What Can We Learn From Hedonic Models
Where Markets Are Dominated By Foreclosures?

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Abstract

Hedonic property value models have been frequently used to value environmental amenities (or dis-amenities) since markets for these goods (bads) do not usually exist. Typically, researchers cite Rosen's (1974) seminal work that allows one to interpret functions of the hedonic regression coefficients as the marginal willingness to pay (MWTP) for the environmental good. This allows the results from the hedonic models to be used to evaluate the net benefits from environmental policies and actions such as cleaning up Superfund sites and improving air and water quality.

There are a number of assumptions needed for the Rosen result to hold. However, under extreme circumstances in the housing market, these assumptions are unlikely to be realistic. Recent years have witnessed such extreme circumstances, such as wild swings in housing prices, high levels of mortgage default, and most significantly, high levels of foreclosure. In this paper, we address the following question "How can we interpret the coefficient estimates for environmental goods in hedonic property value models where markets are dominated by foreclosures?"

The key point is that the Rosen framework for developing the hedonic model and interpreting the coefficients in this model as MWTP relies on an equilibrium assumption that is questionable in today's housing market that is dominated by foreclosures. In order to evaluate the impact of foreclosures on the housing market in general and more specifically on the interpretation of the coefficients for environmental variables in the hedonic model, we develop a disequilibrium model of the housing market that explicitly accounts for foreclosures through their impact on vacancies. We also raise issues having to do with composition bias in hot and cold markets and how this affects the coefficients in the hedonic model.

I. Introduction

Hedonic property value models have been frequently used to value environmental amenities (or dis-amenities) since markets for these goods (bads) do not usually exist. Typically, researchers cite Rosen's (1974) seminal work that allows one to interpret functions of the hedonic regression coefficients as the marginal willingness to pay (MWTP) for the environmental good. This allows the results from the hedonic models to be used to evaluate the net benefits from environmental policies and actions such as cleaning up Superfund sites and improving air and water quality.

There are a number of assumptions needed for the Rosen result to hold. However, under extreme circumstances in the housing market, these assumptions are unlikely to be realistic. Recent years have witnessed such extreme circumstances, such as wild swings in housing prices, high levels of mortgage default, and most significantly, high levels of foreclosure. In this paper, we address the following question "How can we interpret the coefficient estimates for environmental goods in hedonic property value models where markets are dominated by foreclosures?"

Even when the market is in equilibrium, there are problems with the standard hedonic model that can result in coefficient estimates that are biased estimates of MWTP. In particular, endogeneity and omitted variables bias plague early studies that attempt to estimate MWTP for environmental goods. Recent studies rely on more modern methodologies to mitigate these biases. These include random experiments, instrumental variables, regression discontinuity, and the difference-in-difference framework.

The typical application of one of these approaches in environmental economics uses observational data that varies both spatially and temporally. In these cases, it is a common assumption that the parameters (other than the constant) are constant over time. Bartik (1988), among others, have pointed out that when there is a large-scale change in an environmental good, say, through the imposition of air quality standards, this assumption is unlikely to hold since general equilibrium effects due to residential re-sorting will shift the hedonic function. The impacts of larger-scale changes in environmental quality are probably better measured using recently-developed sorting models that capture the general equilibrium effects that these changes can engender (see Kuminoff et al. (2010) for an excellent review of these models). For example, Smith et al. (2004) show that the general equilibrium effects can be quite different than the partial equilibrium effects from a market-wide change in air quality in Los Angeles.

Still, when the impacts of changes in environmental goods are very local, such as in the discovery and clean up of leaking underground storage tanks, the general equilibrium effects will be relatively small and hence it is more reasonable to interpret the hedonic coefficients as MWTP. When the market equilibrium does not change then the hedonic estimates provide an upper bound on the true net benefits since they do not account for moving costs (Freeman 1993), though even this result has been questioned (Kuminoff and Pope 2010).

These issues aside, there are other reasons to believe that MTWP, itself, can change over time and this can complicate how we use hedonic estimates to evaluate the net benefits from environmental policies. National and urban business cycles can affect the supply and demand for housing which will then affect the housing market outcomes that are the basis for the hedonic equation. These impacts are exacerbated with significant swings in the housing cycle such as what has been experienced in the last decade. In particular, housing demand is affected by household income whose changes are tied to the business cycle. Further, the increase in inequality has changed the shape of the income distribution. The increase in the upper tail is one explanation for Superstar cities (Gyourko et al xxxx).

Leamer (2007) has made the claim that housing IS the business cycle. He shows that residential investment is a much better predictor of recessions than business activity. Leamer's explanation for the importance of housing is that house prices are sticky downward. Hence the reaction in the housing market to excess supply (due to a drop in demand) is not a drop in price but a drop in sales. The fall in sales leads to a decline in new housing supply and the commensurate drop in construction, finance, and real estate jobs. It is declines in volume that leads declines in prices.

It is clear that the housing market is not as liquid as other asset markets and hence cannot quickly re-equilibrate after macroeconomic shocks push the market out of equilibrium. Houses are the largest purchase made by households and hence transactions are not likely to be spontaneous. Houses are not divisible and heterogeneous characteristics and information asymmetries can make matching buyers and sellers more difficult. Brokers act as intermediaries and this only adds to transaction costs. DiPasquale and Wheaton (1994) find evidence that the housing market takes years to clear. Riddel (2004) also finds evidence that housing market exhibits long periods of disequilibrium.

A key to prolonged market disequilibrium, particularly in a down market, is the downward stickiness of house prices. There are numerous reasons for this downward stickiness. Leamer (2007) offers one: sellers' valuations of their houses are based on recent comparable transactions whereas buyers' valuations are based on their take on future values. So when the market is hot and prices are rising, buyers value units more than sellers and sales volume is high. But when the market is cold, the opposite occurs. Sales only occur when sellers get "lucky" and are matched with a buyer with a relatively high valuation. As Leamer (2007) points out, what are observed in a cold market are sellers' prices, not market prices.

Another explanation is given by Genevose and Mayer (2001); owners are not (psychologically) willing to sell their houses for less than they paid for it; so called "loss aversion". Kiel and Zabel (1999) offer a similar psychological mechanism to explain why new owners tend to over-value their homes more than owners who have been in their homes for longer periods of time; self-serving bias (Lowenstein, Issacharoff, Camerer, and Babcock 1993) that arises because the value that new owners place on their house reflects their perceived abilities in bargaining in the housing market. In particular, new owners would not be inclined to believe that their home is worth less than they paid for it since this would indicate they had been duped by the market. It is exactly in a down market, when buyers' valuations are falling, that new owners are reluctant to drop their valuations below the recent price they paid for their home.

One sign that the market is not in equilibrium is a large number of vacancies. Vacancy rates above the "natural rate" (that arises from housing search) are an indication of excess housing supply. The recent downturn in the housing market has led to an unprecedented number of foreclosures at the national level that has push the vacancy rate in many housing markets above the natural rate. This has resulted in a state of housing market disequilibrium which violates one of the key assumptions underlying the Rosen framework. The analysis of how the housing cycle affects the hedonic function is the goal of this study. We will pay particular attention to the role that foreclosures play in determining market outcomes and hence the market hedonic.

Finally, the composition of transactions that are used to estimate the hedonic can affect the estimates of the hedonic parameters. This composition bias is known to be an issue when generating house price indices but it may also affect the estimates of MWTP for environmental goods as well. This is particularly relevant in the context of the recent housing downturn, as the sale of foreclosed properties has significantly impacted the composition bias of transacted units.

In the case of a large number of foreclosures, one might be tempted to throw out foreclosed sales. We investigate how this affects the interpretation of hedonic regression coefficients. Another related issue is that coefficient estimates can be affected by the housing cycle; that is estimated implicit prices of housing characteristics can vary across the cycle. This ties into the literature on hot and cold markets and "thin" markets in particular. We investigate this issue as well.

The key point is that the Rosen framework for developing the hedonic model and interpreting the coefficients in this model as MWTP relies on an equilibrium assumption that is questionable in today's housing market that is dominated by foreclosures. In order to evaluate the impact of foreclosures on the housing market in general and more specifically on the interpretation of the coefficients for environmental variables in the hedonic model, we develop a disequilibrium model of the housing market that explicitly accounts for foreclosures through their impact on vacancies. We also raise issues having to do with composition bias in hot and cold markets and how this affects the coefficients in the hedonic model.

The results of this analysis will have important implications for the evaluation of the benefits of environmental goods and hence the economic efficiency of policies that affect the provision of environmental goods. For example, there is a large literature that uses hedonic models to estimate the benefits from cleaning up Superfund sites (e.g. Kiel and Williams (2007), Greenstone and Gallagher (2008), and Gamper-Rabindran and Timmons (2011)). Given our findings, we will provide a re-interpretation of these results. Finally, we will come back to the initial issue of foreclosures and review the latest literature on estimating the MWTP for environmental goods and provide a critical interpretation of these results.

II. The Rosen Framework of Hedonic Prices in Spatial Equilibrium

The basis of the Rosen model is the pricing of a heterogeneous good with multiple characteristics. The problem is cast in characteristic space where consumers and producers of the good decide where to locate based on their optimal outcomes from utility and profit maximization. Hence we can think of each point in the characteristic space as a specific good; that is the heterogeneous good with a specific set of characteristics.

This framework lends itself quite naturally to the residential location decision whereby individuals choose over a set of housing units located across a housing market. The choice of a particular spatial location results in housing services that emanate from the structural characteristics that comprise the housing unit and from the local public goods and other spatial amenities that are associated from this location. Further, producers or housing developers (assumed to be owners of undeveloped land) are also making decisions about when to build and what specific structure to construct in this housing market. The outcome of these optimizing decisions, under a set of assumptions, will result in an equilibrium hedonic price function. This function can be used to determine the implicit prices of the structural and neighborhood characteristics. The interest in environmental economics is the pricing of local environmental (dis)amenities such as hazardous waste sites and air and water quality.

Based on the solutions to the consumer and producer maximization problems, the equilibrium hedonic price schedule p(z) represents a set of tangencies between consumer bid functions and producer offer functions. Rosen shows that under these equilibrium conditions that the coefficients corresponding to the housing characteristics in the hedonic equation can be interpreted as consumers' marginal willingness to pay for these characteristics.

One issue is that Rosen doesn't distinguish between structural characteristics, *s* and neighborhood characteristics, *n*. A distinguishing factor is that the amount of *s* is determined by the developer whereas, to a certain extent, *n* is not. The latter might require a Tiebout-type framework to produce a similar result as Rosen derived; the hedonic function can be used to estimate MWTP for these goods. Tiebout's (1956) main point is that local public goods that are provided by the local jurisdiction can be efficiently allocated without federal involvement because households will reveal their true preferences for these goods by choosing where to live – their choice of residence will reflect the outcome of an optimization problem that is similar to what occurs for private goods. Hence local public goods should be capitalized into house prices and the general Rosen result holds that the marginal valuation of the local public goods will reflect consumer marginal willingness to pay for these goods.

Hedonic valuation of environmental commodities is based on this model. If the function were known, we could take the derivative of p(z) with respect to environmental characteristic z_i and claim, on the basis of either (1) or (3) that this derivative represents the willingness to pay for z_i, and on that basis cost-benefit analysis of some environmental improvement can be undertaken. Of course p(z) is not known and must be estimated from data. There are two sets of issues which then arise: first the hedonic function is based on both the bid and offer functions and the points on the hedonic are due to factors that affect both consumers and producers. This introduces a classic simultaneous equations problem in the estimation of p(z). But, as Palmquist (1991) points out

> Although it is important to include both consumer and producer behavior when describing the market, for many environmental issues the critical information is contained on the consumer side of the market. Fortunately, it is often possible to focus on the equilibrium price schedule and on consumers' decisions. In these cases, ignoring the producer side does not create theoretical or econometric problems." (Palmquist, p80)

This is because housing supply is dominated by an existing stock which is fixed in place by historical circumstances. On this account the above model of builder/supplier decisions can be replaced by one in which consumers are matched with a given distribution of z (Epple 1987). Environmental goods in this model are simply one more element of z which consumers take as given. Even on this assumption of fixed supply, a second issue arises, which is that absent full information on both the distribution of z and consumer taste and income, the functional form of p(z) cannot be determined from the model. As Epple (1987) points out p(z) can be either concave or convex at some value z*, depending on the densities of y, α, and z in the neighborhood of z*[1].

$\beta_{jt} p_t$

Estimates of p(z) therefore must be estimated from regression analysis, where the dependent variable is the price of the house and the independent variables are the z's which are given some nonlinear functional form. This functional form is generally taken to be one that fits the data well, since (to repeat) the theory gives no guidance. In any case, with the parameters of p(z) estimated, derivatives can be calculated and cost-benefit analysis undertaken. To take a common example, it is often assumed (again, because the fit of the regression is good) that the hedonic function takes the form:

$$\ln p_{it} = \beta_{0t} + \sum_j X_{ijt} \beta_{jt} + u_{it} \tag{1}$$

where p_{it} is the price of the i^{th} unit at time t and X_{ijt} is the value of characteristic j for unit i at time t. In this case, the hedonic price of the j^{th} characteristic in period t is $\beta_{jt} \overline{p}_t$ where $\overline{p}_t$ is the average price at time t. This particular functional form highlights two ways in which the hedonic price can vary over time: (1) the overall price of housing can vary; (2) the parameter associated with the environmental characteristic can vary over time. While other functional forms will require different calculations of hedonic prices, these basic principles generally still apply.

Now consider the price of this characteristic as time passes, particularly in light of the events of 2007 and beyond. The housing market of this era can be characterized by three phenomena:

1. A fall in the general price of housing
2. A fall in the frequency of trading—so-called "cold housing market"
3. An increase in the number of foreclosures and vacancies in general and in particularly so in certain neighborhoods.

The question then is whether these phenomena have an effect on either β_{jt} or $\overline{p}_t$. Clearly 1. has an effect on price

III. Foreclosures, Vacancy Rates, and the Housing Market

[1] Perhaps a footnote here explaining that even if everything here were solved you would usually only have a local approximation to willingness to pay and that for real cost-benefit analysis to take place you would need to estimate the bid functions a la Kiel and Zabel or Coulson and Bond.

The housing crisis of 2007 and going forward has led, as noted, to a large increase in foreclosed properties. This has generated real effects in the housing market, among which is a notable increase in housing vacancy rates. Figure 1 displays historical trends in what the Census calls ownership vacancy rates for the period 1986-2009[2] for the US as a whole and for four selected states: Florida, Nevada, Ohio, and Pennsylvania. Note first that the U.S. rate was more or less constant between 1 and 2 percent until the time of the crisis, whereupon it basically doubled to nearly 2 percent between 2005 and 2009. However the changes in this rate were quite heterogenous across states. The first two, Florida and Nevada, were widely regarded as centers of the housing bubble and its deflation in the key years. The vacancy rates displayed in Figure 1 reflect this. These states' vacancy rates were, though above the national average, quite stable until 2005, whereupon they rose dramatically, to above 5 percent in 2008. This is widely viewed as being the result of homeowners leaving their property in the wake of default and foreclosure events[3]. This interpretation is reinforced by examining the vacancy trend for Ohio, whose residents were also severely hit by foreclosures. Ohio had a lower than average vacancy rate for much of the pre-crisis period but beginning even in 2004 had a strong upsurge in vacancies which left it well above average at the end of the period. By contrast, Pennsylvania which had a rather less severe foreclosure crisis, did not experience a rise in vacancies during the crisis period. One last point to note is that all of the states, and the US generally, experienced a downturn in the vacancy rate in 2009.

The stable behavior of vacancy rates over time (at least up until the recent crisis), and in particular the fact that rates are persistently greater than zero suggests that even in equilibrium it is optimal for vacancy rates to be greater than zero. This positive equilibrium rate has been dubbed the "natural" vacancy rate, and is congruent with the notion that search and matching in housing markets is costly, given the heterogeneous housing stock (Arnott, 1989, Wheaton, 1990). The "natural" vacancy rate has been confirmed by Smith and Rosen (1983). It can vary across housing markets as it is affected by factors that affect the cost of holding vacant units, search costs, transaction costs and credit market imperfections. Gabriel and Nothaft (1998) estimate the natural vacancy rates for 1981-1985 for 16 MSAs. They show that these rates depend on the change in renter occupied housing units, rents (level), the variability in rents, the percent minority, and the change in population.

> If a homeowner chooses to keep a unit vacant rather than selling in response to an offer, this is a decision to hold a real option. That is, when the owner of a vacant unit decides to keep a unit vacant rather than selling it at the current market price, this is because she believes that waiting is worthwhile. Waiting is more worthwhile if prices are expected to increase and if the volatility of housing investment returns is larger (Rosen and Smith).

These ideas can be made more precise with a simple model, similar in spirit to Wheaton (1990) and to models of the natural unemployment rate (e.g. Wright, 1986). Suppose there is a stock of

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[2] This is the vacancy rate for single family and condominium units, and is distinguished from the rental vacancy rates derived from apartment buildings and is traditionally several percentage points greater than the owner rate. The source is http://www.census.gov/hhes/www/housing/hvs/rates/index.html.

[3] See Malloy and Shan (2012); O'Donnell and Coulson (2012)

housing of population normalized to unity. At any point in time some fraction of them, v_t are vacant. Owners of vacant property post an asking rent, r_a, and await offers. They receive one offer per period, which has probability p(r_a) of being from a (potential) buyer with an offer rent greater than r_a (i.e. p(.) is the cumulative distribution function of offer rents). Owners of occupied units (who may themselves be the occupiers) dis-attach from their units (and make them vacant) with probability α. This is because of desired location change or, in the case of Wheaton (1990), demand for a different type of housing structure. Whatever the reason, these units also become vacant and receive an offer immediately, from the save distribution.

Thus, in time t, vacancies can exist for two reasons. First, there are units that were vacant in t-1, and did not receive a sufficiently high offer. The mass of these is $(1 - \mathrm{p}(\mathrm{r_a}))\mathrm{v_{t-1}}$. Second, there are newly vacant units which also did not receive a sufficiently high offer. The mass of these is $\alpha(1 - \mathrm{p}(\mathrm{r_a}))(1 - \mathrm{v_{t-1}})$. Therefore the law of motion for vacancies is

$$\mathrm{v_t} = (1 - \mathrm{p}(\mathrm{r_a}))\mathrm{v_{t-1}} + \alpha(1 - \mathrm{p}(\mathrm{r_a}))(1 - \mathrm{v_{t-1}}) + \mathrm{e_t} \qquad (2)$$

where e_t represents shocks to vacancies arising from either source. The fact that both p(.) and α are between zero and one suggests that v_t is a stationary AR(1) process with first order coefficient $(1 - \alpha)(1 - p(r_a))$ and a long run equilibrium—or natural vacancy rate, v*, of

$$\mathrm{v}^* = \frac{\alpha(1 - \mathrm{p}(\mathrm{r_a}))}{\alpha(1 - \mathrm{p}(\mathrm{r_a})) + \mathrm{p}(\mathrm{r_a})} \qquad (3)$$

On this interpretation, positive shocks will have persistent effects and higher than average vacancy rates will persist for some time, but in the end, vacancy rates will ultimately return to their equilibrium level.

The increase in vacancies due to foreclosures, on this account, is a large shock to the second source of vacancies which has pushed the vacancy rate above the natural rate and this has resulted in disequilibrium in the housing market. Therefore, and importantly, the effect of the foreclosure crisis is to only temporarily raise vacancy rates, which will return to their long run natural rates in due time.

While the simple model above leaves out the role of housing price and quantity adjustment in the face of all these new vacancies, it is intuitive (though not mathematically straightforward) to augment the model accordingly. Gabriel and Nothaft (1988), following Rosen and Smith (1985), in their investigation of rental vacancy rates, posit that

$$\Delta \mathrm{R_t} = \mathrm{g}(\mathrm{v}^* - \mathrm{v_t}) + \mathrm{u_t} \qquad (4)$$

where $g > 0$ and u_t is a random error term. Thus rents rise when the market is short of vacant units, and vice-versa, as is natural. Note that such a rent-adjustment model complicates the dynamics of equation (2) since it suggests that the AR(1) coefficient is time-varying, but we ignore that here. In any case, the persistence of vacancies in (4) causes the sign of g to be positive.

We can extend Gabriel and Nothaft to owner-occupied housing in two ways: (1) we can argue that property prices are the present discounted value of future rents, so that even a temporary increase in rents should have an effect on prices, especially if the effect, though temporary, is persistent and (2) we can argue that a similar price-adjustment dynamic applies to ownership property. Since the variability of rents is less than the variability of prices (Sinai and Souleles, 2005) the latter interpretation may be preferable.

III.1 A Disequilibrium Model of the Housing Market

We now develop a structural model of the housing market that allows for disequilibrium where the vacancy rate falls out naturally as an error correction mechanism. This builds on models developed by DiPasquale and Wheaton (1994), Follain and Velez (1995), and, in particular, Hwang and Quigley (2006).

We first specify demand and supply equations for housing $Q_t^S(P_t, X_t^S)$ and $Q_t^D(P_t, X_t^D)$. Given that the housing market is in (long run) equilibrium, $(Q_t^S = Q_t^D = Q_t)$, Q^S and Q^D, will likely be cointegrated with cointegrating parameter equal to 1. That is $Q_t^S - Q_t^D = V_t$ is I(0). Following the discussion of the natural vacancy rate, $V_t^* = V_t - V_t^N$ is the error correction mechanism where V_t^N is the natural rate. Further, to make the relationship with foreclosures clear, V_t^* is specified as a function of foreclosures, f, $V_t^*(f)$. The error correction model for inverse demand is

$$\Delta p_t = \alpha_1 \Delta q_t + \alpha_2 v_{t-1}^*(f) + \alpha_3 \Delta f_t + \alpha_4 \Delta x_t^d + \alpha_5 \Delta p_{t-1} + \Delta \varepsilon_t^d \quad (5)$$

where lower case letters indicate logs, and x^d includes the user-cost of housing, rents, income, the number of households and employment. It is expected that $\alpha_2 < 0$; if $v_{t-1}^* > 0$ then there is excess supply of housing and prices will decrease and vice versa. Note that the number of foreclosures also enters by itself in the model. That is, they are viewed as a local disamenity which directly affects the demand for housing. Hence it is expected that $\alpha_3 < 0$. Δp_{t-1} is included by specifying a partial adjustment mechanism for prices.

Note that Δq_t is essentially (the log of) new housing supply

$$\Delta q_t = \beta_1 \Delta p_t + \beta_2 v_{t-1}^*(f) + \beta_3 x_t^s + \beta_4 \Delta q_{t-1} + \Delta \varepsilon_t^s \quad (6)$$

x^s includes input prices, financing costs, average time on the market (TOM), and local regulations. It is expected that $\beta_2 < 0$, a rise in vacancies above the natural rate will reduce the supply of new housing. The lag of Δq_t is included by specifying a partial adjustment mechanism for new housing supply. Economic conditions can indirectly affect new housing supply through Δp_t. That is, as economic conditions worsen, prices will fall and this will reduce supply given that $\beta_1 > 0$.

Following Topel and Rosen (1988), we include TOM in x^S. They note that interest rates should only affect supply through demand-side effects on prices. But if increases in the interest rate lead to a drop in demand and prices are sticky downward then houses are likely to spend more time on the market. In fact, Topel and Rosen find that TOM has a large effect on new supply. They point out that TOM is potentially endogenous but IV results differ little from OLS. In essence, TOM is a very similar means for capturing market disequilibrium as is vacancies. The length of time a unit is vacant is clearly part of TOM for that unit. But TOM does not appear to fall out naturally as an error correction mechanism as do vacancies (should be included as a lag?)

To complete the system, the vacancy equation is modeled as a function of foreclosures and

$$\Delta v^*_t = \gamma_1 \Delta p_t + \gamma_2 \Delta q_t + \gamma_3 \Delta f_t + \gamma_4 \Delta x^v_t + \gamma_5 \Delta v^*_{t-1} + \varepsilon^v_t \quad (7)$$

x^v will include the expectation and variance of future price changes, E(p_{t+1}) and V(p_{t+1}). It is expected that $\gamma_1 < 0$, $\gamma_2 > 0$, and $\gamma_3 > 0$. The lag of Δv^*_{t-1} is included by specifying a partial adjustment mechanism for new housing supply.

Since Leamer points out that the business cycle is really a housing volume cycle, how can we introduce sales volume into the model? Follain and Velez include it (actually the turnover rate) as one of the equations in their structural model of the housing market. They also include it in the supply equation. They claim to find the anomalous result that the turnover rate is negatively correlated with price but this might not actually be surprising given that Leamer show that volume leads price so that volume turns down before price does. The turnover rate is clearly related to TOM as a higher TOM means a lower turnover rate.

III.2 Hot and Cold Markets

Now consider again the housing and foreclosure crisis as a shock to both prices and vacancies. There is not only a house price decline, but also an increase in vacancies due to the default and foreclosure process. What models like Hwang and Quigley's empirically demonstrate is that the interconnectedness of these variables exacerbates the effects of these shocks, but that nevertheless the effects on price are only temporary.

Another strand of literature takes a slightly different approach. Krainer (2001) notes that whether a market is "hot" or "cold" can have profound effects on the price and vacancy rates in a market. To summarize his model, in a hot market, sellers are able to (and want to) sell houses quickly, thus vacancy rates are low and prices are high. Since these quantities depend on the “state of nature” there is nothing that drives vacancy rates back to their “natural” values. These ideas are amplified in Novy-Marx (2009) who notes that additional entry by buyers is induced when markets are hot, because the value of entry increases. This raises prices, and reduces vacancy, even more, exacerbating the values of these fundamentals.

The opposite of course is true in these models during cold markets, when buyer entry is low, prices fall, illiquidity and vacancies increase. Thus to the extent that hedonic prices depend on housing prices, the recent crisis will cause a fall in hedonic prices, and it is possible that this is a more permanent state of nature for that housing market.

Chernobai and Chernobai (2012) note that buyer heterogeneity exists in these markets. They categorize buyers into long- and short-term buyers, and note that short-term buyers are more likely to buy low quality units than long-term buyers (because the costs of attaching themselves to the low quality unit are lower). The authors do not distinguish between hot and cold markets, nor apply the quality heterogeneity of housing to environmental goods in particular, one can nevertheless assume that people who buy houses in areas with negative environmental attributes are more likely to be short term buyers. Transaction rates will therefore be higher in these areas and the hedonic price of environmental attributes is likely to be higher than it would be if this buyer selection did not exist (i.e. in a market where buyers and sellers are randomly matched). A cold market is cold, therefore, because these short term buyers are the ones who have left the market. The price of housing falls in all markets, but the price in low-quality (i.e. with negative environmental attributes) areas will fall farther—that is, the hedonic price of environmental commodities falls. Long-term buyers, who now dominate the market, have less desire to live near a superfund site. Thus not only P falls in a cold market, but β does as well.

The result of this analysis of the housing market is that the market is often in a state of disequilibrium where down markets are characterized by excess supply that is due to downward sticky prices. The recent experience of excess supply is exacerbated by the increased foreclosures. The market has been slow to return to an equilibrium that requires prices to fall enough to bring vacancies back to their natural rate.

When the market is in disequilibrium, the market price is not likely to be equal to MTWP. The actual price will depend on the bargaining power of the buyers and sellers. This is displayed in Figure 2. The bottom line is, in periods of disequilibrium, interpreting coefficients in the hedonic as MTWP for a particular characteristic is questionable. At best, one should view these coefficients as capitalization effects and not as MWTP. One key indicator that the market is in disequilibrium, as characterized by excess supply, is a large increase in the number of foreclosures as is currently exhibited in many U.S. housing markets.

IV. Econometric Model

The goal of the paper is to assess what we can learn from hedonic models when the market is dominated by foreclosures. So we now move from the structural model of the housing market to the hedonic function.

Assume one housing market that consists of N units. N_t transactions are observed every period t = 1,…,T. The general econometric specification of the hedonic model is

$$p_{it} = g(X_{it}, u_{it}; \beta_t) \tag{8}$$

where p_{it} is the transaction price for unit i in period t, X_{it} is a vector of housing characteristics (structural and neighborhood), and u_{it} is a stochastic error term that needs not be i.i.d. but, for now, assume $E[u_{it}|z_{it}] = 0$. β_t is a parameter vector that is allowed to vary over time. This will allow for the "price" of housing to vary over time (i.e. time-varying intercept) as well as the coefficients for the individual components of X_{it}. In particular, as our development and discussion of the disequilibrium model of the housing market shows, not only will the market equilibrium vary over the housing cycle but the transition between equilibriums will be drawn out. This will lead to changes in β_t over time.

A typical functional form is a log-linear model that allows for nonlinear relationships between the elements of X_{it} and ln(p).

$$\ln p_{it} = \beta_{0t} + X_{it}\beta_t + u_{it} \tag{9}$$

where some of the elements of X_{it} could be binary or squares of other variables. Then the hedonic price for characteristic j is $\beta_{jt} \cdot \overline{p}_t$ where this price is evaluated at the mean of p in period t. Given that prices will change over the housing cycle, the price for characteristic j will also change over the housing cycle unless β_{jt} increases by the same percentage that $\overline{p}_t$ declines such that $\beta_{jt} \cdot \overline{p}_t$ is constant.

Of interest to environmental economists are the costs of residing near hazardous waste sites, landfills, incinerators, nuclear power plants, industrial facilities and commercial sites such as gas stations and water and air quality. Other environmental goods are actually amenities such as open space in the form of parks or wetlands. But these can also have negative impacts on house prices as the existence of open space can impose restrictions on development. A classic example is the imposition of critical habitat designation for endangered species.

When the characteristic of interest is one of these environmental goods or some other neighborhood characteristic, getting accurate estimates of the corresponding hedonic price is complicated by the likely presence of omitted variables and/or endogeneity bias. Modern methods that attempt to mitigate these biases usually require panel data in order to mimic the treatment/control framework of randomized experiments where outcomes are compared before and after the treatment is administered. When the "treatment" is a large-scale change in an environmental good, the hedonic price for that good will likely change as the market re-equilibrates. This is true even if the housing market is otherwise stable. Kuminoff and Pope (2011) show that this can make it particularly difficult to accurately estimate MWTP.

A common assumption in hedonic models is that β_t is constant over time. As we know from the literature on aggregation bias, the estimated value for β will be some kind of average (though Kuminoff and Pope (2011) show that even this is not necessarily the case) of the β_t 's. Further, to get an estimate of the hedonic price, it is common to multiply the estimated value of β by $\bar{p}$. Both of these actions will distort the actual hedonic price at a given point in time.

So here are two questions: (1) Suppose one thought that the price of air pollution was constant over the cycle. In a semilog function does this imply that beta(air pollution) rises as P falls during a downturn.? (2) If not, can we make recommendations for functional forms and/or estimation practices that provide better, more robust, estimates of hedonic prices at various points in the cycle? Jaren Pope and Nick Kuminoff have outlined a series of "best practices" that address the second question. They show in Kuminoff and Pope (2010) that the Box-Cox specification is preferable in many circumstances.

The problem of how to interpret the estimated hedonic price under these conditions is even more complex when the market is in disequilibrium. Again, the bottom line is that it is likely to be a stretch to interpret the estimated hedonic price as MWTP for the environmental good.

IV.1 Adding Foreclosures to the Hedonic Model

Now introduce foreclosures into the model. Foreclosed houses are likely to sell at lower prices than non-foreclosed units both because financial institutions have an incentive to sell them quickly because they do not collect rents while vacant units and because these units are subject to vandalism (but is this different than other vacant properties?) and because foreclosed properties are likely to not have received proper maintenance during the foreclosure process. This might indicate that foreclosed properties that sell can be included with just the addition of a dummy for foreclosures or with some other characteristics such as time vacant.

$$\ln p_{it} = \beta_{0t} + z_{it}\beta_t + f_{it}\gamma_t + u_{it}$$

where f_{it} is a binary indicator that the property is foreclosed.

A recent paper that looks at how foreclosed properties affect house prices is Campbell, Giglio, and Pathak (2011, henceforth CGP). They estimate a hedonic equation using transaction data for Massachusetts for 1987 to 2009. CGP's estimate of γ_t is -0.260, -0.344, and -0.308 for single-family, multi-family, and condos.

It could also be the case that the coefficients are different for foreclosed units.

$$\ln p_{it} = \beta_{0t} + z_{it}\beta_t + f_{it}\gamma_t + z_{it}\cdot f_{it}\delta_t + u_{it}$$

in this case allowing for separate coefficients for foreclosures is the same as dropping them from the sample. CGP find that there is a larger discount for foreclosed properties that are found in low quality census tracts and larger when the structure is worth less. They claim that this result may be due to greater vandalism in lower quality neighborhoods and "fixed costs of protection that justify larger proportional discounts on cheaper houses."

Foreclosed properties can also affect the prices of nearby properties. So at the least, we need to modify the model for non-foreclosed properties to account for this affect

$$p_{it} = g\left(z_{1it}, \ldots, z_{kit}, f_{it}(d_i), u_{it}; \beta_t\right)$$

where $f_{it}(d_i)$ is the number of foreclosures within distance d_i of unit i at time t. CGP find that an additional foreclosure that is 0.05 miles away causes prices to fall by about 1 percent. Using similar data, Gerardi, Rosenblatt, Willen, and Yao (2012) find that properties within 1/16 of a mile of (1) a seriously delinquent property, (2) a bank-owned property, (3) a property sold by the bank in the last year and (4) a property sold by the bank more than a year ago sell at 2.8%, 3.3%, 2.4% and -0.2% discounts, respectively. The authors claim that the best explanation for the discount is the reduced investment by owners of distressed properties.

V. Analysis of Empirical Studies that estimate Hedonic Prices for Environmental Goods

V.1 Noise Pollution

Consistent data of the type that is recommended to get "best" estimates of hedonic prices for environmental goods is quite difficult to assemble. We can obtain some intuition from meta-studies of the hedonic prices of environmental goods. This evidence has more cross-sectional variation than time variation, but the evidence contained there can still be quite informative. Take, for example, the studies of aircraft noise gathered for the meta-analysis of Nelson (2004). Nelson reports, for each of these studies both the average property price and the hedonic price of one decibel of aircraft noise, expressed as a percentage of property value- he calls this the NDI%. In the case of the semilog hedonic function this would be simply the hedonic parameter β, and for the linear functional form it would be the parameter value divided by the average property price[4]. We convert this hedonic valuation to price levels by converting back to marginal prices (i.e. multiplying NDI% by the average property value in the sample). As it happens, the studies used by Nelson encompass two distinct periods of analysis. The first set uses property data from the period 1969 through 1971 and the second draws from 1980 to 1993. Because of the differences between these two periods it is prudent to analyze them separately, so Figures 3 and 4 provide scatter plots of the relationship between the hedonic price of aircraft noise and the average housing price, for each of the two periods. Within each period there is a clear positive relationship between the two. It may be thought that this is a product of including the price itself in the calculation of the hedonic price, but this is not the case In a more rigorous (meta)-regression analysis, Nelson finds that that the NDI% itself is positively related to sales price.

[4] We exclude a few Canadian studies and those which use rent rather than sales price as the variable of interest.

Would this positive relationship between housing prices and hedonic prices apply to time series variation within a given market? There is no reason to think not. Willingness to pay for everything, including environmental amenities, will be higher when the economy is in a boom phase, and lower during recessions; environmental commodities are presumably normal goods. In addition, the above analyses suggest that this will be the case simply because of the types of buyers who enter and exit at different phases of the cycle.

MORE TO COME HERE.

VI Conclusion

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Figure 1

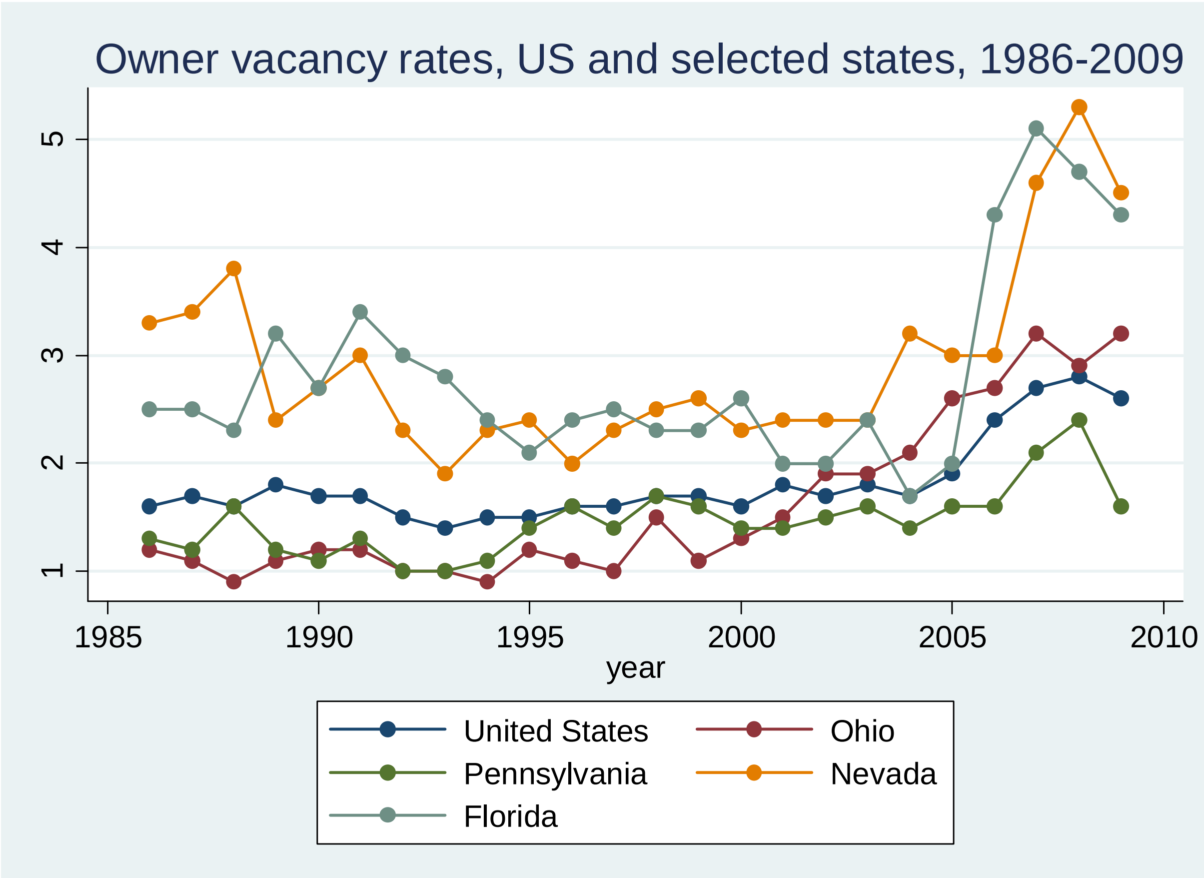

Owner vacancy rates, US and selected states, 1986-2009
1
2
3
4
5
1985
1990
1995
2000
2005
2010
year
United States
Ohio
Pennsylvania
Nevada
Florida

Figure 2

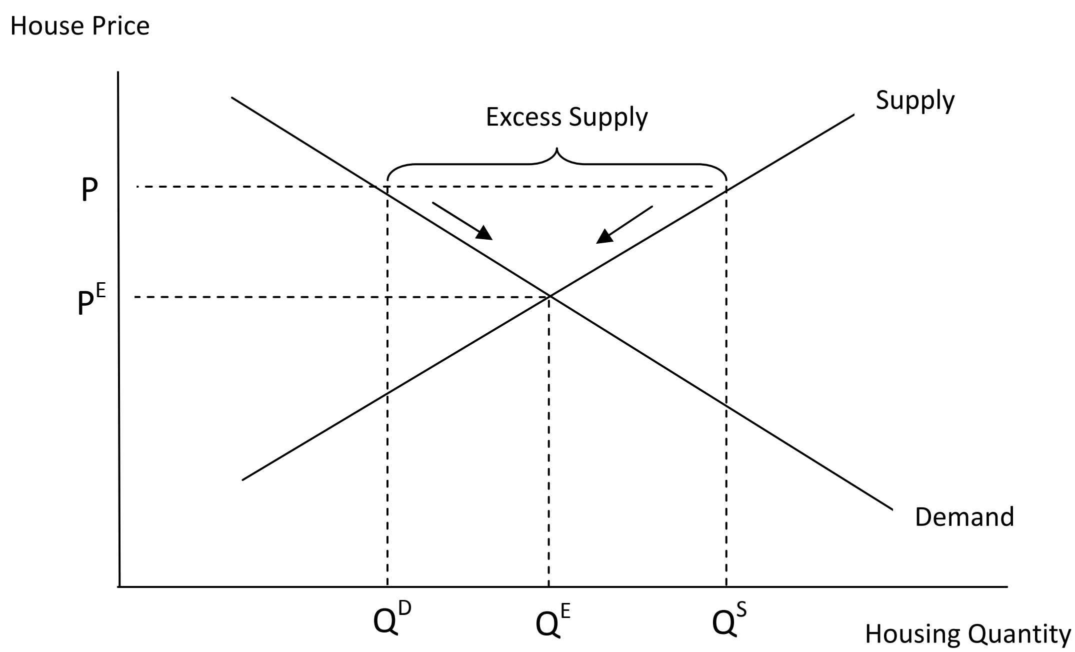

House Price
Excess Supply
Supply
P
P^E
Demand
Q^D
Q^E
Q^S
Housing Quantity

Figure 3

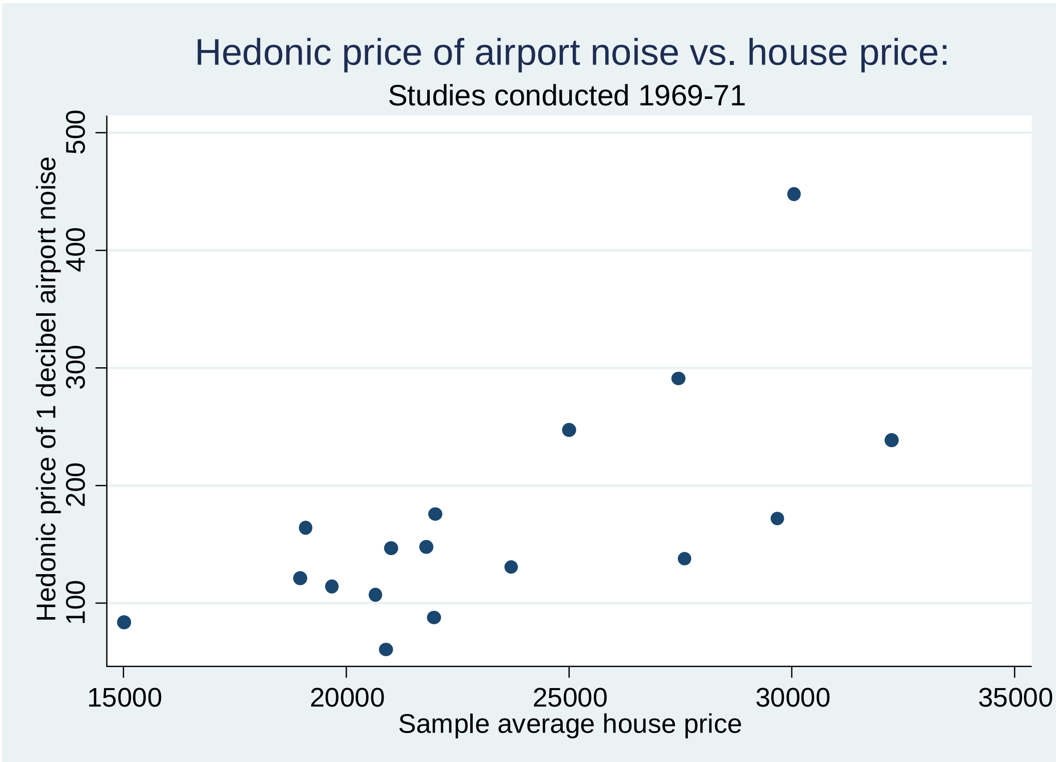
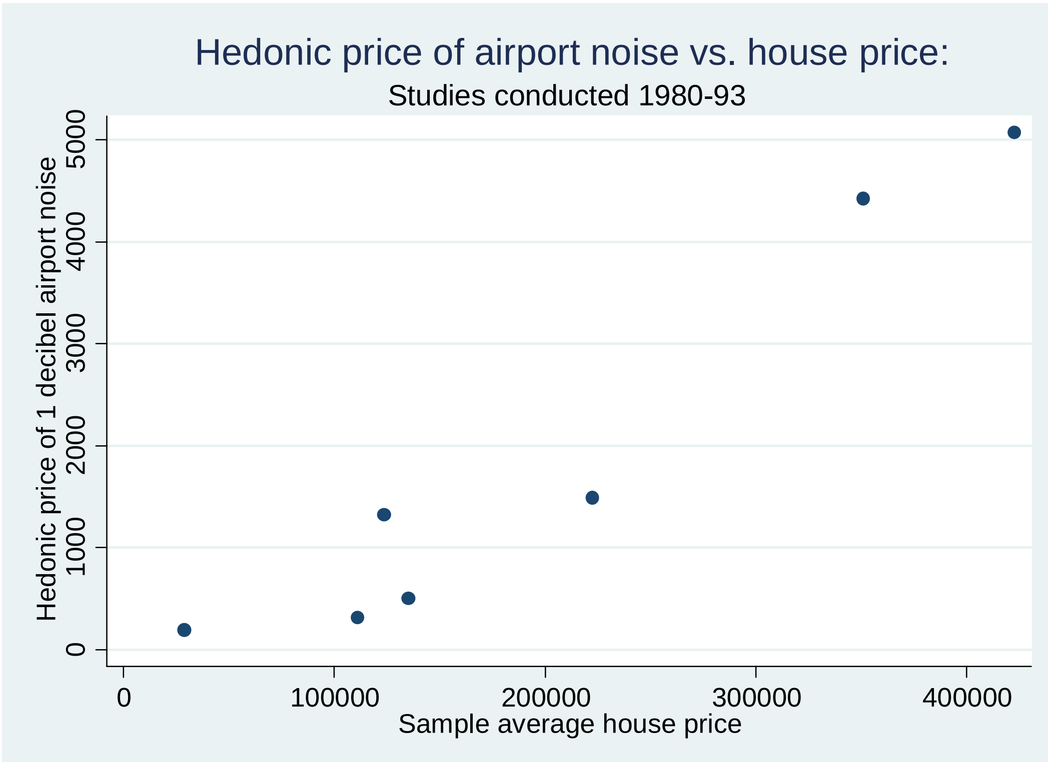

Hedonic price of airport noise vs. house price:
Studies conducted 1969-71
Hedonic price of 1 decibel airport noise
100
200
300
400
500
15000
20000
25000
30000
35000
Sample average house price

Figure 4


Hedonic price of airport noise vs. house price:
Studies conducted 1980-93
Hedonic price of 1 decibel airport noise
0
1000
2000
3000
4000
5000
0
100000
200000
300000
400000
Sample average house price

Appendix 1: General Equilibrium Model 1: Rosen Model

Define $z = (z_1, z_2, \ldots, z_k)$ to be a vector of n housing characteristics. The good is completely determined by this vector of characteristics. Hence z corresponds to a specific good in the full R^k product space. Further, p(z) is the price associated with this vector of characteristics that corresponds to a specific element in this product space. p(z) is determined by market clearing conditions: the amount supplied at each point in the product space must equal the amount demanded by consumers choosing to locate there. Thus p is the house price observed in market transactions, while the markets for individual z's are not, but must be inferred from the market for houses.

Given that each z_i is a "good" and not a "bad", p(z) is continuously increasing in each z_i and is assumed to have continuous second derivatives. p(z) is not assumed to have any specific functional form and can clearly be nonlinear in its arguments. It is assumed that the market is not "thin." That is, it is assumed that there is a continuous spectrum of products so that the choice set is continuous.

Consumers: It is assumed that consumers purchase only one unit of the product that is located in the goods space. The consumer's utility function is $U(x, z_1, z_2, \ldots, z_k; \alpha)$ where x is all other goods and the price of x is set to one and α is a taste parameter. U(·) is assumed to be strictly concave.

Consumers maximize utility subject to the budget constraint: y = x + p(z) where y is income. The first-order conditions are

$$\frac{\partial p}{\partial z_i} = p_i = \frac{U_{z_i}}{U_x} \quad i = 1, \ldots, k \tag{1}$$

Thus p_i, the derivative of the hedonic price function, can be interpreted as the "price" of z, the implicit housing characteristic. Note that this comes from the usual equivalence between the ratio of prices and the marginal rate of substitution between any two commodities.

Another way to express this problem is in terms of the bid function $B(z_1, z_2, \ldots z_k; u_0, y, \alpha)$ that is defined implicitly through the indirect utility function

$$U\left(y - B, z_1, \ldots, z_k; \alpha\right) = u_0 \tag{2}$$

where B(·) is the expenditure a consumer is willing to pay for $z = (z_1, z_2, \ldots, z_k)$ at a given utility u_0 and income level y. Taking derivates of (2) results in

$$\frac{\partial B}{\partial z_i} = B_i = \frac{U_{z_i}}{U_x} > 0,\ B_u = \frac{1}{U_x} < 0, \text{ and } B_y = 1 \tag{3}$$

B_i is the marginal rate of substitution between z_i and income (given that the price of x is 1). This is the consumer's marginal value of z_i (given u_0 and y). The bid function is increasing in z_i; consumers value more z_i over less. It can be shown that the second derivative is negative so that the increase in how much a consumer will spend for a marginal increase in z_i declines in z_i; a standard result in consumer theory.

Note that from equations (1) and (3), it follows that the marginal bid is equated to the marginal price: $p_i = B_i$. Utility is maximized when $B(z^*; u^*, y) = p(z^*)$ and $B_i(z^*; u^*,y) = p_i(z^*)$, i = 1, . . ., k, where z* and u* are optimal values. Thus the optimal value for z occurs where the two surfaces p(z) and B(z; u*,y) are tangent to each other. This optimal outcome is conditional on y and α that are assumed to have the joint distribution function F(y,α). Then the population equilibrium is characterized by a set of bid functions whose envelope is the market hedonic function.

Producers: To simplify the analysis, it is assumed that each z is produced separately with no joint production or spillovers. Hence each firm produces one product z. Let M(z) denote the number of units of z that are produced. It is assumed that each firm takes the hedonic price function as given and maximizes profit $\pi(M,z) = Mp(z) - C(M, z; \beta)$ where $C(M, z; \beta)$ is the cost function that is the outcome of minimizing costs subject to the production technology that is a function of M, z, and other input factors. β represents factors that vary across firms such as input prices and production function parameters. Assume C is convex with C(0, z) = 0 and C_M and $C_{zi} > 0$. The first-order conditions are

$$p_i = C_{z_i}(M, z; \beta) \;\; i = 1,..., k \text{ and } p(z) = C_M(M, z; \beta) \tag{4}$$

These first-order conditions indicate that the marginal revenue from an additional unit of each attribute that is sold equals the marginal cost of producing that unit. Furthermore, the amount of z produced is determined up to the point where the revenue p(z) equals the marginal cost of production, evaluated at z*.

Analogous to the consumer's problem, this can be expressed in terms of the offer function $O(z_1, . . .,z_k; \pi_0, \beta)$ indicating the prices the firm is willing to accept on products defined by different levels of the z_i's at fixed profit π_0 and optimal M. $O(z_1, . . .,z_k; \pi_0, \beta)$ is determined by solving out for M in the following two-equation system and hence solving for O(·) in terms of z, π_0, and β

$$\pi_0(M, z) = M \cdot O(z; \pi_0, \beta) - C(M, z; \beta) \tag{5}$$

and

$$O(z; \pi_0, \beta) = C_M(M, z; \beta) \tag{6}$$

By differentiating equations (5) and (6), one obtains

$$O_{z_i} = \frac{C_{z_i}}{M} > 0 \text{ and } O_\pi = \frac{1}{M} > 0 \tag{7}$$

Profit is maximized by setting p(z) = O(z) since O(·) is the minimum price the seller is willing to accept for z at profit level π_0 and p(z) is the maximum price in the market. The first-order conditions are then

$$p_{z_i}(z^*) = O_{z_i}(z^*; \pi^*, \beta) \quad i = 1,..., k \tag{8}$$

and p(z*) = O(z*; π*, β). Let G(β) represent the distribution of β across all producers. Then the equilibrium is as a set of offer functions that are tangent at every point of the market hedonic price function.

General Equilibrium Model 2: Locational Equilibrium Model with Homogeneous Housing

Assume one city with a total of J jurisdictions and the local amenities vary across jurisdictions, n_j. Initially we will assume that s and n_j are each one-dimensional (it is a straightforward generalization to allow both S and L to be multi-dimensional). Assume that both U has a Cobb-Douglas-like functional form

$$U(x, s, n) = x^{1-b}\left(s^a n_j^{1-a}\right)^b. \tag{9}$$

Thus, we assume that housing enters the utility function in a separable function that is homogeneous of degree one. Let the prices for a unit of S and L_j be q_1 and q_2, respectively. Then p(s,n) = $q_1 s + q_2 n$.

Assume that the individual maximizes utility subject to budget constraint $y = x + q_1 s + q_2 n_j$. Solving the budget constraint for x and substituting into the utility function (9) gives the indirect utility function

$$V = \text{Max: } U(y - q_1 S - q_2 L_j, H(S, L_j)). \tag{10}$$

The solution to this problem gives the following expression for the indirect utility function

$$V = \frac{By}{\left(Aq_1^a q_2^{(1-a)}\right)^b} = Byp^{-b} \tag{11}$$

where $B = b^b(1-b)^{1-b}$, $A = a^a(1-a)^{1-a}$, and $p = Aq_1^a q_2^{(1-a)}$ is the unit price of housing services. Thus, even though housing is heterogeneous, the indirect utility only depends on the price index p and income y.

The sub-expenditure function for housing can be derived as

$$E(q_1, q_2, s, n_j) = ps^a n_j^{1-a} = pH. \tag{12}$$

Where $H = s^a n_j^{1-a}$ is the quantity of housing consumed. Thus, expenditures on housing can be expressed as the product of the price index p and the quantity index H. Taking logs of equation (12) gives

$$\ln(E) = \ln p + a\ln(s) + (1\text{-}a)\ln(n_j) \qquad (13)$$

As above, in equilibrium, $E(s,n_j) = p(s,n_j)$, hence

$$\ln(p_{ij}) = \ln(p) + a\ln(s_{ij}) + (1\text{-}a)\ln(n_j) = \beta_0 + \beta_1\ln(s_{ij}) + \beta_2\ln(n_j) \qquad (14)$$

And the parameters in the house price hedonic relate directly to parameters in the utility function. And MWTP(n) = (1-a)*ln(p)/ln(n).

Appendix 2: The Foreclosure Process

"Foreclosure proceedings typically begin after homeowners miss about three payments and are unable to negotiate a solution with their lenders. During this period, homeowners may be able to sell their property prior to actual foreclosure." CGP

The foreclosure process can be judicial or non-judicial and this differs across states. Some states have both (e.g. MA).

"A judicial foreclosure is processed through the courts, beginning with the lender filing and recording a notice which includes the amount of outstanding debt and reasons for foreclosure. This filing is typically called a *lis pendens*.

"Nonjudicial foreclosures, in contrast, are processed without court intervention, and the foreclosure requirements are established by state statutes." "In a non-judicial foreclosure, a lender sends a *notice of default* to the borrower, and the notice is typically also filed with the jurisdiction authority (i.e., county, municipality, etc.). If the borrower fails to pay the debt or dispute the notice, a *notice of sale* is subsequently filed which begins the auction process."

The first attempt at selling the foreclosed property is through an auction. "The trustee or attorney handling the foreclosure sets the opening bid and this is usually advertised in the foreclosure notice. The typical opening bid is the balance of the mortgage plus penalties, unpaid interest, attorney fees, and other costs that the lender has incurred during the process." CGP

Some states have a redemption period "where a homeowner retains the right to buy back the property by paying the full amount of the loan along with taxes, interest, and penalties." Otherwise, the ownership of the property is transferred to the successful bidder in the auction or to the lender if unsuccessful. In the latter case, the property is transferred to the real estate owned (REO) department. This department is responsible for selling the property. "Occasionally, REOs negotiate sales directly with investors rather than place the property on the market, and can even offer purchasers packages of properties." CGP

Once ownership is transferred, the previous owner automatically becomes a tenant of the unit and the new owner must abide by state procedures to evict the previous owner from the property.