\partial \theta} = -\frac{0.2355 * \frac{122.46}{84{,}144.87}}{-0.1194 - 0.04} = 0.0022 \tag{17}$$

The result can be interpreted as: as the current household income increases by 1 dollar, the price per unit of housing services will increase by 0.0022 units. From this result, if housing subsidy is understood as an increase in current household income, policy makers can determine the impact of a change in housing subsidies on the price per unit of housing services. The mathematical expression for this relationship is described as:

$$\Delta P = \frac{\partial P}{\partial \theta} * \Delta\theta \tag{18}$$

Equation (18) allows policymakers to study the effect of, for example, a $1,000 increase in housing subsidy. Note that this study is based on the assumption that every householder receives a housing subsidy. The impacts would be muted if these subsidies were only available to a subset of the population. In specific, a $1,000 increase in housing subsidy will increase the price per unit of housing services by 2.2 units (or a 1.8 percent increase in the price index) in 2005.

For the analysis in 2011, $\frac{\partial P}{\partial \theta}$ is equal to 0.0024. This values indicates that as the current household income increase by 1 dollar, price per unit of housing services will increase by 0.0024 units. Therefore, a $1,000 increase in housing subsidy will increase the price per unit of housing services by 2.4 units (or a 1.96 percent increase in the price index) in 2011. Compared to the result in 2005, housing subsidy have a greater impact on the price per unit of housing services in 2011. Furthermore, in order to fully investigate this impact, it is important to measure the change in the price per unit of housing services at different levels of price elasticity of supply and housing subsidies. Details about these changes in the price per unit of housing services are provided in Table 16.

Table 16: Impact of housing subsidy on price per unit of housing services

	2005			2011		
Housing subsidy in dollars	$\eta_S = 0.02$	$\eta_S = 0.04$	$\eta_S = 0.06$	$\eta_S = 0.02$	$\eta_S = 0.04$	$\eta_S = 0.06$
1,000	2.5	2.2	1.9	2.9	2.4	2.0
2,000	4.9	4.3	3.8	5.7	4.8	4.1
4,000	9.8	8.6	7.6	11.4	9.5	8.1
6,000	14.8	12.9	11.5	17.2	14.3	12.2
8,000	19.7	17.2	15.3	22.9	19.0	16.2
10,000	24.6	21.5	19.1	28.6	23.8	20.3
12,000	29.5	25.8	22.9	34.3	28.5	24.4
14,000	34.4	30.1	26.7	40.1	33.3	28.4

From Table 16, the impact of housing subsidy on the price per unit of housing services at different levels of price elasticity of supply in 2011 is observed to be greater than in 2005. For example, when $\eta_S = 0.04$, a $10,000 increase housing subsidy will cause price per unit of housing services to increase by 21.5 units (or a 17.56 percent increase in the price index) in 2005. In 2011, this value increases to 23.8 units (or a 19.43 percent increase in the price index). Moreover, when price elasticity of supply becomes more elastic, housing subsidy will impose a lesser impact on the price per unit of housing services. For example in 2005, when $\eta_S = 0.02$, a $14,000 increase in housing subsidy will cause price per unit of housing services to increase by

34.4 units (or a 28.09 percent increase in the price index). When η_S increases to 0.04, this value decreases to 30.1 unit (or a 24.58 percent increase in the price index). Similarly, when η_S increases to 0.06, this value decreases to 26.7 units (or a 21.8 percent increase in the price index). In other words, there is a negative relationship between price elasticity of supply and the magnitude of the impact of housing subsidy on the price per unit of housing services.

In addition, equation (15) provides insight about the role of the second hypothesis that the income elasticity of demand has a relatively larger magnitude than the price elasticity of demand. Consider the two cases when the income elasticity of demand has a greater magnitude than the price elasticity (Case 1) and when income elasticity of demand has a smaller magnitude than the income elasticity of demand (Case 2). As demonstrated, Case 1 is the result of the estimated housing demand equation. Suppose Case 2 is the outcome and that income elasticity of demand has a relatively smaller magnitude than the price elasticity. More specifically, let $\varepsilon_\theta = 0.1$ in 2005 and $\varepsilon_\theta = 0.05$ in 2011. Table 17 demonstrates the impact of housing subsidy on the price per unit of housing services at different levels of price elastic of supply and housing subsidies in the case of relatively smaller income elasticity.

Table 17: Impact of housing subsidy on price per unit of housing services

	2005			2011		
Housing subsidy in dollars	$\eta_S = 0.02$	$\eta_S = 0.04$	$\eta_S = 0.06$	$\eta_S = 0.02$	$\eta_S = 0.04$	$\eta_S = 0.06$
1,000	1.0	0.9	0.8	0.7	0.5	0.5
2,000	2.1	1.8	1.6	1.3	1.1	0.9
4,000	4.2	3.7	3.2	2.6	2.2	1.9
6,000	6.3	5.5	4.9	3.9	3.3	2.8
8,000	8.4	7.3	6.5	5.2	4.3	3.7
10,000	10.4	9.1	8.1	6.5	5.4	4.6
12,000	12.5	11.0	9.7	7.8	6.5	5.6
14,000	14.6	12.8	11.4	9.2	7.6	6.5

In Case 2**,** the impact of housing subsidy becomes significantly less than Case 1. For example, when $\eta_S = 0.04$ in 2011, a $10,000 increase in housing subsidy causes the price per unit of housing services to increase by 23.8 units (or a 19.43 percent increase in the price index) in Case 1 and 5.4 units (or a 4.41 percent increase in the price index) in Case 2. When $\eta_S = 0.02$ in 2011, a $10,000 increase in housing subsidy causes the price per unit of housing services to increase by 28.6 units (or a 23.35 percent increase in the price index) in Case 1 and 6.5 units (or a 5.31 percent increase in the price index) in Case 2. This significant change in the impact of housing subsidy on the price per unit of housing services in Case 2 compared to Case 1 allows the assessment of the effect of housing subsidy. Specifically, this implies that when income elasticity of demand has a larger magnitude than the price elasticity of demand, housing subsidy will have a greater impact on the price per unit of housing services. This signifies that the quantity demanded for housing services is increasing at a faster rate in Case 1 compared to Case 2. Thus, the implementation of housing subsidy programs is more effective when income elasticity of demand has a larger magnitude than the price elasticity of demand than the case when income elasticity of demand has a smaller magnitude than the price elasticity of demand**.**

The theoretical framework of comparative statistics allows policy makers to measure the impact of a change in housing subsidy on the price and quantity demanded of housing services. In addition, this impact varies among different levels of price elasticity of supply and depends on the difference in the magnitude between income and price elasticity of demand. Understanding the change in the impact will allow policy makers to determine and provide incentives that lead to the production of the required level of housing stock, especially through affordable housing programs in areas where intrinsic housing demand might be inadequate to incentivize construction**.**

VII. Conclusion

This research project estimates the demand for housing services across 33 urban markets in the United States. This research project adopts Zabel's conceptual model and incorporates additional housing structural and neighborhood characteristics. According to Zabel's model, housing demand is modeled as a continuous quantity that represents the flow of housing services (Zabel 2004). The housing demand equation is derived from the consumer's maximization model. In order to estimate the demand for housing services, it is necessary to calculate the price per unit of housing services and the quantity of housing services. The price index is constructed based on the result of a series of hedonic regressions. Each hedonic regression takes into account both the effect of housing structural and neighborhood characteristics on the market value of a house in an attempt to address the issue of endogeneity. Under the assumption that there is one price per market, prices vary across MSAs. Therefore, the requirement of exogenous variation in

p to increase the accuracy of the estimated parameters is satisfied. From the calculation of the price per unit of housing services, the quantity of housing services is generated before the estimation of the housing demand equation.

It is standard practice to incorporate permanent household income rather than current household income in the housing demand equation. The research paper provides two housing demand regression models. Model 1 uses current household income and Model 2 uses permanent household income.

An empirical analysis on 33 MSAs across the United States in 2005 and 2011 supports the hypotheses that demand for housing services is inelastic with respect to price per unit of housing services, and income elasticity of demand has a relatively larger magnitude compared to price elasticity of demand. The regression results for two housing demand models suggest that permanent household income elasticity is higher than current household income elasticity. Moreover, the incorporation of current household income improves the fitness of the housing demand regression equation rather than that of permanent household income. Finally, the empirical analysis concludes that there is a structural break in the housing demand equation between 2005 and 2011. This structural break signifies a change in market reaction to a change in exogenous variables including current housing income from 2005 to 2011.

Past research suggests that the choice of functional form for the hedonic equations also has a significant effect on the estimated parameters and subsequently, the housing demand equation. This might explain why the OLS model for the housing demand equation does not explain the data very well. Another limitation is the use of owner's rating of the neighborhood as one of the neighborhood variables due to the unavailability of data. Apart from explicit neighborhood characteristics, it is possible that this variable also reflects other unobserved implicit characteristics, which leads to an inaccurate estimation of coefficient parameters in the housing demand equation.

From the housing demand equation, policy makers can measure the change in price and quantity demanded for housing services with respect to the change in current household income. If housing subsidy serves as a change in current household income, it will impose an effect on price and quantity demanded for housing services. In addition, this effect varies depending on different levels of price elasticity of supply and the difference in the magnitude between income and price elasticity of demand. A preliminary policy analysis suggests that compared to the result in 2005, a housing subsidy would have a greater impact on the price per unit of housing services in 2011. In addition, when income elasticity of demand has a larger magnitude than the price elasticity of demand, housing subsidy will have a greater impact on the price per unit of housing services. Understanding this effect is important for policy makers to determine and allocate resources to achieve the required level of housing stock to affordable housing programs in an area.

Data citation

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Appendix

For the analysis in 2005, other neighborhood characteristics include dummy variables for the presence of crime and public transportation. The dummy variable for crime is incorporated into the hedonic price model based on the conjecture that there is an inverse relationship between crime rate and property values. This conjecture is supported by Pope's (2012) research, in which the authors provide an empirical analysis and a graphical analysis suggesting that decreasing crime leads to increasing property values. In addition, spatial location has always been included in past research on estimating the housing demand based on neighborhood characteristics. Various studies have investigated the relationship between the availability of public transportation and property value. Von Thunen (1826) explores the economic benefits of accessibility expressed as proximity to a transit station. The model suggests that reducing commuting costs, which are measured in time, increases housing prices due to accessibility to public transportation. Reduced transportation costs allow households to spend more on housing and, in turn, bid up the rents or prices of homes located in areas with low commuting costs (Kilpatrick et al. 2007). This reflects the consideration of Alonso's approach to some degree. At the same time, since accessibility also associates with negative externalities of pollution and noise, home buyers might try to avoid this risk. Ideally, other variables indicating school quality or if the unit locates in flood zone are included. Information about these variables are collected in the American Housing Survey (AHS). Unfortunately, the large amount of missing data on these variables reduces the sample size significantly. Appendix Table 1 provides the housing regression result of the housing demand equations for the analysis in 2005.

Appendix Table 1 : Regression result of the housing demand equation for 32 MSAs in 2005 with robust standard errors (with crime and public transportation)		
Variable	**Model 1**	**Model 2**
LnHOUSESER		
LnHPRICE	-0.1736*** (0.01948)	-0.1303*** (0.0189)
LnHINC	0.2564*** (0.0297)	-
LnPHINC	-	0.4249*** (0.0867)
PER	0.0237* (0.0088)	0.0371*** (0.0093)
HHAGE	0.0061*** (0.0012)	0.0094*** (0.0018)
HHGRAD	0.2933*** (0.0454)	0.1885** (0.0712)
HHMAR	0.0849*** (0.0313)	-0.0186 (0.0490)
HHBLACK	-0.3815*** (0.0350)	-0.3287*** (0.0434)
HHMALE	-0.0199 (0.2836)	-0.0442 (0.0330)
HHMOV	-0.0059* (0.0026)	-0.0087*** (0.0029)
HHMOVSQ	0.0001 (0.00005)	0.0001* (0.00005)
INTERCEPT	5.1471 (0.3092)	3.8466 (0.9257)
Observations	6783	6783
R^2	0.1268	0.0705

A correlation statistics among the homeowner's rating of the neighborhood and the presence of crime and public transportation is investigated. Appendix Table 2 provides the result of the pairwise correlation statistics of these variables.

Appendix Table 2: Pairwise correlation statistics for neighborhood variables used in 2 analyses in 2005

	HOWN	*CRIME*	*PUBTRAN*
HOWN	1	-0.261**	-0.061**
CRIME	-0.261**	1	0.119**
PUBTRAN	-0.061**	0.119**	1

*. Correlation is significant at the 5% level (2-tailed).
**. Correlation is significant at the 1% level (2-tailed)

There are 9,791 observations used in the pairwise correlation statistics analysis in 2005. The negative correlation value between *HOWN* and *CRIME* as well as *HOWN* and *PUBTRAN* suggests the homeowner's neighborhood satisfaction is negatively associated with the presence of crime and public transportation. Homeowner's neighborhood satisfaction is more correlated with crime compared to compared to public transportation (-0.261 versus -0.061). This result accords with the expectation that homeowners can either benefit or experience the inconvenience of noise and pollution associated with public transportation. The variables are not highly correlated with each other, which implies that there are other neighborhood characteristics that influence homeowner's neighborhood satisfaction. These correlations are both significant at 1% level. Therefore, *HOWN* can be used as a variable to measure neighborhood characteristics.

Appendix Table 3: Pairwise correlation statistics for variables used in the hedonic regression in the case of Baltimore in 2005

	AIRSYS	*BATHS*	*BEDRMS*	*AGEUNIT*	*CRACK*	*FPLWK*	*GARAGE*	*LEAK*	*PORCH*	*HOWN*	*HHAGE*	*HHGRAD*	*HHMAR*	*HHBLACK*	*HHMALE*	*HHMOV*	*HINC*
AIRSYS	1	0.183*	0.0161	-0.5040	-0.0028	0.1433	0.153*	-0.1650	0.1139	0.180*	0.0901	0.165*	0.1010	-0.3510	-0.0688	-0.0356	0.176*
BATHS	0.183*	1	0.372**	-0.3680	-0.0800	0.266**	0.208**	-0.0772	0.0044	0.1205	-0.1283	0.0485	0.261**	-0.1630	0.1281	-0.1860	0.403**
BEDRMS	0.0161	0.372**	1	-0.0303	0.0129	0.253**	0.221**	0.0393	-0.0486	0.1315	-0.1411	0.0678	0.284**	-0.0978	0.206**	-0.0346	0.345**
AGEUNIT	-0.5040	-0.3680	-0.0303	1	-0.0231	-0.2570	-0.1386	0.1356	-0.1095	-0.2920	0.0308	-0.2040	-0.1800	0.263**	0.1156	0.257**	-0.1750
CRACK	-0.0028	-0.0800	0.0129	-0.0231	1	-0.1145	-0.0260	0.198*	0.0441	0.0534	0.1271	-0.1980	-0.0281	0.0888	-0.1710	0.0811	-0.0912
FPLWK	0.1433	0.266**	0.253**	-0.2570	-0.1145	1	0.1180	-0.0498	0.0562	0.0785	0.0273	0.1316	0.168*	-0.2780	0.237**	-0.0238	0.344**
GARAGE	0.153*	0.208**	0.221**	-0.1386	-0.0260	0.1180	1	0.0045	0.1456	0.194*	0.0298	0.161*	0.1116	-0.1700	0.1004	-0.0863	0.225**
LEAK	-0.1650	-0.0772	0.0393	0.1356	0.198*	-0.0498	0.0045	1	0.0980	-0.1372	0.0182	-0.0023	-0.0230	-0.0260	-0.1447	0.0474	-0.0239
PORCH	0.1139	0.0044	-0.0486	-0.1095	0.0441	0.0562	0.1456	0.0980	1	0.0586	0.0925	0.0517	0.0974	-0.1042	-0.0247	-0.0379	0.0385
HOWN	0.180*	0.1205	0.1315	-0.2920	0.0534	0.0785	0.194*	-0.1372	0.0586	1	0.0437	0.329**	0.1213	-0.0308	-0.0332	-0.1393	0.171*
HHAGE	0.0901	-0.1283	-0.1411	0.0308	0.1271	0.0273	0.0298	0.0182	0.0925	0.0437	1	-0.2660	-0.1242	-0.0307	-0.2060	0.685**	-0.1085
HHGRAD	0.165*	0.0485	0.0678	-0.2040	-0.1980	0.1316	0.161*	-0.0023	0.0517	0.329**	-0.2660	1	0.181*	-0.0187	0.1447	-0.3350	0.227**
HHMAR	0.1010	0.261**	0.284**	-0.1800	-0.0281	0.168*	0.1116	-0.0230	0.0974	0.1213	-0.1242	0.181*	1	-0.2460	0.264**	-0.0726	0.238**
HHBLACK	-0.3510	-0.1630	-0.0978	0.263**	0.0888	-0.2780	-0.1700	-0.0260	-0.1042	-0.0308	-0.0307	-0.0187	-0.2460	1	-0.0183	0.0311	-0.2740
HHMALE	-0.0688	0.1281	0.206**	0.1156	-0.1710	0.237**	0.1004	-0.1447	-0.0247	-0.0332	-0.2060	0.1447	0.264**	-0.0183	1	-0.0849	0.166*
HHMOV	-0.0356	-0.1860	-0.0346	0.257**	0.0811	-0.0238	-0.0863	0.0474	-0.0379	-0.1393	0.685**	-0.3350	-0.0726	0.0311	-0.0849	1	-0.1433
HINC	0.176*	0.403**	0.345**	-0.1750	-0.0912	0.344**	0.225**	-0.0239	0.0385	0.171*	-0.1085	0.227**	0.238**	-0.2740	0.166*	-0.1433	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Appendix Table 4: Pairwise correlation statistics for variables used in the hedonic regression in the case of Phoenix in 2011

	AIRSYS	*BATHS*	*BEDRMS*	*AGEUNIT*	*CRACK*	*FPLWK*	*GARAGE*	*LEAK*	*PORCH*	*HOWN*	*HHAGE*	*HHGRAD*	*HHMAR*	*HHBLACK*	*HHMALE*	*HHMOV*	*HINC*
AIRSYS	1	-0.0014	0.0124	0.0010	0.0104	0.0506	-0.0184	-0.2090	0.282**	-0.0211	0.0023	0.194**	0.0772	0.0142	0.0727	0.0704	0.0399
BATHS	-0.0014	1	0.542**	-0.4180	-0.0874	0.309**	0.155*	0.0317	0.0276	0.1135	-0.0368	0.158*	0.198**	-0.1310	0.152*	-0.1820	0.466**
BEDRMS	0.0124	0.542**	1	-0.2210	-0.0306	0.256**	0.0958	-0.0012	-0.0063	0.0993	-0.2620	0.0819	0.282**	0.0103	0.247**	-0.0152	0.419**
AGEUNIT	0.0010	-0.4180	-0.2210	1	0.0595	-0.0930	-0.1890	0.0504	0.0164	-0.0640	0.205**	-0.1192	-0.0544	0.1162	0.0405	0.411**	-0.2430
CRACK	0.0104	-0.0874	-0.0306	0.0595	1	-0.0151	0.0456	-0.0496	0.0367	0.0521	-0.0299	0.0534	0.0258	-0.0351	-0.1263	0.0825	0.0105
FPLWK	0.0506	0.309**	0.256**	-0.0930	-0.0151	1	0.1247	0.0011	0.179**	0.167**	0.0487	0.203**	0.254**	-0.0481	0.0898	0.0522	0.248**
GARAGE	-0.0184	0.155*	0.0958	-0.1890	0.0456	0.1247	1	-0.0238	0.0798	0.0148	-0.0307	0.169**	0.0185	-0.0889	0.0016	-0.0609	0.153*
LEAK	-0.2090	0.0317	-0.0012	0.0504	-0.0496	0.0011	-0.0238	1	-.132*	-0.0996	-0.0082	-0.0442	-0.0401	0.144*	0.0379	0.0131	0.0365
PORCH	0.282**	0.0276	-0.0063	0.0164	0.0367	0.179**	0.0798	-0.1320	1	.185**	0.0688	0.1147	0.0408	-0.0411	-0.0115	0.0462	-0.0140
HOWN	-0.0211	0.1135	0.0993	-0.0640	0.0521	0.167**	0.0148	-0.0996	0.185**	1	0.0098	0.0330	0.159*	-0.0640	0.1095	-0.0557	0.151*
HHAGE	0.0023	-0.0368	-0.2620	0.205**	-0.0299	0.0487	-0.0307	-0.0082	0.0688	0.0098	1	-0.0537	-0.0850	0.0244	-0.1910	0.513**	-0.1710
HHGRAD	0.194**	0.158*	0.0819	-0.1192	0.0534	0.203**	0.169**	-0.0442	0.1147	0.0330	-0.0537	1	0.0028	0.0066	-0.0448	-0.0296	0.146*
HHMAR	0.0772	0.198**	0.282**	-0.0544	0.0258	0.254**	0.0185	-0.0401	0.0408	0.159*	-0.0850	0.0028	1	-0.0592	0.380**	0.0223	0.323**
HHBLACK	0.0142	-0.1310	0.0103	0.1162	-0.0351	-0.0481	-0.0889	0.144*	-0.0411	-0.0640	0.0244	0.0066	-0.0592	1	-0.0458	0.200**	-0.0708
HHMALE	0.0727	0.152*	0.247**	0.0405	-0.1263	0.0898	0.0016	0.0379	-0.0115	0.1095	-0.1910	-0.0448	0.380**	-0.0458	1	-0.0857	0.319**
HHMOV	0.0704	-0.1820	-0.0152	0.411**	0.0825	0.0522	-0.0609	0.0131	0.0462	-0.0557	0.513**	-0.0296	0.0223	0.200**	-0.0857	1	-0.1007
HINC	0.0399	0.466**	0.419**	-0.2430	0.0105	0.248**	0.153*	0.0365	-0.0140	0.151*	-0.1710	0.146*	0.323**	-0.0708	0.319**	-0.1007	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Appendix Table 5: Regression result of the hedonic regression for 33 MSAs in 2005							
Variable	**Baltimore**	**Bergen-Passaic**	**Boston**	**Chicago**	**Cleveland**	**Dallas**	**Detroit**
AIRSYS	0.0933 (0.2036)	0.6739*** (0.2088)	0.1856 (0.1103)	0.1459 (0.0947)	-0.4113 (0.4401)	0.7471*** (0.1734)	0.1850 (0.0975)
BATHS	0.0975 (0.1272)	-0.1005 (0.1713)	0.2183*** (0.0732)	0.1853*** (0.0640)	0.0123 (0.3647)	0.4059*** (0.0696)	0.1224 (0.0748)
BEDRMS	0.1396 (0.0916)	0.1795 (0.1074)	0.0418 (0.0546)	0.1041* (0.0484)	0.6761* (0.2708)	0.0811 (0.0642)	0.2550*** (0.0562)
AGEUNIT	0.0022 (0.0156)	-0.0130 (0.0204)	-0.0073 (0.0103)	0.0058 (0.0074)	-0.0499 (0.0524)	-0.0092 (0.0082)	-0.0105 (0.0064)
AGEUNITSQ	-0.0001 (0.0001)	0.0002 (0.0002)	0.0001 (0.0001)	0.0000 (0.0001)	0.0003 (0.0005)	0.0002** (0.0001)	0.0001 (0.0001)
CRACKS	0.8235 (0.5162)	-0.0707 (0.7189)	-0.0915 (0.2396)	0.1427 (0.1932)	0.4934 (0.9828)	-0.0295 (0.1840)	-0.5691* (0.2836)
FPLWK	0.1430 (0.1692)	0.5207* (0.2328)	0.3268*** (0.0995)	0.3054*** (0.0847)	0.4011 (0.4439)	0.1884 (0.1114)	0.3514*** (0.0884)
GARAGE	0.2437 (0.1618)	0.3817 (0.2391)	0.1219 (0.0965)	0.2645** (0.0993)	-1.3146 (0.9894)	0.2707** (0.1292)	0.4675*** (0.1134)
LEAK	0.0943 (0.2443)	-0.0165 (0.3294)	0.0509 (0.1217)	-0.0315 (0.1187)	-0.6572 (0.6418)	-0.2075 (0.1782)	-0.0193 (0.1107)
PORCH	0.5297 (0.2867)	0.1037 (0.3460)	0.0972 (0.1562)	0.1774 (0.1023)	-0.6355 (0.6270)	-0.2328 (0.1924)	0.3829* (0.1936)
HOWN	0.0738 (0.2854)	0.1504 (0.3120)	-0.0050 (0.2002)	0.1131 (0.1391)	0.1959 (0.6339)	0.1674 (0.1482)	0.0245 (0.1427)
HHAGE	0.0220*** (0.0068)	0.0121 (0.0099)	-0.0004 (0.0041)	0.0098*** (0.0030)	0.0296 (0.0169)	0.0037 (0.0036)	0.0016 (0.0032)
HHGRAD	0.6342* (0.2724)	-0.1387 (0.2950)	0.3356 (0.1750)	0.2446 (0.1024)	-0.5691 (0.5884)	0.1840 (0.1259)	0.0684 (0.1296)
HHMAR	0.1063 (0.1663)	0.0127 (0.2460)	0.1890 (0.0999)	0.2025 (0.0820)	-0.6271 (0.4524)	0.1496 (0.0967)	0.0883 (0.0893)
HHBLACK	-0.3958 (0.1912)	0.0726 (0.4809)	-0.0356 (0.1961)	-0.4239*** (0.1095)	0.1132 (0.5337)	-0.1925 (0.1297)	-0.0175 (0.1161)
HHMALE	0.0293 (0.1617)	-0.1739 (0.1998)	-0.0191 (0.0920)	-0.1402 (0.0757)	0.1019 (0.4040)	-0.0359 (0.0962)	-0.0217 (0.0810)
HHMOV	-0.0278 (0.0181)	-0.0189 (0.0195)	0.0081 (0.0087)	-0.0112 (0.0082)	-0.0411 (0.0421)	-0.0093 (0.0125)	-0.0060 (0.0090)
HHMOVSQ	0.0002 (0.0003)	0.0001 (0.0003)	-0.0001 (0.0001)	0.0000 (0.0002)	0.0008 (0.0008)	0.0001 (0.0003)	0.0002 (0.0002)
LnHINC	0.2164*** (0.0430)	-0.0120 (0.1012)	-0.031 (0.0421)	0.1412*** (0.0401)	0.6606*** (0.1891)	0.1033*** (0.0370)	0.0051 (0.0508)
INTERCEPT	7.1363 (0.7912)	11.4644 (1.3182)	11.972 (0.6463)	8.6704 (0.5036)	5.2616 (2.6449)	8.3543 (0.5152)	9.9736 (0.6282)
Observations	164	124	215	484	161	169	487
R^2	0.5269	0.2846	0.3098	0.3275	0.1977	0.5952	0.3147

Appendix Table 5: Regression result of the hedonic regression for 33 MSAs in 2005 (continued)							
Variable	**Fort Lauderdale**	**Fort Worth**	**Houston**	**Kansas City**	**Los Angeles**	**Miami**	**Milwaukee**
AIRSYS	0.1465 (0.2774)	-0.0168 (0.1925)	0.2768* (0.1373)	1.3247*** (0.2395)	0.0788 (0.0584)	-0.0062 (0.1735)	0.1578 (0.0912)
BATHS	0.2162 (0.1195)	0.4009*** (0.0812)	0.2949*** (0.0846)	0.1477 (0.0891)	0.1836*** (0.0460)	0.1408* (0.0707)	0.1898* (0.0800)
BEDRMS	0.4447*** (0.1142)	0.1662* (0.0694)	0.1393* (0.0624)	0.1761* (0.0679)	0.0961** (0.0343)	0.1104* (0.0554)	0.1385* (0.0531)
AGEUNIT	0.0268 (0.0260)	-0.0051 (0.0078)	0.0025 (0.0097)	-0.0202* (0.0082)	0.0060 (0.0069)	0.0000 (0.0160)	0.0120 (0.0093)
AGEUNITSQ	-0.0002 (0.0003)	0.0002 (0.0001)	0.0001 (0.0001)	0.0002* (0.0001)	0.0000 (0.0001)	0.0000 (0.0002)	-0.0001 (0.0001)
CRACKS	0.6576 (0.5878)	-0.1298 (0.1719)	-0.0851 (0.1379)	0.2854 (0.2941)	0.0662 (0.1386)	0.3900 (0.3299)	0.3017 (0.2079)
FPLWK	0.2200 (0.3498)	0.4110*** (0.1180)	0.1403 (0.0945)	0.0444 (0.1145)	0.1557** (0.0590)	0.5577*** (0.1742)	0.3684*** (0.0986)
GARAGE	0.0782 (0.1641)	0.2211 (0.1692)	0.1976 (0.1446)	-0.0714 (0.1869)	-0.0038 (0.1128)	0.1999* (0.0952)	0.2140 (0.1558)
LEAK	0.2283 (0.2407)	0.1769 (0.1577)	-0.0081 (0.1413)	0.1511 (0.1458)	0.1380 (0.0748)	-0.1786 (0.1760)	0.0255 (0.1558)
PORCH	0.1314 (0.4703)	0.0520 (0.2227)	-0.1746 (0.1985)	0.3702 (0.2344)	0.0894 (0.0854)	-0.1750 (0.2447)	0.1027 (0.1287)
HOWN	0.1621 (0.2966)	0.3258 (0.1917)	0.0779 (0.1318)	0.6525 (0.2979)	0.1516 (0.0991)	-0.0027 (0.2175)	0.4492 (0.1540)
HHAGE	0.0005 (0.0059)	-0.0028 (0.0042)	0.0062 (0.0033)	-0.0035 (0.0041)	0.0018 (0.0023)	0.0031 (0.0040)	-0.0022 (0.0036)
HHGRAD	0.2353 (0.2853)	0.2016 (0.1342)	0.1008 (0.0975)	-0.0634 (0.1785)	0.0485 (0.0705)	0.1538 (0.1254)	0.0689 (0.1163)
HHMAR	0.0586 (0.1683)	0.0596 (0.1050)	-0.0269 (0.0911)	-0.2044 (0.1141)	-0.0525 (0.0566)	-0.0504 (0.0940)	0.0476 (0.0942)
HHBLACK	-0.0880 (0.2340)	0.0115 (0.1561)	-0.1353 (0.1070)	-0.1286 (0.1483)	-0.2325* (0.1025)	-0.4569*** (0.1230)	-0.4353** (0.1614)
HHMALE	0.1439 (0.1695)	-0.0300 (0.1045)	0.0045 (0.0790)	-0.0213 (0.1126)	-0.0069 (0.0532)	-0.0465 (0.0949)	0.0864 (0.0916)
HHMOV	-0.0110 (0.0269)	0.0081 (0.0130)	0.0002 (0.0094)	0.0086 (0.0157)	-0.0008 (0.0061)	0.0004 (0.0129)	-0.0007 (0.0091)
HHMOVSQ	0.0001 (0.0007)	-0.0002 (0.0003)	-0.0001 (0.0002)	-0.0001 (0.0004)	0.0000 (0.0001)	0.0000 (0.0003)	0.0000 (0.0002)
LnHINC	0.0607 (0.0692)	0.0643 (0.0647)	0.1044*** (0.0336)	0.1278 (0.0711)	0.0709** (0.0261)	0.1507 (0.0610)	0.0153 (0.0211)
INTERCEPT	8.5506 (1.1449)	8.5840 (0.6373)	8.6312 (0.4739)	7.9994 (0.9639)	11.0155 (0.3636)	9.9856* (0.7728)	9.7888 (0.4533)
Observations	128	107	196	112	504	150	103
R^2	0.4235	0.7005	0.4712	0.5920	0.2402	0.4594	0.6320

Appendix Table 5: Regression result of the hedonic regression for 33 MSAs in 2005 (continued)							
Variable	**Minneapolis Saint Paul**	**Nassau-Suffolk**	**New York City**	**Newark**	**Norfolk-Virginia Beach**	**Oakland**	**Philadelphia**
AIRSYS	-0.0125 (0.1233)	0.0322 (0.1401)	0.1335 (0.2016)	-0.0758 (0.4386)	-0.7750* (0.3743)	0.0475 (0.0677)	0.3495*** (0.0791)
BATHS	0.1776* (0.0749)	0.1510 (0.1223)	0.0398 (0.1291)	-0.1766 (0.3058)	0.2706 (0.2083)	0.2912*** (0.0560)	0.1559* (0.0617)
BEDRMS	0.0785 (0.0502)	0.0771 (0.0754)	0.0508 (0.0846)	0.4135* (0.1659)	-0.0394 (0.1575)	0.0685 (0.0377)	0.2026*** (0.0417)
AGEUNIT	-0.0029 (0.0099)	0.0071 (0.0178)	-0.0094 (0.0155)	-0.0412 (0.0360)	0.0039 (0.0178)	-0.0028 (0.0066)	0.0025 (0.0051)
AGEUNITSQ	0.0001 (0.0001)	-0.0001 (0.0002)	0.0001 (0.0001)	0.0003 (0.0003)	-0.0002 (0.0002)	0.0001 (0.0001)	0.0000 (0.0001)
CRACKS	0.0839 (0.2304)	-0.0128 (0.3977)	-0.4277 (0.4286)	1.1286 (1.1126)	0.0865 (0.4346)	0.1140 (0.1947)	-0.1601 (0.1602)
FPLWK	0.2212* (0.0922)	0.2755 (0.1419)	0.4321* (0.2104)	0.2362 (0.3689)	0.1972 (0.2247)	0.1221 (0.0682)	0.0420 (0.0665)
GARAGE	1.0088*** (0.2044)	0.0927 (0.1708)	0.1269 (0.1702)	0.1135 (0.4324)	0.4628* (0.2183)	-0.0488 (0.1175)	0.1925*** (0.0656)
LEAK	-0.2762 (0.1541)	-0.0658 (0.2182)	-0.0354 (0.2490)	0.4346 (0.5113)	-0.3870 (0.3595)	-0.0435 (0.1055)	0.0309 (0.0780)
PORCH	-0.0077 (0.1339)	0.3227 (0.1721)	0.1639 (0.1770)	-0.1083 (0.5346)	1.1751*** (0.3929)	0.0157 (0.1193)	0.2008 (0.0973)
HOWN	0.0944 (0.2164)	0.0978 (0.2509)	0.2171 (0.3273)	0.8416 (0.5664)	-0.3896 (0.4352)	0.2925*** (0.0931)	0.4632*** (0.1162)
HHAGE	0.0082 (0.0038)	-0.0006 (0.0060)	0.0022 (0.0067)	-0.0029 (0.0166)	0.0040 (0.0081)	-0.0008 (0.0026)	0.0045 (0.0029)
HHGRAD	0.6106*** (0.1803)	-0.2637 (0.2241)	-0.1519 (0.2496)	1.7769*** (0.5069)	0.6173 (0.3678)	0.1522 (0.1023)	0.0505 (0.0947)
HHMAR	0.0344 (0.0987)	-0.2000 (0.1561)	-0.1979 (0.1852)	-0.1964 (0.4047)	-0.3289 (0.2451)	0.0044 (0.0679)	0.0279 (0.0690)
HHBLACK	0.3504 (0.2555)	-0.0336 (0.2663)	-0.1109 (0.2120)	-1.2543* (0.5380)	-0.5033* (0.2437)	-0.0955 (0.0988)	-0.5095*** (0.0943)
HHMALE	0.0055 (0.0931)	-0.1807 (0.1337)	0.1442 (0.1635)	-0.0587 (0.3521)	0.0484 (0.2140)	-0.1280* (0.0612)	0.0199 (0.0649)
HHMOV	-0.0198 (0.0104)	-0.0008 (0.0140)	-0.0212 (0.0155)	-0.0381 (0.0358)	-0.0071 (0.0228)	0.0048 (0.0071)	-0.0071 (0.0066)
HHMOVSQ	0.0002 (0.0002)	0.0000 (0.0003)	0.0006* (0.0003)	0.0010 (0.0006)	0.0004 (0.0005)	0.0000 (0.0001)	0.0001 (0.0001)
LnHINC	0.2006*** (0.0619)	0.3354*** (0.0491)	0.5663*** (0.0886)	-0.0244 (0.1973)	0.5778*** (0.1417)	0.1159*** (0.0383)	0.1585*** (0.0255)
INTERCEPT	7.5701 (0.7442)	8.4106 (0.9376)	6.0255 (1.1272)	11.3281 (2.3694)	4.6144 (1.6191)	10.8279 (0.4663)	8.3754 (0.3713)
Observations	211	250	452	132	119	175	505
R^2	0.4466	0.2920	0.1739	0.2777	0.5307	0.5506	0.4791

Appendix Table 5: Regression result of the hedonic regression for 33 MSAs in 2005 (continued)							
Variable	**Phoenix**	**Pittsburg**	**Riverside San Bernardino**	**Saint Louis**	**San Antonio**	**San Diego**	**San Francisco**
AIRSYS	0.2567 (0.2134)	0.1130 (0.0969)	0.2678 (0.1849)	0.2640 (0.2157)	0.1161 (0.1480)	-0.1135 (0.0778)	0.1501 (0.1339)
BATHS	0.0595 (0.0730)	0.1736** (0.0648)	-0.0522 (0.1149)	0.2891*** (0.0901)	0.2498* (0.1095)	0.0885 (0.0847)	0.1653** (0.0667)
BEDRMS	0.1976*** (0.0492)	0.2449*** (0.0484)	0.2312*** (0.0764)	0.0948 (0.0553)	0.1228 (0.0743)	0.1885*** (0.0551)	0.1447** (0.0527)
AGEUNIT	-0.0234*** (0.0079)	-0.0117 (0.0124)	-0.0007 (0.0125)	-0.0056 (0.0085)	-0.0150 (0.0090)	-0.0165 (0.0099)	0.0113 (0.0090)
AGEUNITSQ	0.0003*** (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0003* (0.0001)	-0.0001 (0.0001)
CRACKS	0.2639 (0.2541)	0.1218 (0.2221)	-0.0891 (0.6831)	0.0088 (0.2469)	-0.3335 (0.1679)	0.1050 (0.1620)	0.2747 (0.2436)
FPLWK	0.2735*** (0.0826)	0.2613** (0.0942)	0.5895*** (0.1493)	0.3378*** (0.1084)	0.2155 (0.1225)	0.3281*** (0.0902)	0.2495* (0.1061)
GARAGE	0.0053 (0.1462)	0.1642 (0.1142)	0.4611 (0.2634)	0.3445** (0.1255)	0.2879* (0.1363)	0.7925*** (0.1680)	-0.0482 (0.1982)
LEAK	0.0735 (0.1230)	0.0094 (0.0905)	-0.1878 (0.1726)	0.0662 (0.1137)	0.1420 (0.2034)	0.0772 (0.1210)	-0.3987 (0.1368)
PORCH	0.4144* (0.1761)	0.2143 (0.1975)	0.2816 (0.3640)	0.1265 (0.2760)	0.5007* (0.1931)	0.0186 (0.1796)	-0.1352 (0.1803)
HOWN	0.3651 (0.1558)	0.2139 (0.1357)	0.1496 (0.2830)	0.4266** (0.1579)	0.0843 (0.1369)	0.0253 (0.1367)	-0.0129 (0.2580)
HHAGE	0.0047 (0.0029)	0.0029 (0.0036)	-0.0079 (0.0043)	0.0018 (0.0046)	0.0025 (0.0039)	-0.0022 (0.0032)	0.0050 (0.0043)
HHGRAD	0.6150*** (0.1165)	-0.0045 (0.1588)	-0.0935 (0.1986)	-0.1664 (0.1819)	0.3903*** (0.1302)	0.1552 (0.1193)	0.6506*** (0.1666)
HHMAR	-0.0230 (0.0890)	0.2622** (0.0934)	0.1688 (0.1353)	-0.2023 (0.1038)	-0.0202 (0.1133)	0.1162 (0.0869)	-0.1510 (0.0949)
HHBLACK	-0.5869* (0.2570)	-0.2694 (0.1828)	0.0114 (0.2726)	-0.2206 (0.1153)	-0.6582 (0.3725)	-0.7825*** (0.2716)	0.0022 (0.1843)
HHMALE	0.1183 (0.0852)	0.0200 (0.0833)	0.0264 (0.1253)	-0.1555 (0.0921)	0.0793 (0.1079)	-0.0322 (0.0791)	0.1596 (0.0920)
HHMOV	0.0086 (0.0109)	-0.0101 (0.0098)	0.0051 (0.0177)	0.0053 (0.0106)	-0.0382 (0.0134)	-0.0045 (0.0095)	-0.0177 (0.0100)
HHMOVSQ	-0.0003 (0.0003)	0.0002 (0.0002)	-0.0001 (0.0004)	-0.0001 (0.0002)	0.0010*** (0.0002)	0.0002 (0.0002)	0.0001 (0.0002)
LnHINC	0.2360*** (0.0461)	0.0838 (0.0641)	0.2395*** (0.0836)	0.3017*** (0.0811)	0.0443 (0.0572)	0.1171* (0.0481)	0.0710* (0.0324)
INTERCEPT	7.2235 (0.5763)	9.0167 (0.8440)	8.0347 (1.1088)	6.8329 (0.9203)	9.3053 (0.7023)	10.2335 (0.6178)	11.2112 (0.6396)
Observations	235	150	146	149	113	178	133
R^2	0.5301	0.6319	0.5027	0.5956	0.6399	0.4953	0.4649

Appendix Table 5: Regression result of the hedonic regression for 33 MSAs in 2005 (continued)					
Variable	**Sacramento**	**San Jose**	**Seattle**	**Tampa Saint Petersburg**	**Washington D.C.**
LnVALUE					
AIRSYS	0.0388 (0.2439)	0.0641 (0.1075)	-0.0351 (0.1894)	0.7095* (0.3099)	0.1002 (0.1469)
BATHS	0.1038 (0.1359)	0.1751* (0.0797)	0.1697* (0.0828)	0.3348* (0.1632)	-0.0686 (0.0564)
BEDRMS	0.2720*** (0.0874)	0.1888** (0.0676)	0.1238* (0.0599)	0.2341* (0.1126)	0.1208** (0.0463)
AGEUNIT	-0.0044 (0.0090)	0.0208 (0.0114)	-0.0160 (0.0094)	-0.0129 (0.0176)	-0.0254** (0.0094)
AGEUNITSQ	0.0001 (0.0001)	-0.0001 (0.0001)	0.0003** (0.0001)	0.0001 (0.0002)	0.0003*** (0.0001)
CRACKS	-0.0876 (0.3859)	-0.6264* (0.3026)	0.3449 (0.2410)	-0.0069 (0.5147)	0.0470 (0.1996)
FPLWK	0.2269 (0.1229)	0.3793** (0.1319)	0.2118 (0.1159)	0.3503 (0.2001)	0.3452*** (0.0856)
GARAGE	0.8220*** (0.2843)	0.0000 (0.0000)	0.1846 (0.1531)	-0.0282 (0.1931)	0.1829* (0.0829)
LEAK	0.0550 (0.1878)	-0.2544 (0.2414)	-0.0350 (0.1956)	0.0099 (0.2475)	0.0799 (0.1036)
PORCH	-0.2363 (0.3145)	-0.1529 (0.2407)	0.6405* (0.3081)	-0.2451 (0.2176)	-0.0329 (0.1155)
HOWN	0.0904 (0.1834)	0.4264* (0.2103)	0.2321 (0.1806)	0.2241 (0.2593)	0.3111 (0.1620)
HHAGE	0.0040 (0.0047)	0.0052 (0.0056)	0.0098* (0.0048)	-0.0073 (0.0062)	-0.0005 (0.0033)
HHGRAD	0.3148 (0.2452)	0.3332* (0.1572)	0.2370 (0.2108)	0.0324 (0.2416)	0.1073 (0.1363)
HHMAR	0.0397 (0.1158)	0.0800 (0.1322)	-0.2342* (0.1163)	0.1445 (0.1570)	0.0816 (0.0901)
HHBLACK	0.0795 (0.2214)	-0.4149 (0.3139)	0.1841 (0.3497)	0.1148 (0.2397)	-0.3305*** (0.0870)
HHMALE	-0.0840 (0.1188)	-0.2507* (0.1207)	0.0228 (0.1016)	-0.0154 (0.1484)	-0.1723* (0.0784)
HHMOV	0.0010 (0.0143)	-0.0107 (0.0150)	0.0102 (0.0126)	0.0236 (0.0217)	0.0162 (0.0090)
HHMOVSQ	0.0000 (0.0003)	0.0003 (0.0003)	-0.0001 (0.0002)	-0.0004 (0.0005)	-0.0002 (0.0002)
LnHINC	0.2349** (0.0885)	0.1203 (0.0745)	0.4585*** (0.0758)	0.1109 (0.0856)	0.0570* (0.0289)
INTERCEPT	7.7073 (0.9668)	9.5901 (0.9176)	5.0661 (0.8599)	9.0994 (1.1546)	11.5980 (0.4488)
Observations	102	115	158	160	263
R^2	0.5443	0.5452	0.5763	0.3558	0.3405

Appendix Table 6: Regression result of the hedonic regression for 33 MSAs in 2011							
Variable	**Anaheim-Santa Ana**	**Atlanta**	**Baltimore**	**Bergen-Passaic**	**Boston**	**Chicago**	**Cleveland**
LnVALUE							
AIRSYS	-0.2822* (0.1202)	0.5306** (0.1916)	0.3871* (0.1563)	0.2016 (0.1735)	0.2426* (0.1142)	0.0212 (0.0916)	0.0822 (0.1148)
BATHS	0.2061* (0.0982)	0.2058*** (0.0688)	-0.0745 (0.0980)	0.2203 (0.1335)	0.1655* (0.0780)	0.2103*** (0.0596)	0.1270 (0.0873)
BEDRMS	-0.0335 (0.0687)	0.1374* (0.0641)	0.1926*** (0.0637)	0.0996 (0.0915)	0.0083 (0.0597)	0.1211** (0.0445)	0.1992*** (0.0579)
AGEUNIT	-0.0268* (0.0115)	-0.0369*** (0.0085)	-0.0210* (0.0106)	0.0038 (0.0167)	-0.0033 (0.0085)	-0.0051 (0.0067)	0.0006 (0.0131)
AGEUNITSQ	0.0004*** (0.0001)	0.0005*** (0.0001)	0.0002* (0.0001)	-0.0001 (0.0001)	0.0001 (0.0001)	0.0000 (0.0001)	-0.0001 (0.0001)
CRACKS	0.1885 (0.5104)	-0.1048 (0.2393)	0.1183 (0.3330)	-0.7469 (0.4495)	0.5810* (0.2536)	-0.1926 (0.1639)	-0.9097*** (0.2055)
FPLWK	0.5396*** (0.1409)	-0.0316 (0.1005)	0.2539* (0.1218)	0.3189 (0.1865)	0.1762 (0.1119)	0.1476 (0.0804)	0.2394* (0.0963)
GARAGE	-0.0092 (0.3335)	0.4378*** (0.1189)	0.0116 (0.1094)	-0.1379 (0.1911)	0.0046 (0.1033)	0.2433* (0.1071)	-0.1327 (0.1982)
LEAK	-0.2536 (0.2013)	-0.1791 (0.1263)	-0.1780 (0.1348)	0.2585 (0.2167)	0.1162 (0.1205)	0.0651 (0.0959)	0.1105 (0.1178)
PORCH	0.3058 (0.2203)	-0.4250** (0.1487)	-0.0439 (0.2465)	-0.0633 (0.2473)	0.0644 (0.1501)	-0.0041 (0.0908)	0.2144 (0.1425)
HOWN	0.4507 (0.2540)	0.2459 (0.1407)	0.2160 (0.1731)	0.0254 (0.2841)	0.2315 (0.1911)	0.1985 (0.1134)	0.2676 (0.1520)
HHAGE	0.0018 (0.0047)	0.0027 (0.0041)	0.0023 (0.0056)	-0.0116 (0.0071)	0.0025 (0.0049)	0.0020 (0.0028)	-0.0045 (0.0038)
HHGRAD	0.7846*** (0.1888)	0.2804 (0.1563)	0.8331*** (0.2188)	-0.1027 (0.2819)	0.0191 (0.1945)	0.0994 (0.1118)	0.2615 (0.1665)
HHMAR	0.2999* (0.1211)	-0.1917 (0.1075)	-0.1638 (0.1219)	0.0943 (0.1936)	-0.0855 (0.1105)	0.1108 (0.0775)	-0.0788 (0.1041)
HHBLACK	-0.1729 (0.4869)	-0.4723*** (0.1032)	-0.3311* (0.1318)	-0.5450* (0.2553)	-0.0603 (0.2167)	-0.2579* (0.1080)	-0.2015 (0.1230)
HHMALE	-0.0751 (0.1084)	-0.0520 (0.0899)	0.0825 (0.1107)	0.1954 (0.1501)	0.0603 (0.0987)	-0.0895 (0.0708)	0.1609 (0.0927)
HHMOV	0.0254 (0.0142)	0.0260* (0.0116)	0.0008 (0.0134)	0.0119 (0.0167)	0.0057 (0.0109)	-0.0037 (0.0072)	0.0019 (0.0107)
HHMOVSQ	-0.0006* (0.0003)	-0.0005* (0.0002)	0.0001 (0.0003)	0.0000 (0.0003)	-0.0001 (0.0002)	0.0001 (0.0001)	0.0001 (0.0002)
LnHINC	0.2061*** (0.0559)	0.2096*** (0.0511)	0.1432* (0.0583)	0.1822 (0.1153)	0.0599 (0.0531)	0.1423*** (0.0393)	0.0134 (0.0446)
INTERCEPT	8.6553 (0.8373)	8.3197 (0.5752)	9.2699 (0.8377)	10.4087 (1.3178)	11.0582 (0.6922)	9.2624 (0.5155)	10.2630 (0.7080)
Observations	178	142	145	108	221	454	147
R^2	0.4423	0.6619	0.4799	0.4292	0.2108	0.2923	0.4992

Appendix Table 6: Regression result of the hedonic regression for 33 MSAs in 2011 (continued)							
Variable	**Dallas**	**Detroit**	**Fort Worth-Arlington**	**Houston**	**Kansas City**	**Los Angeles**	**Miami**
LnVALUE							
AIRSYS	0.4375** (0.1577)	0.2994* (0.1350)	-0.1514 (0.3073)	-0.0271 (0.1633)	0.3997 (0.2313)	-0.0317 (0.0423)	0.1742 (0.2154)
BATHS	0.3532*** (0.0654)	0.2524** (0.0904)	0.3624*** (0.0960)	0.4706*** (0.0887)	0.1412 (0.1025)	0.1654*** (0.0281)	0.2160* (0.0884)
BEDRMS	0.0842 (0.0567)	0.3326*** (0.0741)	0.0821 (0.0929)	0.1163 (0.0640)	0.0311 (0.0874)	0.0983*** (0.0260)	0.1595* (0.0750)
AGEUNIT	-0.0124 (0.0067)	-0.0162 (0.0083)	-0.0073 (0.0097)	-0.0125 (0.0078)	-0.0261*** (0.0085)	0.0063 (0.0036)	-0.0013 (0.0149)
AGEUNITSQ	0.0002*** (0.0001)	0.0002* (0.0001)	0.0001 (0.0001)	0.0002** (0.0001)	0.0003*** (0.0001)	0.0000 (0.0000)	0.0001 (0.0002)
CRACKS	-0.0074 (0.1225)	-0.1023 (0.2467)	0.0826 (0.2229)	-0.0262 (0.1310)	0.0189 (0.3131)	-0.1433 (0.1054)	-0.7066 (0.6078)
FPLWK	0.2946*** (0.0906)	0.2048 (0.1142)	-0.0949 (0.1330)	0.0421 (0.0971)	0.3713** (0.1328)	0.2972*** (0.0421)	-0.1133 (0.2143)
GARAGE	0.0881 (0.1233)	0.5204*** (0.1580)	0.2032 (0.2738)	0.1264 (0.1387)	0.7233*** (0.2373)	0.1504* (0.0750)	-0.0096 (0.1094)
LEAK	-0.0761 (0.1407)	-0.2901* (0.1445)	0.1586 (0.2468)	0.0141 (0.1743)	-0.1803 (0.1497)	0.0562 (0.0608)	-0.1430 (0.1549)
PORCH	-0.2771 (0.1741)	-0.3437 (0.2442)	0.6693 (0.3891)	-0.0186 (0.1406)	-0.4124 (0.3429)	-0.0028 (0.0550)	0.4845 (0.2504)
HOWN	0.2407 (0.1249)	0.6988*** (0.1701)	0.2396 (0.1862)	0.0412 (0.1262)	-0.0550 (0.1855)	0.2070*** (0.0703)	0.3707* (0.1686)
HHAGE	0.0057 (0.0035)	0.0012 (0.0043)	0.0031 (0.0048)	0.0059 (0.0039)	-0.0013 (0.0043)	0.0005 (0.0016)	0.0080 (0.0044)
HHGRAD	0.3441 (0.1134)	0.0123 (0.1781)	0.3373 (0.1783)	0.1333 (0.1168)	0.6843** (0.2410)	0.1585*** (0.0555)	0.3447* (0.1429)
HHMAR	-0.0580 (0.0923)	0.1241 (0.1175)	0.0569 (0.1291)	-0.0526 (0.1002)	-0.0653 (0.1389)	-0.0650 (0.0417)	-0.1800 (0.1094)
HHBLACK	-0.4003 (0.1131)	-0.2025 (0.1498)	-0.2287 (0.1804)	-0.1428 (0.1182)	-0.2287 (0.1746)	-0.1836** (0.0700)	-0.2453 (0.1372)
HHMALE	0.0449 (0.0841)	0.0204 (0.1050)	-0.1735 (0.1188)	0.0003 (0.0904)	0.2048 (0.1239)	0.0040 (0.0384)	-0.0907 (0.1039)
HHMOV	0.0063 (0.0112)	0.0207* (0.0104)	0.1188 (0.0169)	-0.0080 (0.0112)	0.0044 (0.0152)	0.0072 (0.0042)	0.0050 (0.0133)
HHMOVSQ	-0.0002 (0.0002)	-0.0003 (0.0002)	0.0003 (0.0004)	0.0000 (0.0002)	0.0000 (0.0003)	0.0000 (0.0001)	0.0000 (0.0003)
LnHINC	0.1726*** (0.0476)	0.1273* (0.0566)	0.1030 (0.0631)	0.1850*** (0.0459)	0.1661* (0.0728)	0.1458*** (0.0180)	0.2837*** (0.0624)
INTERCEPT	7.7310 (0.6125)	7.5390 (0.7384)	8.6429 (0.8995)	8.1194 (0.5527)	8.4656 (0.7655)	9.5682 (0.2449)	6.2128 (0.8359)
Observations	179	490	120	210	116	1340	154
R^2	0.6108	0.3351	0.4901	0.4792	0.5751	0.2823	0.5450

Appendix Table 6: Regression result of the hedonic regression for 33 MSAs in 2011 (continued)							
Variable	**Milwaukee**	**Minneapolis-Saint Paul**	**Nassau-Suffolk**	**New York City**	**Newark**	**Norfolk-Virginia Beach**	**Oakland**
LnVALUE							
AIRSYS	0.8490*** (0.2223)	0.2692*** (0.0946)	0.1721* (0.0693)	0.1553 (0.1062)	0.3658*** (0.0883)	0.2948* (0.1350)	-0.0612 (0.1211)
BATHS	0.1991 (0.1573)	0.2496*** (0.0509)***	0.0791 (0.0506)	0.1850*** (0.0643)	0.1198* (0.0564)	0.2648*** (0.0594)	0.2583** (0.0958)
BEDRMS	0.1398 (0.1182)	0.1421 (0.0410)	0.0848* (0.0387)	0.0818 (0.0418)	0.1484*** (0.0407)	0.1412*** (0.0456)	0.0503 (0.0687)
AGEUNIT	0.0279 (0.0207)	-0.0179** (0.0067)	0.0098 (0.0098)	-0.0127 (0.0070)	0.0032 (0.0072)	-0.0010 (0.0051)	-0.0162 (0.0100)
AGEUNITSQ	-0.0003 (0.0002)	0.0002*** (0.0001)	0.0000 (0.0001)	0.0001* (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0002 (0.0001)
CRACKS	0.2701 (0.4349)	-0.3986 (0.1767)	-0.1668 (0.1817)	0.2035 (0.1884)	0.0299 (0.1682)	0.0668 (0.1661)	0.0930 (0.2928)
FPLWK	0.3699 (0.1935)	0.1931*** (0.0669)	0.1904** (0.0719)	0.1880 (0.1089)	0.2093* (0.0848)	0.1717* (0.0700)	0.3116* (0.1248)
GARAGE	0.1497 (0.3657)	0.2820 (0.1644)	0.1639 (0.0801)	-0.1134 (0.0866)	0.0908 (0.1028)	0.1225 (0.0728)	-0.0292 (0.2242)
LEAK	0.3743 (0.2504)	-0.1554 (0.0845)	-0.0677 (0.0908)	-0.0512 (0.1059)	0.0278 (0.0810)	-0.0054 (0.0802)	-0.0108 (0.2481)
PORCH	0.2057 (0.2872)	0.0128 (0.1124)	0.1035 (0.0833)	-0.0701 (0.0893)	-0.2339* (0.1046)	-0.0065 (0.1069)	0.2800 (0.2019)
HOWN	0.0974 (0.2873)	0.0670 (0.1511)	-0.1071 (0.1256)	0.2593 (0.1770)	0.4136*** (0.1344)	0.2301 (0.1174)	0.0293 (0.1972)
HHAGE	0.0207** (0.0072)	0.0091*** (0.0029)	0.0078* (0.0032)	-0.0020 (0.0034)	0.0061 (0.0042)	0.0005 (0.0028)	0.0077 (0.0047)
HHGRAD	-0.1194 (0.3137)	0.2356 (0.1792)	0.1005 (0.1363)	-0.0165 (0.1402)	0.1429 (0.1282)	0.1847 (0.1600)	0.1007 (0.2209)
HHMAR	0.0732 (0.1916)	-0.0302 (0.0749)	0.0559 (0.0770)	-0.0317 (0.0892)	0.0511 (0.0941)	-0.0173 (0.0680)	0.1495 (0.1338)
HHBLACK	-0.0903 (0.2766)	-0.2224 (0.2333)	-0.0312 (0.1165)	-0.3269*** (0.1019)	-0.1941 (0.1141)	-0.1164 (0.0738)	0.0832 (0.2193)
HHMALE	-0.1778 (0.1845)	0.0026 (0.0662)	0.0020 (0.0663)	-0.0404 (0.0816)	-0.0220 (0.0791)	0.0948 (0.0615)	-0.0979 (0.1049)
HHMOV	-0.0226 (0.0181)	-0.0038 (0.0080)	-0.0002 (0.0069)	0.0011 (0.0098)	-0.0002 (0.0099)	-0.0117 (0.0073)	-0.0053 (0.0123)
HHMOVSQ	0.0002 (0.0003)	0.0000 (0.0002)	-0.0001 (0.0001)	0.0000 (0.0002)	0.0000 (0.0002)	0.0003 (0.0001)	0.0000 (0.0002)
LnHINC	0.2318* (0.1107)	0.1268 (0.0466)	0.0262 (0.0329)	0.1405*** (0.0436)	0.0863 (0.0442)	0.0746* (0.0367)	0.2666 (0.0609)
INTERCEPT	5.9161 (1.4986)	8.9610 (0.5877)	10.8841 (0.5571)	11.0263 (0.5746)	9.8496 (0.5897)	9.6378 (0.4921)	8.5587*** (0.8145)
Observations	113	201	224	486	146	128	167
R^2	0.44	0.5046	0.2758	0.1809	0.6539	0.6764	0.4316

Appendix Table 6: Regression result of the hedonic regression for 33 MSAs in 2011 (continued)							
Variable	**Philadelphia**	**Phoenix**	**Pittsburg**	**Riverside-San Bernardino**	**Saint Louis**	**San Antonio**	**San Diego**
LnVALUE							
AIRSYS	0.2692*** (0.0573)	1.0750 (0.8251)	-0.0307 (0.1121)	-0.1058 (0.2301)	0.2808 (0.1912)	0.1396 (0.1365)	-0.0639 (0.1512)
BATHS	0.1483*** (0.0386)	0.3432*** (0.1173)	0.2990*** (0.0728)	0.1648 (0.1171)	0.2126** (0.0809)	0.2360* (0.1089)	-0.0642 (0.1445)
BEDRMS	0.1677*** (0.0292)	0.0608 (0.0861)	0.1948*** (0.0601)	0.2271** (0.0794)	0.1990*** (0.0559)	0.0560 (0.0727)	0.2573** (0.0988)
AGEUNIT	0.0015 (0.0035)	-0.0131 (0.0105)	-0.0193 (0.0145)	0.0191 (0.0121)	0.0029 (0.0088)	-0.0167* (0.0082)	-0.0373** (0.0156)
AGEUNITSQ	0.0000 (0.0000)	0.0001 (0.0001)	0.0001 (0.0001)	-0.0001 (0.0001)	0.0000 (0.0001)	0.0001 (0.0001)	0.0004** (0.0002)
CRACKS	-0.1564 (0.0869)	0.0016 (0.3222)	-0.4517 (0.2309)	0.2352 (0.3109)	-0.4491 (0.2300)	-0.0361 (0.1563)	-0.0182 (0.5296)
FPLWK	0.2252*** (0.0494)	0.3808*** (0.1181)	0.2706*** (0.0892)	0.7950*** (0.1527)	0.3055** (0.1111)	0.2089* (0.1044)	0.5268*** (0.1602)
GARAGE	0.0984* (0.0474)	0.7344*** (0.1948)	0.1195 (0.1156)	1.1140* (0.5508)	0.1513 (0.1361)	0.2236 (0.1343)	-0.1911 (0.3470)
LEAK	-0.0192 (0.0529)	0.0438 (0.1801)	0.2355* (0.1104)	-0.3339 (0.1699)	0.2874 (0.1210)	-0.0097 (0.1893)	-0.3810 (0.2636)
PORCH	0.0082 (0.0674)	0.2406 (0.2440)	-0.1389 (0.2062)	-0.6222* (0.3075)	-0.2027* (0.2343)	-0.2484 (0.2148)	0.9261 (0.3482)
HOWN	0.2359*** (0.0726)	0.2990 (0.1737)	0.3512* (0.1571)	0.2516 (0.1857)	0.0002 (0.1798)	0.0739 (0.1394)	0.9392*** (0.2898)
HHAGE	0.0008 (0.0019)	0.0046 (0.0042)	0.0008 (0.0035)	0.0042 (0.0044)	-0.0056 (0.0045)	0.0022 (0.0037)	0.0038 (0.0060)
HHGRAD	0.0484 (0.0801)	0.2225 (0.1744)	-0.1871 (0.2607)	-0.0901 (0.2152)	0.0055 (0.2109)	0.0756 (0.1371)	0.1954 (0.2718)
HHMAR	0.0197 (0.0471)	0.0000 (0.1150)	0.1407 (0.1004)	-0.1632 0.1247	-0.0275 (0.1098)	-0.2121 (0.1136)	0.0451 (0.1751)
HHBLACK	-0.3034*** (0.0656)	0.0306 (0.2444)	-0.0786 (0.2044)	0.0930 (0.2363)	-0.3304** (0.1186)	-0.6382* (0.3143)	0.3210 (0.5381)
HHMALE	-0.0074 (0.0445)	0.0776 (0.1132)	0.0715 (0.0849)	0.1767 (0.1095)	-0.1968 (0.1023)	0.2136* (0.1004)	-0.1490 (0.1521)
HHMOV	-0.0023 (0.0050)	0.0159 (0.0143)	-0.0065 (0.0091)	0.0177 (0.0158)	0.0116 (0.0105)	-0.0128 (0.0119)	0.0156 (0.0171)
HHMOVSQ	0.0000 (0.0001)	-0.0001 (0.0004)	0.0002 (0.0002)	-0.0002 (0.0003)	-0.0001 (0.0002)	0.0004 (0.0002)	0.0000 (0.0003)
LnHINC	0.0955*** (0.0257)	0.2044*** (0.0627)	0.0841 (0.0607)	0.3356*** (0.0676)	0.1211* (0.0521)	0.1668*** (0.0593)	0.2119** (0.0786)
INTERCEPT	9.8491 (0.3141)	5.8677 (1.0955)	10.0822 (1.0123)	5.3104 (0.8581)	9.4624 (0.7252)	9.3970 (0.6615)	7.9912 (1.1194)
Observations	561	239	146	130	130	100	162
R^2	0.5	0.4144	0.598	0.6312	0.5804	0.6441	0.337

Appendix Table 6: Regression result of the hedonic regression for 33 MSAs in 2011 (continued)					
Variable	**San Francisco**	**San Jose**	**Seattle**	**Tampa – Saint Petersburg**	**Washington D.C.**
LnVALUE					
AIRSYS	0.0827 (0.1148)	-0.0628 (0.1845)	-0.0618 (0.2492)	0.7999** (0.2895)	0.0717 (0.1156)
BATHS	0.1725* (0.0673)	0.1609 (0.1394)	0.2870* (0.1203)	0.2779 (0.1460)	0.1722*** (0.0428)
BEDRMS	0.0550 (0.0540)	0.3194* (0.1293)	0.0976 (0.0913)	0.2497* (0.0991)	0.0719* (0.0336)
AGEUNIT	-0.0109 (0.0091)	-0.0136 (0.0172)	-0.0180 (0.0126)	-0.0185 (0.0148)	-0.0127* (0.0053)
AGEUNITSQ	0.0001 (0.0001)	0.0002 (0.0002)	0.0002* (0.0001)	0.0002 (0.0002)	0.0002*** (0.0001)
CRACKS	-0.1678 (0.4027)	0.0000 (0.0000)	-0.0821 (0.3949)	0.0897 (0.4864)	-0.1206 (0.1354)
FPLWK	0.1901* (0.0907)	0.4448* (0.2072)	0.5937*** (0.1703)	0.2038 (0.2032)	0.1904*** (0.0649)
GARAGE	0.0068 (0.1964)	-0.1693 (0.4874)	0.1882 (0.2497)	0.1483 (0.1628)	0.2153*** (0.0619)
LEAK	0.1950 (0.2279)	0.1786 (0.2965)	0.1468 (0.2224)	-0.0256 (0.3035)	-0.0353 (0.0724)
PORCH	0.0754 (0.1272)	-0.3466 (0.2688)	-0.4571 (0.2896)	-0.0315 (0.2015)	-0.0288 (0.0820)
HOWN	0.3426* (0.1705)	-0.1762 (0.4761)	0.4168 (0.2797)	0.6733*** (0.1802)	0.2394 (0.1748)
HHAGE	0.0030 (0.0036)	0.0050 (0.0096)	-0.0089 (0.0071)	-0.0100 (0.0054)	0.0034 (0.0025)
HHGRAD	0.2827 (0.1927)	-0.0200 (0.4445)	0.6082* (0.3501)	-0.7309* (0.2804)	0.5359*** (0.1586)
HHMAR	0.0791 (0.0894)	-0.1695 (0.2172)	-0.1805 (0.1614)	0.2005 (0.1442)	0.0435 (0.0666)
HHBLACK	-0.0480 (0.1702)	-0.1231 (0.6530)	-0.3302 (0.4484)	-0.4344 (0.3122)	-0.2511*** (0.0685)
HHMALE	-0.0201 (0.0796)	0.0483 (0.1864)	-0.0129 (0.1444)	-0.0569 (0.1373)	-0.0684 (0.0575)
HHMOV	0.0033 (0.0082)	-0.0201 (0.0229)	0.0375* (0.0170)	0.0140 (0.0167)	-0.0054 (0.0063)
HHMOVSQ	-0.0001 (0.0001)	0.0005 (0.0004)	-0.0003 (0.0003)	0.0001 (0.0004)	0.0002 (0.0001)
LnHINC	0.1435** (0.0545)	0.1922* (0.0941)	0.2342* (0.1032)	0.1255* (0.0617)	0.0861** (0.0284)
INTERCEPT	10.4303 (0.7047)	9.8745 (1.4261)	8.3389 (1.2726)	8.9775 (0.9935)	10.2546 (0.4356)
Observations	116	144	150	151	264
R^2	0.456	0.2999	0.3856	0.4584	0.526