Big Yards and Big Profits: Regulation, Housing, and the "Implicit Market" for Land *

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Abstract

This paper tests the hypothesis of competitive equilibrium in the market for housing. The test is based on the theoretical result developed in part by Brueckner [1983]: in a competitive equilibrium, the marginal return to land from new housing construction equals the return to land from increasing lot size for additional yard space. The hypothesis of a competitive housing equilibrium is rejected for this study after concluding that the returns to land devoted to additional housing construction are significantly greater than the returns for additional yard space. This "implicit market" for land is inconsistent with a competitive market for housing since competitive housing producers could increase their profits by reallocating land to housing construction. The empirical results are instead consistent with a market equilibrium of housing producer market power or regulatory rationing. Sales transaction and construction data are used to test the model for over 18,000 single family homes recently built and sold between 1993 and 2003 in the Inland Empire of Southern California. Estimates of the resulting market distortion for housing are over $80,000 per unit in some cases. As a result, future regulatory interventions may have substantially larger welfare impacts than predicted under the assumption of a competitive market and the test presented here may prove to be a useful first step in policy cost-benefit analysis.

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1 Introduction

The neo-classical view of housing and the urban economy developed by Alonso [1964], Mills [1967, 1972], Muth [1969] and Beckmann [1969] is in many ways the standard economic view of the housing market. [1] It is appealing for its numerous intuitive results, most notable of which are the inverse relationships between a location's distance from the Central Business District (CBD) and the prices of land and housing. It also predicts that consumers purchase more housing at locations farther from the CBD, as well as housing produced at lower densities. An extensive body of literature has since developed around and expanded upon the original model (See Wheaton [1974], Anas [1978], Fujita [1982], or Arnott et al. [1986] as examples of this literature).

One assumption common throughout this literature is that housing developers are competitive and do not face regulatory rationing. Brueckner [1983] shows that in a competitive economy where consumers demand both housing and yard space, the equilibrium housing quantity and lot size equates the marginal returns to land for additional housing and additional yard space. This condition is appealing for its economic intuition: if land were valued higher at one margin, producers could increase their profits by reallocating land toward the higher valued use. However, Brueckner's theoretical result rests on the assumption that housing developers are perfectly competitive and face no regulations that restrict the quantity of housing.

This paper implements a test for the existence of a competitive market for housing by comparing the returns to land for additional housing (the extensive margin value of land) and the returns to yard space (the intensive margin value of land). The paper shows that if the housing market is instead characterized by market power or regulatory rationing, the extensive margin value of land will be greater than the intensive margin value of land. Sales transaction and construction data for over 18,000 new homes sold between 1993 and 2003 in the Inland Empire of Southern California are used to test this hypothesis. Box-Cox and linear regressions estimate the intensive margin value of land while the extensive margin value of land is calculated by combining location and quality specific construction cost data with the sales data. The analysis allows for variation in the price of land, housing qualities, construction costs, and the use of Geographic Information Systems (GIS) allows analysis at varying levels of geographic aggregation. The null hypothesis of a competitive housing market is rejected for a majority of the study region, and results suggest that the market distortion is as large as $80,000 per house in some instances.

In a recent study, Glaeser and Gyourko [2003] attempt to measure the impacts of existing regulation by comparing the value of land at the intensive and extensive

[1] Brueckner [1987] provides a great synthesis of the "Muth–Mills" model and the accompanying literature in the *Handbook of Regional and Urban Economics*.

margin for Metropolitan Statistical Areas (MSAs) across the United States. They find that the difference in most markets is insignificant. However, the inequality of the intensive and extensive margin value of land is neither a necessary nor sufficient condition for market regulation impacts. O'Flaherty [2003] notes several issues facing Glaeser and Gyourko [2003] which limit the conclusions that may be drawn from their analysis. Rather than claiming to measure the impacts of past policy interventions, the analysis in this paper focuses on the future impacts of policy interventions in housing markets.

Policy impacts in markets where the assumption of competitive equilibria fail will be radically different from the impacts predicted under the assumption of a competitive housing market. First, in markets for which the value of land is greater at the extensive margin, taxes, fees, and other price policies should have little impact on the quantity of housing produced. This prediction is consistent with the findings of Mayer and Somerville [2000], who find that regulatory fees have little impact on new construction quantities in their panel data of 44 MSAs between 1985 and 1996.

Secondly, policy analysis performed under the false assumption of an initial competitive equilibrium will vastly underestimate the welfare impacts of housing production restrictions. Underestimation occurs because of the mistaken assumption that the price of housing is equal to its marginal production cost. Rather than a marginal cost of quantity restrictions equal to zero, as assumed in a competitive market, the empirical results from this analysis suggest that the marginal costs may be on the order of tens of thousands of dollars in some housing markets. As a result, a test similar to the one used in this analysis may be a useful first step in policy cost-benefit analysis given the intense interest in the impacts of regulation in the urban economy. [2]

The remainder of the paper is laid out as follows. The next section presents the model of housing production and develops the testable hypothesis that the value of land should be equal at the intensive and extensive margins if housing developers are competitive and do not face regulations that ration housing production. It then shows that the value of land will be higher at the extensive margin if either of these assumptions are relaxed. Section 3 describes the study region and provides summary statistics for the dataset. Section 4 provides a detailed description of the process used to calculate the extensive margin value of land and presents the results of the extensive margin calculations. Section 5 explains the Box-Cox regression analysis used to estimate the hedonic price function for housing across the study region. These results are then used to calculate the intensive margin value of land. Section 6 uses the estimates from the previous two sections to test the null hypothesis, which is rejected for a majority of houses across the region. Section

[2] See Gyourko [1991], Malpezzi and Mayo [1997], and Glaeser and Gyourko [2003] as examples of papers examining the impacts of regulation in the urban economy.

7 then tests the robustness of the results by performing the analysis with different econometric specifications, and varying the assumptions regarding the extensive margin value of land. Section 8 discusses the implications of rejecting the null hypothesis, paying particular attention to the impacts of future policy interventions in the market. Section 9 presents a brief summary of the paper, a discussion of future research in the area, and some conclusions.

2 The Model

This section describes the basic model used to determine the housing market equilibrium. It first derives the result that the value of land should be equal at the intensive and extensive margins. Later, this assumption of competitive and unregulated housing is relaxed, to show that in such circumstances the value of land at the extensive margin is greater than the intensive margin value of land. Thus, comparing the intensive and extensive margin values of land is one way to test the hypothesis of unregulated and competitive housing developers.

Imagine a competitive firm in a neighborhood building houses in a profit maximizing manner. The firm must choose the number of houses to build and the amount of land associated with each house. Let H be the total number of houses produced (ignore, for now, issues of housing quality, and only consider issues of quantity), L be the quantity of land used per house, and $P(\cdot)$ represent the price facing the producer for each house produced as a function of the amount of land associated with it and the neighborhood specific index of amenities (α). If r is the per unit price of land, and $k(\cdot)$ is the cost of constructing H units of housing, then the profit maximization problem is

$$max_{L,H}\ \pi = P(L,\alpha)H - rLH - k(H), \tag{1}$$

with the First Order Conditions…

$$\pi_H = P - rL - k_H = 0 \text{ and} \tag{2}$$

$$\pi_L = P_L H - rH = 0. \tag{3}$$

Equation (2) states that housing will be produced until the price of housing is equal to the marginal cost of providing housing (physical construction costs plus the value of the land). Equation (3) simplifies to state that land will continue to be devoted to yard space until the marginal willingness to pay for land by consumers equals the price of land. Combining equations (2) and (3) implies that in equilibrium …

$$P_L = \frac{P - k_H}{L}. \tag{4}$$

The LHS of (4) is the revealed valuation of additional yard space by consumers, the intensive margin value of land. The RHS of (4) is the value of using an additional unit of land to produce more housing, the extensive margin value of land. Equation (4) shows in equilibrium, the intensive margin value of land is equal to the extensive margin value of land. If this equality did not hold, a profit maximizing housing developer could increase its profits by devoting more land towards the higher valued use. For notational ease, let P_L denote the value of land at intensive margin and ω be the extensive margin value of land.

2.1 Relaxing the Assumption of Unregulated, Competitive Developers

Now relax the assumption of unregulated and perfectly competitive housing developers. This paper explores two possible reasons, regulations that ration the number of houses that can be built and housing developer market power. This section shows that under such circumstances, the the equilibrium housing number and density is such that the extensive margin value of land is greater than the intensive margin value of land.

First assume that housing developers represent a monopoly in the market for housing. Equation (1) is now replaced by (5), where the developer understands that the price of housing is now a function of its production decision.

$$max_{L,H}\ \pi = P(L,H,\alpha)H - rLH - k(H). \tag{5}$$

Equation (2) now becomes

$$\pi_H = P + P_H H - rL - k_H = 0. \tag{6}$$

This causes the equilibrium condition in equation (4) to be replaced by equation (7)

$$P_L = \frac{P + P_H H - k_H}{L} \Rightarrow \omega - P_L = \frac{-P_H H}{L} > 0 \tag{7}$$

Since $P_H < 0$, equation (7) implies that the value of land at the extensive margin is greater than the intensive margin in a market where housing developers have market power. This is still the profit maximizing allocation of land because the developer understands that by producing more housing, the revenue earned on all previous houses would be reduced.

Alternatively, assume that forces constrain the maximum number of houses produced in a neighborhood to be $\overline{H}$. Equation (1) is now replaced by (8), where λ is the shadow price of housing.

$$max_{L,H}\ \pi = P(L,\alpha)H - rLH - k(H) + \lambda(\overline{H} - H) \tag{8}$$

The equilibrium in (4) is now replaced by

$$P_L = \frac{p - k_H - \lambda}{L} \Rightarrow \omega - P_L = \frac{\lambda}{L} > 0. \tag{9}$$

Equation (9) shows that in regulatory rationed markets, the standard urban economics result no longer holds; land will be valued higher at the extensive margin than at the intensive margin. Since producers no longer have the option of devoting more land towards the construction of more housing, producers continue to devote more land to yard space until consumers are no longer willing to pay for the marginal unit of land.

While the extensive margin value of land is directly calculated once the proper data are obtained, the intensive margin value of land cannot be calculated explicitly; it is the implicit price that consumers pay for an extra unit of land. As such, it must be inferred using hedonic regression techniques to estimate the marginal contribution of land to the price of the overall bundle of housing purchased.

3 The Data

The data for this analysis were originally purchased from DataQuick. com, a company that aggregates and distributes real estate data. In this case, the data are the sales of roughly 18,000 newly built homes in Southern California between 1993 and 2002. For each home sale, the dataset contains information on the transaction, including the physical attributes of the home and basic characteristics of the sale. The study region includes parts of Los Angeles, San Bernardino and Riverside Counties, and is mapped in Figure 1. It is a region characterized by high rates of recent growth, and represents a substantial portion of the Los Angeles exurban growth. It is also beginning to feel growth pressure from the south as San Diego continues to expand. To the north lie the San Gabriel and San Bernardino Mountain Ranges, and the southwestern border of the study region is bordered by the Santa Ana Mountains.

Recently, Glaeser and Gyourko [2003] conducted a nationwide study and found that in most MSAs, housing prices are very close to their production costs (Anaheim and Los Angeles were two for which this did not hold). However, the dataset used in this paper has four distinct advantages over their previous work.

(1) The price data are from arms-length market transactions, whereas Glaeser and Gyourko rely on survey data of homeowners' opinions of their home's value.
(2) This dataset is composed entirely of newly constructed homes, which means that each observation represents recent production density decisions. Issues of quality and depreciation are also reduced since the homes are of a common vintage.
(3) Each observation includes the exact latitude and longitude of its location, allowing the use of geographic information systems to conduct analysis at varying levels of geographic aggregation.
(4) This analysis differentiates among housing construction qualities, rather than

assuming all houses are of “average” quality.

An important step in calculating the intensive margin value of land is to estimate the hedonic price function for housing. Most of this section is devoted to describing the variables in this function, the quantity of land, size of the house, as well as other variables that may affect the price of a house in Southern California. However, an important component of the analysis involves choosing an appropriate aggregation level at which to analyze the data. The smaller the individual neighborhood, such as census tract, the more homogeneous the data, but the fewer observations with which to estimate the price. Larger analysis regions, such as the county level, afford a greater number of observations, but decrease the accuracy of a single hedonic price function. In the end, “sub-county” regions were used as the compromise aggregation level. These regions are defined by the U.S. Census Bureau, and are displayed in Figure 2.

3.1 The Price of Housing

Table 1 shows the distribution of housing sale prices by subregion. Figure 3 shows the distribution of sales price over the entire study region. The distribution is characterized by a majority of the observations at the lower end of the distribution (minimum sale price = $43,250, mean sale price = $208,996), and a few observations at extremely high values skewing the distribution to the right (maximum sale price = $1,137,000).

3.2 Lot Size

The variable of most interest in this study is the amount of land associated with each house. Equation (4) states that profit maximizing house producers will continue to demand land as an input for yard space until the marginal revenue is driven to the marginal cost of its provision. The median lot size for all observations is 7405 ft^2, with a mean of roughly 8200 ft^2 (essentially .2 acres). In the original dataset, less than 5% of homes had lot sizes over one-half acre (approximately 22,000ft^2), and in the final analysis, the data were censored to include only observations with lots smaller than an acre (this removed fewer than .9% of the observations). Figure 4 gives the reader a visual sense of the overall distribution of lots in the study area, while Table 2 gives the reader a more detailed description of the distribution of lot size throughout the region.

3.3 Other Control Variables

This section describes the available variables in the dataset. Although land is an important determinant of the price of a house, other characteristics of the homes are vital in any housing price hedonic function. The dataset contains the following elements variables the size of the house (living space) and the number of bedrooms and bathrooms in the house. Other important variables may be flags for the presence or absence of other potentially important housing amenities like a swimming pool or fireplace.

The variables for the number of bedrooms and bathrooms in the house are treated as continuous variables since the values are in fact cardinal, and a difference of one represents a real difference between homes regardless of scale. Although it seems implausible to consider rooms in non-integer quantities, it is conceivable, and quite common, for the number of bathrooms to consist of a fraction of a bathroom (for example, a "half bathroom" is equivalent to a bathroom consisting of only a toilet and sink). Descriptive statistics for the square footage of living space, and number of bedrooms and bathrooms in each house in the dataset are given in Table 3. The binary variables representing the presence or absence of housing amenities are summarized in Table 4.

3.4 Time

The home sales are well distributed throughout the study period, from 1993 to 2003, as seen in Table 5. In order to avoid problems of improper comparisons, all analysis is in terms of 2003 dollars. Understanding that real estate prices change over time subject to macroeconomic fluctuations and other market changes, the house prices were transformed into year 2003 dollars using the Conventional Mortgage Home Price Index (CMHPI), which is published quarterly by FreddieMac [2004]. This index uses repeat home sales to establish a price index for Metropolitan Statistical Areas (defined by the Office of Management and Budget) over time in order to compare home prices across time. The index for Los Angeles and San Bernardino/Riverside were used for this analysis. The sales prices of homes, adjusted by the index, are shown in Figure 5.

A "median house" for the entire region would have four bedrooms, two-and-a-half baths, 2100 square feet of living space, a fireplace, no pool, have a lot size of 7405 square feet, and cost approximately $275,000.

4 The Extensive Margin Value of Land

The value of a unit of land at the extensive margin is the return to land from producing another unit of housing. Equation (4) shows that the extensive margin value of land, ω, is calculated as the difference between the price of the home and the construction costs of the home divided by the amount of land associated with the home. The DataQuick dataset contains the sales price and other attributes of the house, including its lot size. The *Residential Cost Handbook* by Marshall and Swift [2002] is used to estimate the construction costs for each house in the dataset.

4.1 Construction Costs

The *Handbook* provides a means of estimating the construction costs of homes based on their location, size, construction materials used, and overall quality level. Marshall and Swift [2002] distinguish among six quality levels, ranging from fair to excellent. The DataQuick dataset contains the absolute location and size of each house, two of the most important determinants of housing construction costs, but assumptions regarding the construction materials and overall quality are needed in order to estimate the construction costs. We make the simplifying assumption that all houses are constructed of the same material, wood framed stucco. This construction material has the advantage of being common, and is neither the most, or least, expensive material detailed in the *Handbook*.

Rather than assuming all of the houses in the study are of one quality, we characterize house quality as one of the four highest quality levels described in the *Handbook*. Home quality is determined as follows, average quality for homes with adjusted sales price less than $\$350,000$, good quality $\$350,000 - \$750,000$, very good quality for homes $\$750,000 - \$1,000,000$, and excellent quality for homes greater than one million dollars.

The largest fear of a less-than perfect quality determination is that it leads to over rejection of the null hypothesis. A type 1 error is likely if the estimated construction costs are biased downward. In an effort to combat this potential problem, we assume that housing quality is only among the four highest quality levels, an assumption that is further restricted in Section 7. (It should be noted that this initial rule results in 14% of the homes having estimated construction costs greater than 90% of their sale price.)

With an estimate of the quality, and location and size data, the total production costs can be calculated. Aside from the physical construction costs, other costs of the design process are incorporated too, such as site preparation, marketing, and other fees. Just as costs of construction vary across quality levels, these additional costs vary across quality levels. These additional costs can be considered either "hard costs", costs associated with converting land to a suitable construction site, and "soft costs", fees and other costs associated with design, marketing, and obtaining the necessary permits for construction. Estimates of $35 per square foot for hard and soft costs for average quality homes, $45 for good quality homes, and $55 for higher quality houses. [3] These assumptions combined with the Marshall and Swift [2002] data result in construction cost estimates of roughly $90 per square foot for the lowest assumed quality level, to $175 per square foot for excellent quality homes.

Table 6 shows the mean and standard deviation of the house-level calculated extensive margin value of land. The mean values range from a low of $2.64 in Lake Mathews, to a high of $23.31 in East San Gabriel Valley. The middle 50% of the entire sample approximately falls between $5.50 and $14.00.

5 The Intensive Margin Value of Land

This section describes and implements the regression analysis used to estimate the intensive margin value of land. As stated earlier, a crucial step in determining the intensive margin value of land is first estimating a hedonic price function.

$$House\ Price = P(location,\ living\ space,\ lot\ size,\ amenities) \tag{10}$$

Given a hedonic function, the intensive margin value of land is simply the marginal effect of lot size, P_L, and represents the opportunity cost of devoting land to the production of more housing.

$$\widehat{P_L} = \frac{\partial \text{ House Price}}{\partial \text{ Lot Size}} \tag{11}$$

5.1 Box-Cox Transformation

This section calculates the intensive margin value of land for the study region using the Box-Cox transformation as the specification of the housing price hedonic. The Box-Cox transformation was chosen because it is a flexible functional form that is commonly used in hedonic estimates. There is no a priori reason to choose one functional form over another and the Box-Cox transformation encompasses multiple commonly used functional forms, from the pure linear formulation (when $\theta = 1$), to log-linear ($\theta = 0$), to even a model that is linear in reciprocals ($\theta = -1$).

[3] Personal communication with the Newhall Construction Company

The Box-Cox Transformation regression estimates $\widehat{P}(x)$, where

$$P = \hat{\beta}_0 + \hat{\beta}_1 \frac{x^{\hat{\theta}} - 1}{\hat{\theta}} + \varepsilon. \tag{12}$$

Note, however, that the coefficient associated with lot size is not a measure of the marginal value of land (the exception, of course, is if $\theta = 1$ in which case the Box-Cox model is equivalent to the simple linear case). Under the Box-Cox transformation, the intensive margin value of land, P_L, must be calculated as shown in equation (13).

$$\widehat{P_L} = \hat{\beta}_1 L^{\hat{\theta}-1} \tag{13}$$

Table 7 shows the Box-Cox regression results by region. Since the Box-Cox transformation requires the data to be strictly positive, only the lot size and square footage of housing variables were transformed. With the hedonic function estimates from Table 7, the estimated intensive margin values of land can be calculated for each house using equation (13). Table 8 shows the distribution of the estimates of the intensive margin value of land, with the mean, median, and standard deviation of the individual estimates. The mean estimates range from a low of \$0.29 per square foot in Elsinore Valley, to \$4.32 per square foot in Corona. The 25th and 75th percentiles for the entire study area are approximately \$1.25 and \$3.75.

Since $\widehat{P_L}$ is a function of both $\hat{\beta}_1$ and $\hat{\theta}$, the delta method is used to calculate the standard errors of $\widehat{P_L}$. The standard errors of the marginal effects of land are calculated in equation (14).

$$\widehat{\sigma}_{P_L} = \sqrt{\begin{bmatrix} \frac{\partial \widehat{P_L}}{\partial \hat{\beta}_1} & \frac{\partial \widehat{P_L}}{\partial \hat{\theta}} \end{bmatrix} \begin{bmatrix} Var[\hat{\beta}_1] & Cov[\hat{\beta}_1, \hat{\theta}] \\ Cov[\hat{\beta}_1, \hat{\theta}] & Var[\hat{\theta}] \end{bmatrix} \begin{bmatrix} \frac{\partial \widehat{P_L}}{\partial \hat{\beta}_1} \\ \frac{\partial \widehat{P_L}}{\partial \hat{\theta}} \end{bmatrix}} \tag{14}$$

Equation (14) is estimated using,

$$\frac{\partial \widehat{P_L}}{\partial \hat{\beta}_1} = L^{\widehat{\theta}-1}, \; \frac{\partial \widehat{P_L}}{\partial \hat{\theta}} = \hat{\beta} \ln L \times L^{\widehat{\theta}-1}, \tag{15}$$

and the asymptotic variance-covariance matrix, Ω, where β refers to the vector of all the estimated coefficients.

$$\Omega = \widehat{\sigma}^2 (\widetilde{\mathbf{X}}' \widetilde{\mathbf{X}})^{-1}, \tag{16}$$

$$\widetilde{\mathbf{X}} = \frac{\partial \widehat{y}}{\partial \boldsymbol{\beta}'} \tag{17}$$

The estimates can now be used to compare the estimates of the intensive and extensive margin values of land across the study region.

6 Comparing the Intensive and Extensive Margin Values of Land

This section compares the estimates of the extensive and intensive margin values of land estimated previously. Figure 6 shows the distributions of the difference between the extensive and intensive margin values of land for each region (a vertical line marks zero on each x-axis). Figure 7 provides a larger view of the distribution of the extensive margin value of land minus the estimated intensive margin value of land in Ontario. The mean difference between the extensive and intensive margin values of land for this region is $15.84 per square foot, a median of $16.28 and a standard deviation of $9.92. If the null hypothesis were true, and the intensive margin value of land were equal to the extensive margin value of land as predicted by the neo-classical urban economics literature, the histogram should be centered around zero.

The null hypothesis is:

$$H_0 :\ \omega - P_L \leq 0, \tag{18}$$

while the alternative is:

$$H_a :\ \omega - P_L > 0. \tag{19}$$

The null hypothesis can be tested for each observation using a one-sided t-test and the house-level estimates of ω, $\widehat{P_L}$, and $\hat{\sigma}_{p_L}$ as in equation (20).

$$\frac{\omega - \widehat{P_L}}{\hat{\sigma}_{p_L}} = t \tag{20}$$

Table 9 displays the percentage of houses in each region for which the null hypothesis is rejected at the 1% level. The null hypothesis is rejected at the 1% level for an astonishing 87% of houses in the entire study area. Lake Mathews has the lowest rejection rate, at 50%. Only four regions reject the null hypothesis at a rate lower than 80%, while six regions reject at the 1% level for over 90% of the observations. These results call into question the neo-classical assumption of competitive and unregulated housing developers.

7 Robustness Tests

This section tests the robustness of the results presented in the previous section. Specifically, it uses different econometric functional forms to infer the intensive margin value of land, different techniques to measure the extensive margin value of land, and conducts the analysis at finer geographic and temporal scale. The results appear to be rather robust, with the null hypothesis continuing to be rejected at high rates for most regions.

7.1 Alternate Functional Forms

As stated earlier, there is little theoretical justification for any particular functional form for the hedonic used to estimate the intensive margin value of land. Glaeser and Gyourko [2003] use a Log-Log formulation, while others have used Ordinary Least Squares (OLS) to estimate the marginal effect of land for housing. This section re-estimates the intensive margin value of land using alternative specifications to check for the robustness of the estimates. The intensive margin value of land is measured using a Log-Log formulation, OLS, OLS with robust standard errors, and linear robust regression.

7.1.1 Log-Log Formulation

Under a log-log specification, equation (21) is estimated.

$$ln(P) = \hat{\alpha} + \hat{\beta} ln(L) + \varepsilon \tag{21}$$

Given the formulation in equation (21), the intensive margin value of land varies with the lot size and predicted price. Equation (22) shows how the intensive margin value of land is calculated in a log-log specification, while the standard errors are estimated using (23).

$$\widehat{P_L} = \frac{\hat{P}}{L}\hat{\beta} \tag{22}$$

$$\widehat{\sigma}_{P_L} = \widehat{\sigma}_{\hat{\beta}} \times \frac{\hat{P}}{L} \tag{23}$$

Column **(2)** in Table 10 displays the percentage of houses in each region for which the null hypothesis can be rejected at the 1% level using the log-log formulation to estimate the intensive margin value of land.

7.1.2 Linear Formulation

Assuming a pure linear formulation allows the use of Ordinary Least Squares with untransformed data. This specification implies that the intensive margin value of land is equal to the land coefficient from the hedonic regression. Similarly, the standard errors of the intensive margin value estimates are simply the standard errors from the regressions. Column **(3)** in Table 10 displays the percentage of houses in each region for which the null hypothesis can be rejected at the 1% level, while column **(4)** displays the same information, but uses the robust standard errors to calculate the t-statistics.

The OLS estimator is especially sensitive to outliers. One solution in such circumstances is to weight these outlying observations less in the optimization used to estimate the parameters. One common technique was developed by Huber [1964], and is commonly implemented in concert with a system of bi-weighting developed by Beaton and Tukey [1974]. Column **(5)** displays the percentage of observations for which the null hypothesis is rejected at the 1% level using the Huber-Tukey method of model estimation.

The results seem robust to these tests of functional form. The overall rejection rate stays above 80% for each specification, with only Lake Mathews, Norco, and Riverside's rejection rate dropping by more than a few percent for any single specification. The overall rejection rates are 85%, 83%, 91%, and 87% for columns **(2)–(5)**.

7.2 Alternate Estimates of The Extensive Margin Value of Land

This section performs two different robustness checks. First, it tests the null hypothesis using a region-wide estimate of the extensive margin value of land rather than individual level data. Then, it alters the assumptions made in Section 4 regarding the construction quality of the houses in the sample. We restrict all observations to be of "good" quality, rather than allowing houses to be considered "average" quality to reduce the calculated extensive margin value of land and decrease the likelihood of rejecting the null hypothesis.

7.2.1 Using Region-wide Estimates of the Extensive Margin Value of Land

Until now, the analysis has assumed that the calculated ω is the true value for each house. This assumption is now relaxed, and the data are aggregated to create a region-wide estimate of the extensive margin value of land. Equation (24) estimates $\widehat{\omega}$ for each region based on the area-weighted mean extensive margin value of land. This provides a region-wide average return to a marginal unit of land devoted to housing.

$$\widehat{\omega} = \frac{1}{n}\Sigma_i \frac{P_i - k_{hi}}{L_i} \cdot \frac{L_i}{\Sigma_i L_i} \tag{24}$$

Table 11 displays the region-wide estimates of the extensive margin value of land. Each estimate is smaller than both the simple mean and median of the individual estimates from Table 6. Estimates range from a low of \$1.69 in Lake Mathews, to a high of \$18.08 in East San Gabriel Valley. Nine of the regions have estimates between \$6–\$9. The null hypothesis, (18), can be tested using the previously estimated intensive margin values of land, and the new estimates and standard errors of the extensive margin value of land given in Table 11. However, since there is uncertainty in the true extensive margin value of land, equation (25) must be used to calculate the t-statistic rather than equation (20).

$$\frac{\widehat{\omega} - \widehat{P_L}}{\sqrt{\hat{\sigma}^2_{\omega} + \hat{\sigma}^2_{P_L}}} = t \tag{25}$$

Column **(6)** of Table 12 shows that, after using region-wide estimates of the extensive margin value of land, and incorporating the uncertainty of region-wide value, the null hypothesis is overwhelmingly rejected across the study region. With the exception of Lake Mathews, the percentage of houses that reject the null hypothesis actually increases from using the region-wide estimate of the extensive margin value of land. Most regions reject at a rate of nearly 100%.

7.2.2 Increased Housing Quality Assumptions

Section 4 presented the methodology used to calculated the extensive margin value of land. This section make a more conservative estimate of housing quality in order to test the robustness of the results presented in section 6. Specifically, rather than allowing housing to be of average quality, it is now assumed that all housing is of good quality. Good quality homes represent the fourth of six quality levels of homes as determined by Marshall and Swift [2002], with only very good and excellent higher. This assumption represents a very strict increase in the construction costs of homes, an increase of nearly $25 per square foot of living space. The minimum cost per square foot of living space is $110. Under this assumption, over one-third of houses in the sample have construction costs greater than their sale price, a result that is not likely for newly constructed homes. However, even with this assumption, column **(7)** of Table 12 shows that several regions still have a significant proportion of houses for which the null hypothesis can be rejected. Specifically, East San Gabriel Valley and Ontario still reject the null hypothesis at rates of 85% or higher. Overall, 44 percent of the observations still reject the null hypothesis.

7.3 Census Tract Level Analysis

One possible reason for the results that have been obtained is that the spatial level of aggregation used to calculate the intensive margin value of land is too large. As stated earlier, the aggregation level chosen represents a trade-off between larger sample sizes and homogeneity of observations. This section calculates the intensive margin value of land at the census tract level. It uses two linear specifications, OLS and the Huber-Tukey robust regression, to calculate the intensive margin value of land. The null hypothesis is then tested at the individual house level, similar to previous sections, in Table 13. The rightmost column shows the total number of observations that remain in the analysis after removing observations in census tracts with fewer than 35 observations (this retained 17,119 of the original 18,227 observations). Note that the census tract boundaries do not perfectly correspond to the region boundaries (this is why only 5 observations from Lake Mathews remain). In the analysis, 79% and 83% of the observations still reject the null hypothesis at the 1% level. Lake Mathews, Hemet-San Jacinto, and Riverside had the largest decreases in rejection rates. Overall, performing the analysis at the census tract level did not remove the qualitative result that the null hypothesis of intensive margin values of land at least as great as the extensive margin values of land is rejected for some areas.

7.4 Assumptions Regarding Time

Previous sections have treated observations across time relatively simply: adjusting sale price by the Freddie Mac Conventional Mortgage Home Price Index, and including a time trend variable in the price hedonic function. This section tests the robustness of previous results by first including time dummy variables, and later performing the analysis by individual year and region.

7.4.1 Time Dummy Variables

Columns **(10)–(13)** of Table 14 show the percentage of houses for which the null hypothesis in equation (18) is rejected while using OLS, **(10)**, OLS with robust standard errors, **(11)**, Huber–Tukey Robust Regression, **(12)**, and Log-Log regression, **(13)**, to calculate the intensive margin value of land with time dummy variables. The overall rejection rate never drops below 83%, and only Lake Mathews and Norco fail to reject at a rate below 60%.

7.4.2 Analysis by Year and Region

In this section, the hedonic analysis is performed independently by year and region. Columns **(14)–(17)** of Table 15 show the percent of houses in each region that reject the null hypothesis at the 1% level using while using OLS, **(14)**, OLS with robust standard errors, **(15)**, Huber–Tukey Robust Regression, **(16)**, and Log-Log regression, **(17)**, to calculate the intensive margin value of land. Column **N** shows the number of observations that remain after removing observations in region-years with fewer than 35 observations. The overall rejection rate drops slightly using this analysis technique, largely as a result of the increase in the uncertainty of the estimates of the intensive margin value of land. However, East San Gabriel Valley, Elsinore Valley, Murrieta, Ontario, and San Bernardino all retain rejection rates above 70%.

8 Discussion of Results

The model presented in the paper and and others has shown that the intensive margin value of land should equal the extensive margin value of land if housing producers are competitive and rationed. If housing producers have market power, or face rationing, the intensive margin value of land will be less than the extensive margin value of land. There are two large implications of rejecting the null hypothesis developed in this paper. First, larger values for land at the extensive margin implies larger lot sizes for housing. Thus, relaxing the assumption of competitive housing developers provides another source of “urban sprawl” and low density development.

Second, the welfare impacts of additional regulations in the housing market are determined in large part by the existence of the competitive equilibrium. If the null hypothesis is true, and housing production is the competitive equilibrium quantity, the social welfare cost of marginally reducing the quantity of housing is zero. However, if the market output is already restricted due to market power or regulation, the lost social welfare from the first house lost due to additional regulation is significantly greater than zero. It also implies that the price is greater than the marginal cost of production. This implies that taxes, or other cost-based policies will be of limited effectiveness. in the case of regulatory rationing, the tax would have to be greater than the shadow price of housing, while in the case of market power, the impacts will be smaller than the case of the competitive equilibrium.

8.1 Impacts of Regulation, Comparing H_0 and H_a

This section uses a partial equilibrium framework to calculate the impacts of additional regulations in the market for housing. It compares the welfare impacts of regulations in markets for which housing developers are correctly and incorrectly assumed to be competitive. The differences are stark, and serve to underscore the importance of the properly testing the assumption of competitive and un-rationed housing producers.

Assume that in the absence of regulation, the equilibrium quantity of housing in a market is Q^*. A regulator wishes to alter the existing equilibrium quantity of housing by $\Delta Q < 0$, and chooses to do so through a command and control regulatory framework. The impacts of such a policy can be calculated by examining the impacts to consumer and producer surplus.

Let $CS(Q^*)$ be the market consumer surplus as a function of the equilibrium market quantity, where $P(Q)$ is the inverse demand curve.

$$CS(Q^*) = \int_0^{Q^*} P(Q) - P(Q^*) dQ \tag{26}$$

Using a second order Taylor expansion of $CS(Q^*)$, the change in consumer surplus can be written as a function of Q^* and ΔQ.

$$\Delta\text{Consumer Surplus} \approx CS'(Q^*)\Delta Q + \frac{CS''(Q^*)}{2}(\Delta Q)^2 \tag{27}$$

$$\Delta\text{CS} \approx \left[-P'(Q^*)Q^*\right]\Delta Q + \left[-P'(Q^*) - P''(Q^*)Q^*\right]\frac{(\Delta Q)^2}{2} \tag{28}$$

Let $PS(Q^*)$ be the market producer surplus as a function of the equilibrium market quantity, where $MC(Q)$ is the marginal cost of production curve and market supply curve if housing developers are competitive and un-regulated.

$$PS(Q^*) = \int_0^{Q^*} P(Q^*) - MC(Q)dQ \tag{29}$$

$$\Delta\text{Producer Surplus} \approx PS'(Q^*)\Delta Q + \frac{PS''(Q^*)}{2}(\Delta Q)^2 \tag{30}$$

$$\begin{aligned}\Delta\text{PS} \approx &\left[P(Q^*) + P'(Q^*)Q^* - MC(Q^*)\right]\Delta Q \\ &+ \left[2P'(Q^*) + P''(Q^*)Q^* - MC'(Q^*)\right]\frac{(\Delta Q)^2}{2}\end{aligned} \tag{31}$$

The total market impacts are equal to the sum of the changes to producer and consumer surplus.

$$\Delta\ \text{TotalSurplus} \approx \left[P(Q^*) - MC(Q^*)\right]\Delta Q + \left[P'(Q^*) - MC'(Q^*)\right]\frac{(\Delta Q)^2}{2} \tag{32}$$

Equation (32) shows the importance of testing for the existence of competitive and unregulated housing developers. If housing developers are competitive, then (32) simplifies to equation (33), because $P(Q^*) = MC(Q^*)$.

$$\Delta\ \text{TS} \approx \left[P'(Q^*) - MC'(Q^*)\right]\frac{(\Delta Q)^2}{2} \tag{33}$$

Equation (33) shows that there are no first order effects from the regulation. The impacts to society occur only from the second order effects, the slopes of the supply and demand curve. Now consider the impacts if the assumption of competitive and un-rationed housing developers is wrong, that is to say, if the statistical test developed here is implemented and the null hypothesis is suitably rejected. Then, equation (32) does not simplify to equation (33) because $P(Q^*) > MC(Q^*)$. If the gap between the price and marginal production costs is suitably large, these first order policy impacts may swamp the predicted impacts in (32). In such circumstances, the policy maker performing a cost-benefit analysis of the proposed policy would assume away the largest impacts of the policy by making the standard assumption of competitive and unregulated housing producers.

The estimates of the intensive and extensive margin values of land can be used to estimate the difference between the equilibrium price and marginal production costs, see equations (7) and (9).

$$P - MC = (\omega - P_L)L \tag{34}$$

Table 16 calculates this difference at the median lot size for each region using the estimates Box-Cox transformation of the intensive margin value of land and the region-wide estimates of the extensive margin values of land from Section 7.2.1. Most estimates are between \$20,000—\$40,000; Figure 16 gives the reader a visual sense of how the regions compare. Table 16 also puts these price differences in perspective by calculating their percentage of the median house price in the region. Most of the estimates range from 13%—19% of the median priced house in the region. However, three regions, East San Gabriel Valley, Norco, and Ontario, have estimates over \$80,000 per house. Estimates of this magnitude imply that additional regulations in the region can have profound welfare effects.

8.2 Regulatory Simulations

This section performs a simple partial equilibrium simulation to estimate the impacts of restricting the production of housing in a region. These impacts are then compared to the impacts predicted under the assumption of competitive and unrationed producers. Imagine a proposed housing development comprised of 1000 median priced units of median lot size in each of the 14 analysis regions. Assume that the scale of the project is reduced to 900 units. For simplicity, assume that the production technology is constant returns to scale. Table 17 compares the welfare impacts from the output restrictions for each of the 14 regions under the assumption of a competitive equilibrium vs. the estimated market distortion. It also performs the analysis for different assumptions regarding the elasticity of demand for housing.

Let ε be the elasticity of demand at Q^*, then

$$P'(Q^*) \approx \frac{1}{\varepsilon}\frac{P(Q^*)}{Q^*}. \tag{35}$$

The simulations thus calculate the total change in surplus in equation (36) by combining equations (35), (34), and (32).

$$\Delta \text{ TotalSurplus} \approx [(\omega - P_L)L]\Delta Q + \left[\frac{1}{\varepsilon}\frac{P(Q^*)}{Q^*}\right]\frac{(\Delta Q)^2}{2} \tag{36}$$

The results show a stark contrast between the predicted impacts under the null hypothesis versus using our estimates of the shadow price of housing. The table presents the predicted impacts by region, assuming demand elasticities of -1 and -10. The predicted losses in total surplus increase on the order of three to 20 times when the assumption of competitive and un-rationed housing developers is relaxed, and the shadow price of housing is incorporated into the surplus loss. These simulation results show that the impacts in a market from regulations facing the housing market can be much, much larger than those predicted under a false assumption of competitive housing producers.

9 Conclusion

Economic intuition and previous research has hypothesized that the returns to land must be equal at the intensive and extensive margins. This equilibrium concept is appealing for its simplicity and intuition: if land is more valuable being devoted to the production of additional housing, why keep it in yard space? The answer is that market power and regulation make it optimal for the equilibrium value of land to be higher at the extensive margin. Our results indicate that the value of land at the extensive margin is not less than or equal to the intensive margin value of land. This is consistent with the failure of the hypothesis of competitive and un-rationed housing developers.

While the estimate of this wedge may vary with the econometric techniques used, our research shows that the difference is very real for some areas. The analysis shows that in some regions of Southern California, the difference between the extensive and intensive margin values of land can easily account for over 15% of the price of a home. The results are robust to many variations in the econometric specification. The results are most sensitive to assumptions underlying the construction costs of housing. Future research in the area may strive to obtain better construction data than those available here.

Large estimates of the shadow price of housing have very real implications for the housing market, and housing regulators especially. First, it implies that the impacts of future policy interventions will have much larger welfare effects than predicted under the assumption of a competitive market equilibrium. Our results indicate that the marginal social cost of future regulations may be as high as $80,000 in areas near East San Gabriel Valley and Ontario. At the same time, other policies that aim to limit production through taxation of housing may well have little impact in the market, other than largely acting as wealth transfers. We have shown that in some cases, the costs of providing housing are not the limiting determinant of the ultimate price of housing. Rather than assuming that high housing prices are a result of scarce land and high construction costs, the scarcity is in the housing market itself.

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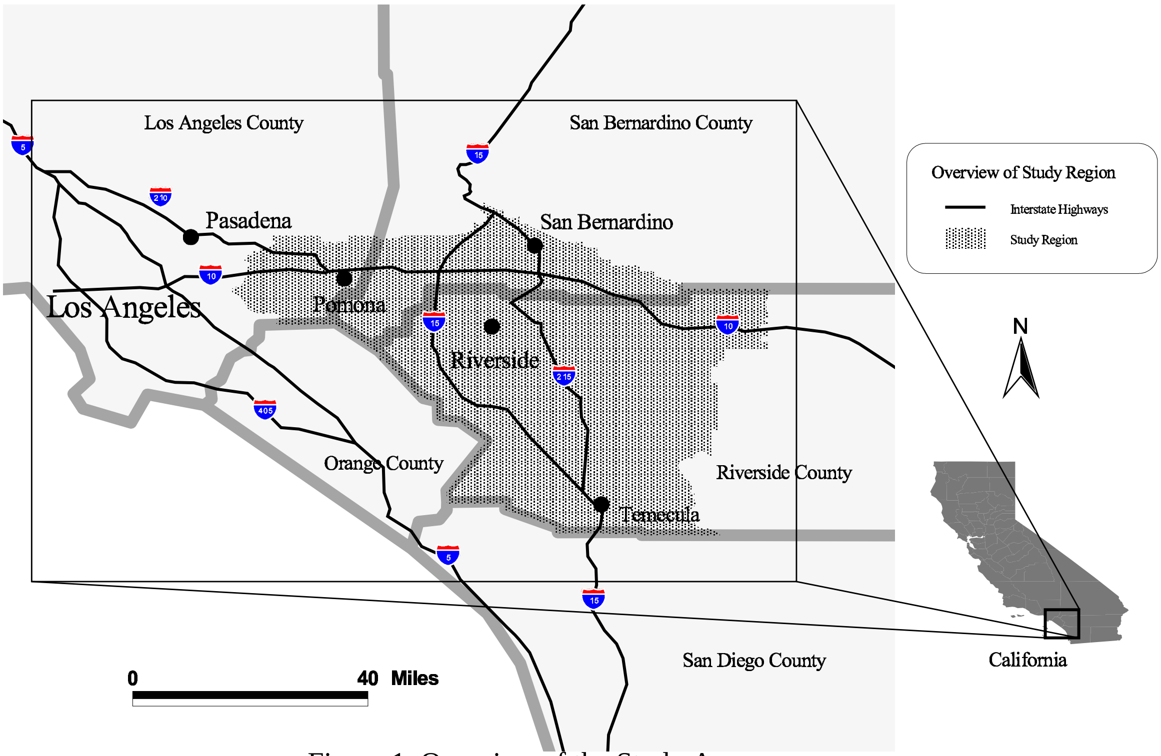

Figure 1. Overview of the Study Area

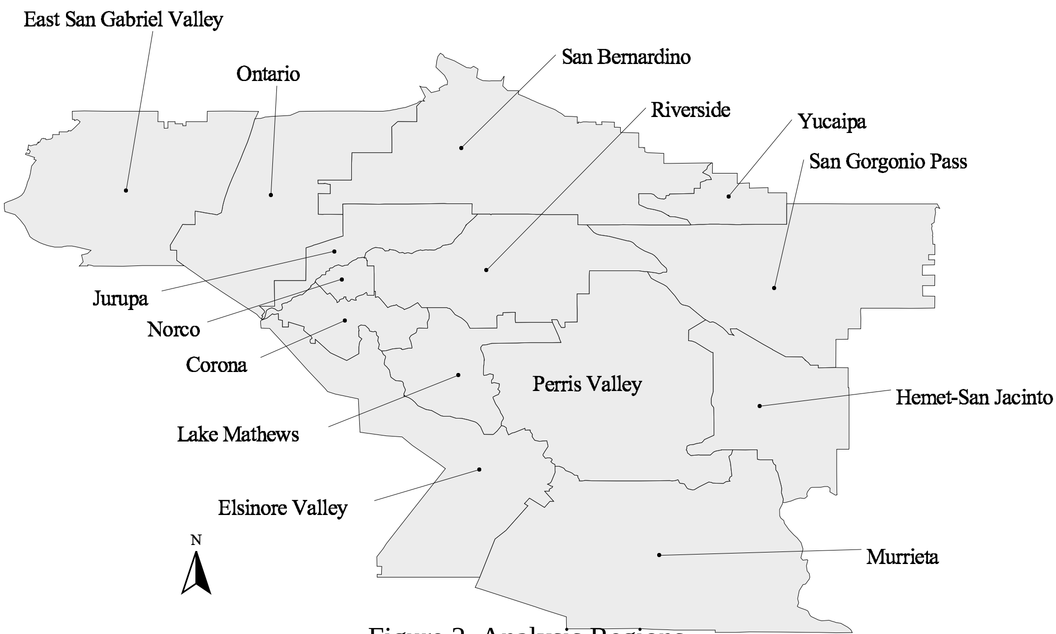

Figure 2. Analysis Regions

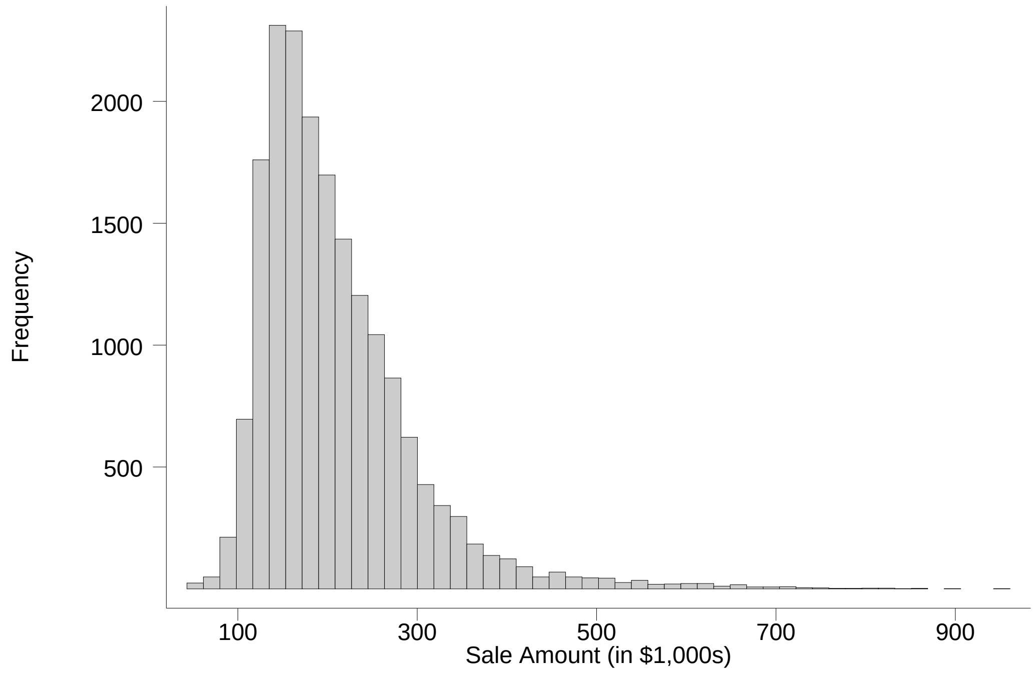

Figure 3. The Distribution of Sale Price

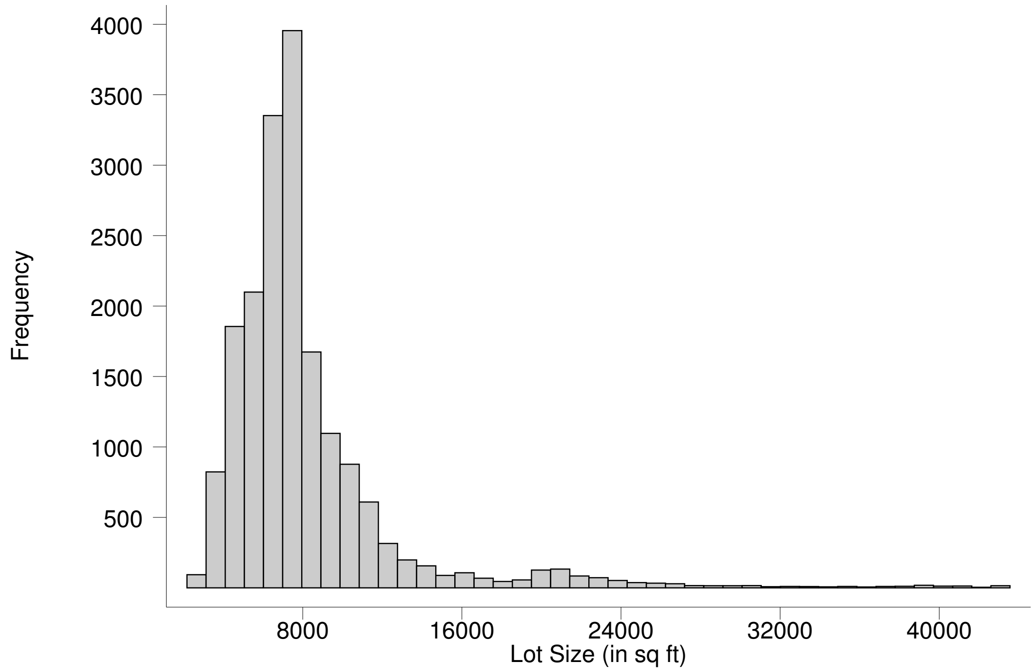

Figure 4. The Distribution of Lot Size

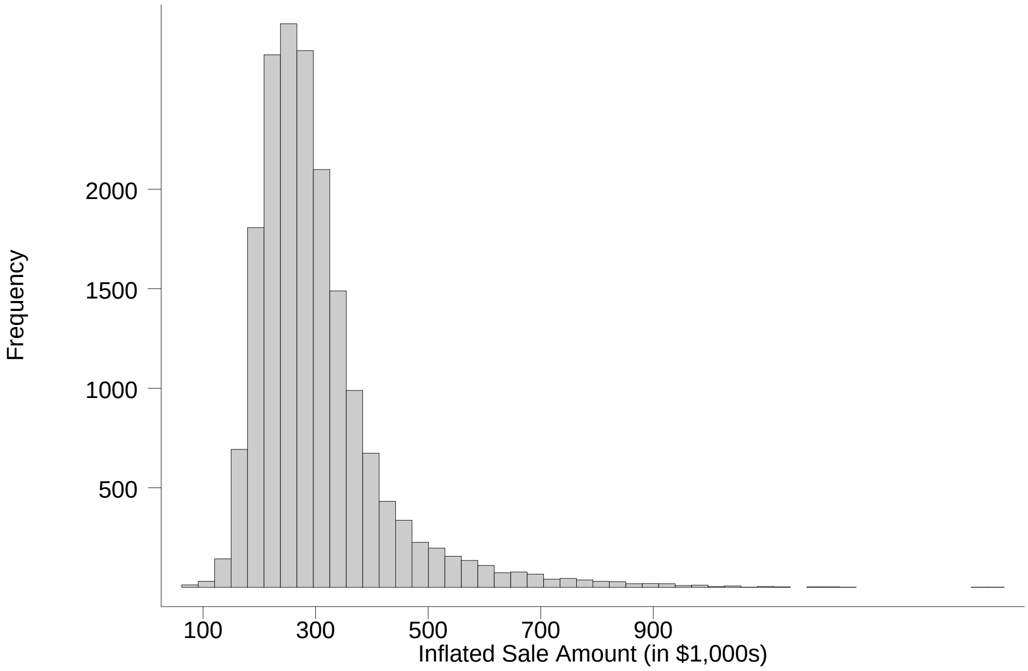

Figure 5. The Distribution of Inflated Sale Price

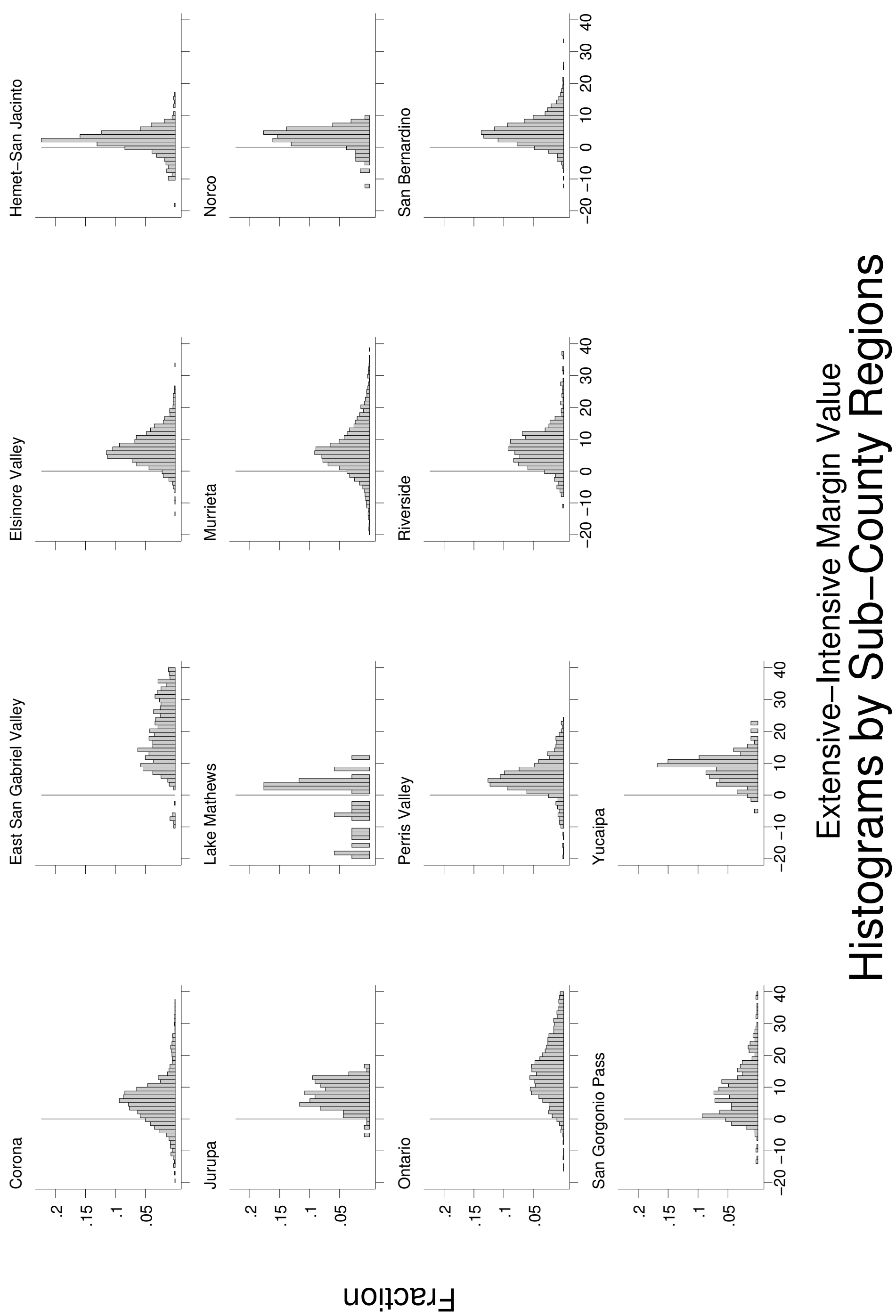

Figure 6. Distribution of Extensive-Intensive Margin Value of Land by Analysis Region

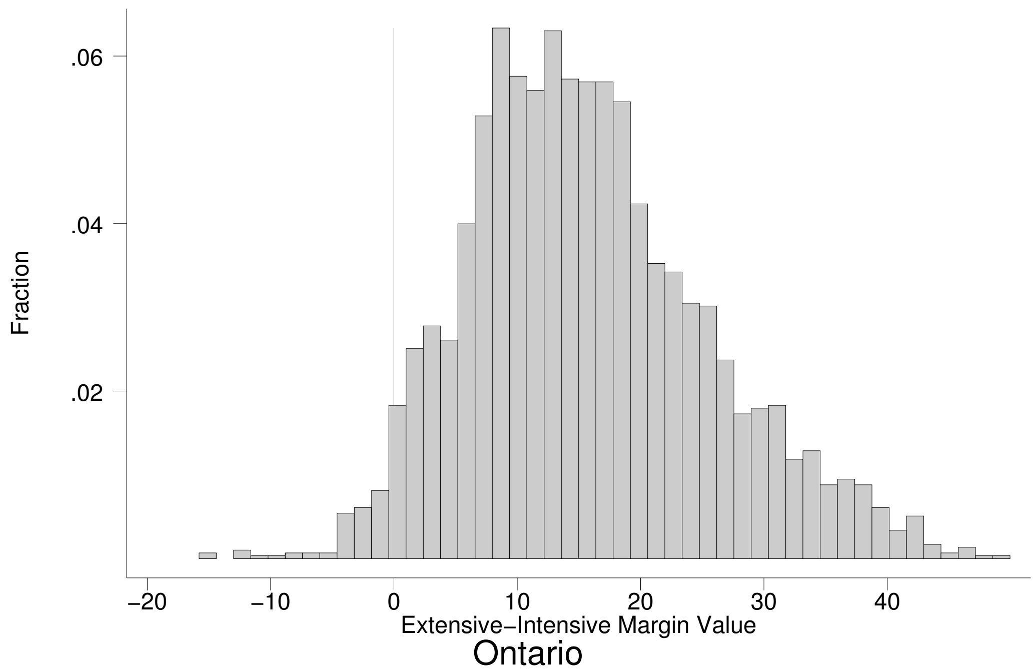

Figure 7. Distribution of Extensive-Intensive Margin Value of Land for Ontario

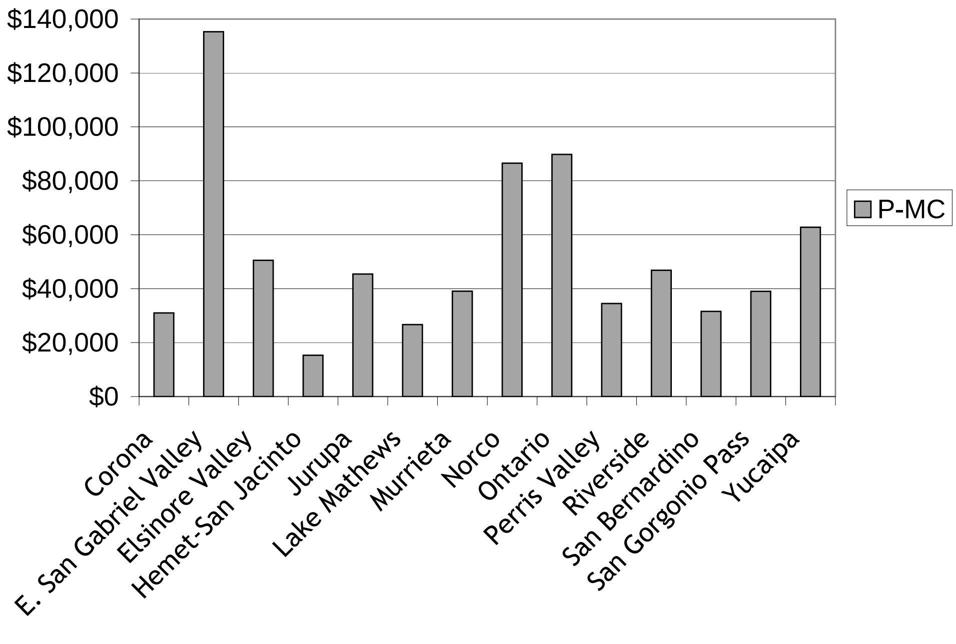

Figure 8. Differences Between Price and Marginal Cost of Provision for Median Houses

Table 1: Distribution of Sale Price, by Region (in $1,000's)

Sub-County Region	Min	Mean	Max	σ	N
Corona	71	236	866	80	1,832
E. San Gabriel Valley	57	364	1,060	153	833
Elsinore Valley	55	211	721	80	1,597
Hemet-San Jacinto	47	142	418	34	774
Jurupa	96	180	343	55	231
Lake Mathews	95	257	531	115	34
Murrieta	58	203	846	68	3,946
Norco	200	369	667	88	130
Ontario	105	240	800	75	2,958
Perris Valley	43	167	439	58	1,465
Riverside	55	202	1,137	95	970
San Bernardino	85	165	504	43	2,672
San Gorgonio Pass	49	158	470	53	612
Yucaipa	97	209	499	80	173
Entire Study Area	43	209	1,137	88	18,227

Table 2: Distribution of Lot Size, by Region (in 1,000s ft^2)

Region	Min	Mean	Max	σ	N
Corona	2.2	8.5	41.3	4.5	1,832
E. San Gabriel Valley	2.6	12.2	42.8	8.0	833
Elsinore Valley	4.4	8.8	37.4	3.5	1,597
Hemet-San Jacinto	3.0	7.2	23.5	2.1	774
Jurupa	4.3	7.6	39.2	4.2	231
Lake Mathews	7.0	23.8	43.6	12.6	34
Murrieta	2.6	7.7	43.1	3.7	3,946
Norco	17.0	24.9	43.1	5.5	130
Ontario	2.8	7.6	41.0	4.0	2,958
Perris Valley	3.0	7.1	43.6	3.3	1,465
Riverside	2.2	9.1	43.6	5.8	970
San Bernardino	3.2	7.4	39.0	3.1	2,672
San Gorgonio Pass	3.0	7.1	39.2	4.2	612
Yucaipa	5.0	11.3	43.6	6.6	173
Total	2.2	8.2	43.6	4.6	18,227

Table 3: Descriptive Statistics for Some Control Variables

Variable	Min	Mean	Max	σ
Living Space (ft^2)	773.0	2,252.4	7,960.0	675.7
Number of Bedrooms	0.0	3.8	15.0	0.9
Number of Bathrooms	0.0	2.6	8.0	.58

Table 4: Description of Binary Variables

	Yes	No
Swimming Pool	7.2%	92.8%
Fireplace	90.7%	9.3%

Table 5: The Distribution of House Observations Over Time

Year Built	N
1993	1439
1994	1599
1995	1595
1996	1907
1997	1605
1998	2165
1999	1682
2000	2226
2001	3697
2002	312

Table 6: The Extensive Margin Value of Land, by Region ($)

Region	mean	median	σ
Corona	9.7	9.7	7.0
E. San Gabriel Valley	23.3	21.8	11.9
Elsinore Valley	7.5	6.9	5.0
Hemet-San Jacinto	3.5	3.6	4.3
Jurupa	8.9	8.7	4.1
Lake Mathews	2.6	3.3	3.5
Murrieta	9.6	9.1	6.9
Norco	4.4	4.4	2.1
Ontario	17.4	16.3	9.5
Perris Valley	7.0	6.7	5.7
Riverside	7.9	7.3	5.9
San Bernardino	8.9	8.6	4.0
San Gorgonio Pass	9.9	8.8	7.7
Yucaipa	9.2	9.8	4.4

Table 7: Coefficient Estimates for Box-Cox Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
# Bedrooms	-$10,887	-$28,334	-$8,022	$1,108	-$715	$28,818	-$4,502
	(1,643)	(4,867)	(1,529)	(1,649)	(3,352)	(14,773)	(1,048)
# Bathrooms	$19,178	$20,858	$15,786	-$5,143	-$11,367	$126,507	-$2,205
	(3,250)	(8,222)	(2,632)	(2,712)	(4,108)	(30,855)	(1,808)
Pool Dummy	$5,887	$1,510	$6,994	$5,379	$15,203		$9,986
	(4,260)	(8,840)	(4,878)	(5,086)	(6,749)		(2,311)
Fireplace Dum.	-$21,854	$35,464	-$10,624	$12,895	$8,701	$44,442	$1,489
	(4,857)	(11,134)	(2,749)	(7,764)	(21,649)	(45,385)	(3,561)
Age	$5,775	$16,633	$7,725	$2,794	$7,608	-$22,175	$11,163
	(1,658)	(3,695)	(1,419)	(1,192)	(1,683)	(17,808)	(1,031)
Time Trend	-$4,409	-$8,393	$2,043	-$1,682	-$620	$11,865	$2,915
	(481)	(1,375)	(414)	(394)	(683)	(5,207)	(276)
Constant	$155,476	-$525,776	$189,922	-$5,925,531	$93,055	-$225,783	$177,376
	(17,861)	(258,261)	(7,120)	(191,328)	(50,426)	(92,823)	(6,090)
Lot Size, ft^2	0.39	0.033	3.6E-07	2.8E+05	2.7	8.3E-24	0.0051
	(0.28)	(0.081)	(2.6E-07)	(8.4E+05)	(6.6)	(4.5E-23)	(0.0012)
House Size, ft^2	10.6	10,260	0.00086	2.2E+06	144.2	-2.8E-17	0.26
	(6.3)	(20,568)	(0.00031)	(4.9E+06)	(274.9)	(1.2E-16)	(0.04)
$\widehat{\theta}$	1.26	0.50	2.46	-0.38	0.91	6.24	1.71
	(0.09)	(0.11)	(0.12)	(0.21)	(0.22)	(3.47)	(0.04)
Observations	1832	833	1597	774	231	34	3946

(1)=Corona, (2)= E. San Gabriel Valley, (3)= Elsinore Valley, (4)=Hemet-San Jacinto, (5)=Jurupa,
(6)=Lake Mathews, (7)=Murrieta, (8)=Norco, (9)=Ontario, (10)=Perris Valley, (11)=Riverside
(12)=San Bernardino, (13)=San Gorgonio Pass, and (14)=Yucaipa

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
# Bedrooms	$1,128	$832	-$15,767	-$992	-$1,926	-$20,582	-$3,508
	(7,487)	(1,557)	(915)	(3,703)	(695)	(2,159)	(3,366)
# Bathrooms	$61,164	$32,879	-$288	$10,109	$1,157	$19,060	-$15,107
	(11,061)	(3,892)	(1,975)	(6,336)	(1,655)	(2,543)	(4,328)
Pool Dummy	-$11,332	$9,894	$9,582	$19,986	$11,995	-$22,899	$2,026
	(17,284)	(5,222)	(3,204)	(8,564)	(2,222)	(4,333)	(8,259)
Fireplace Dum.	-$118,288	$25,281	$26,504	$30,992	$5,955	$21,309	
	(40,623)	(4,826)	(5,643)	(17,824)	(2,200)	(35,723)	
Age	$15,392	-$8,114	$3,197	-$3,286	$1,995	$7,128	$2,463
	(9,069)	(1,837)	(1,417)	(4,061)	(863)	(1,921)	(3,837)
Time Trend	$3,916	-$5,163	-$107	-$82	-$2,726	-$5,873	$3,643
	(2,457)	(558)	(381)	(842)	(199)	(791)	(2,144)
Constant	$356,587	$135,788	-$211,688	$137,305	$105,655	$123,338	$112,998
	(49,111)	(10,436)	(107,082)	(23,005)	(6,234)	(11,397)	(116,137)
Lot Size, ft^2	3.1E-24	0.00038	351	1.3E-07	0.28	0.0082	0.31
	(1.6E-23)	(0.00019)	(763)	(7.3E-08)	(0.084)	(0.0026)	(1.01)
House Size, ft^2	3.6E-18	0.07	9865	1.8E-04	8.9	1.2	62.4
	(1.4E-17)	(0.027)	(18,340)	(7.7E-05)	(2.06)	(0.31)	(162.1)
$\widehat{\theta}$	6.32	1.93	0.38	2.69	1.29	1.60	1.07
	(3.38)	(0.10)	(0.07)	(0.15)	(0.04)	(0.05)	(0.35)
Observations	130	2958	1465	970	2672	612	173

Table 8: The Distribution of House-level Box-Cox Transformation Estimates of the Intensive Margin Values of Land ($)

Region	**mean**	σ
Corona	4.32	0.5
E. San Gabriel Valley	3.58	1.1
Elsinore Valley	0.29	0.2
Hemet-San Jacinto	1.41	0.6
Jurupa	1.31	0.04
Lake Mathews	4.10	6.5
Murrieta	3.14	0.9
Norco	1.38	2.3
Ontario	1.58	0.8
Perris Valley	1.60	0.3
Riverside	0.82	1.2
San Bernardino	3.82	0.4
San Gorgonio Pass	1.67	0.5
Yucaipa	0.64	0.02

Table 9: Percentage of Houses Rejecting H_0 at 1% Level, Box-Cox Transformation

Region	
Corona	78%
E. San Gabriel Valley	98%
Elsinore Valley	93%
Hemet-San Jacinto	70%
Jurupa	97%
Lake Mathews	50%
Murrieta	83%
Norco	66%
Ontario	96%
Perris Valley	88%
Riverside	89%
San Bernardino	90%
San Gorgonio Pass	80%
Yucaipa	94%
Total	87%

Table 10: Percentage of Houses Rejecting H_0 at 1% Level, Alternate Estimates of $\widehat{P_L}$

Region	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Corona	77	76	73	83	79
E. San Gabriel Valley	98	98	98	98	98
Elsinore Valley	93	93	93	94	93
Hemet-San Jacinto	70	72	63	75	72
Jurupa	96	97	97	97	93
Lake Mathews	50	3	9	9	12
Murrieta	83	80	78	94	89
Norco	65	48	20	89	62
Ontario	96	94	93	94	94
Perris Valley	88	91	91	89	86
Riverside	89	70	66	93	72
San Bernardino	89	88	86	93	88
San Gorgonio Pass	80	78	77	77	87
Yucaipa	94	97	96	97	95
Total	87%	85%	83%	91%	87%

(1)=Box-Cox Transformation
(2)=Log-Log
(3)=Ordinary Least Squares
(4)=OLS, robust standard errors
(5)=Huber-Tukey Robust Regression

Table 11: Region-wide Estimates of the Extensive Margin Value of Land ($)

Region	$\widehat{\omega}$	$\widehat{\sigma}_{\widehat{\omega}}$
Corona	8.4	0.1
East San Gabriel Valley	18.1	0.2
Elsinore Valley	6.6	0.1
Hemet-San Jacinto	3.3	0.1
Jurupa	7.8	0.2
Lake Mathews	1.7	0.5
Murrieta	8.4	0.1
Norco	4.3	0.2
Ontario	15.0	0.1
Perris Valley	6.5	0.1
Riverside	6.8	0.2
San Bernardino	8.2	0.1
San Gorgonio Pass	8.0	0.2
Yucaipa	7.5	0.2

Table 12: Percentage of Houses Rejecting H_0 at 1% Level, Alternate Extensive Margin Values of Land

Region	**(6)**	**(7)**
Corona	100	33
E. San Gabriel Valley	100	97
Elsinore Valley	100	52
Hemet-San Jacinto	82	2
Jurupa	100	35
Lake Mathews	41	21
Murrieta	99	35
Norco	79	65
Ontario	100	85
Perris Valley	100	26
Riverside	98	39
San Bernardino	100	20
San Gorgonio Pass	100	39
Yucaipa	100	79
Total	99%	44%

(6)=Region-wide $\widehat{\omega}$
(7)=Increased Housing Quality

Table 13: Percentage of Houses Rejecting H_0 at 1% Level, Census Tract Analysis

Region	**(8)**	**(9)**	**N**
Corona	70	79	1,807
E. San Gabriel Valley	94	93	561
Elsinore Valley	85	88	1,597
Hemet-San Jacinto	33	37	767
Jurupa	92	93	223
Lake Mathews	0	0	5
Murrieta	76	85	3,946
Norco	44	55	87
Ontario	84	83	2,763
Perris Valley	83	84	1,413
Riverside	73	72	908
San Bernardino	90	92	2,311
San Gorgonio Pass	84	81	558
Yucaipa	89	89	173
Total	79%	83%	17,119

(8)= OLS
(9)= Huber-Tukey
N = Observations

Table 14: Percentage of Houses Rejecting H_0 at 1% Level, Time Dummies

Region	**(10)**	**(11)**	**(12)**	**(13)**
Corona	77	74	84	78
E. San Gabriel Valley	98	98	98	98
Elsinore Valley	93	93	94	93
Hemet-San Jacinto	73	64	76	70
Jurupa	97	97	97	92
Lake Mathews	0	0	12	3
Murrieta	80	78	94	89
Norco	45	15	91	66
Ontario	94	93	95	94
Perris Valley	91	91	89	86
Riverside	68	65	92	71
San Bernardino	89	87	94	88
San Gorgonio Pass	76	76	77	87
Yucaipa	95	95	97	95
Total	85%	83%	91%	87%

(10)=OLS
(11)=OLS, robust se's
(12)=Huber-Tukey
(13)=Log-Log

Table 15: Percentage of Houses Rejecting H_0 at 1% Level, Analysis by Year and Region

Region	**(14)**	**(15)**	**(16)**	**(17)**	**N**
Corona	63	56	69	63	1,779
E. San Gabriel Valley	91	90	92	97	738
Elsinore Valley	82	83	87	84	1,595
Hemet-San Jacinto	40	33	56	52	742
Jurupa	88	91	34	88	127
Murrieta	78	75	87	84	3,933
Norco	11	9	51	35	65
Ontario	83	78	89	92	2,942
Perris Valley	67	66	67	80	1,464
Riverside	50	41	75	62	960
San Bernardino	82	70	90	87	2,668
San Gorgonio Pass	34	33	40	71	580
Yucaipa	3	0	71	97	35
Total	73%	68%	80%	81%	17,628

(14)=OLS
(15)=OLS, robust se's
(16)=Huber-Tukey
(17)=Log-Log
N=Observations Remaining

Table 16: Implications of Rejecting H_0 for Median Priced, Median Lot Size Houses, by Region

Region	P-MC	$\frac{P-MC}{Price}$	$\omega - \widehat{P}_L$	Lot Size	Price
Corona	$30,988	10%	$4.18	7,405	$313,446
E. San Gabriel Valley	$135,306	23%	$14.52	9,317	$583,181
Elsinore Valley	$50,494	19%	$6.44	7,841	$271,744
Hemet-San Jacinto	$15,292	8%	$2.07	7,405	$191,075
Jurupa	$45,409	19%	$6.51	6,970	$236,221
Lake Mathews	$26,691	9%	$1.23	21,780	$303,219
Murrieta	$39,084	14%	$5.28	7,405	$279,239
Norco	$86,554	19%	$3.75	23,087	$466,356
Ontario	$89,805	26%	$13.62	6,593	$349,648
Perris Valley	$34,517	16%	$4.95	6,970	$218,348
Riverside	$46,842	18%	$6.33	7,405	$258,790
San Bernardino	$31,584	13%	$4.39	7,202	$235,579
San Gorgonio Pass	$38,996	19%	$6.39	6,098	$206,375
Yucaipa	$62,773	23%	$6.82	9,200	$274,724

Table 17: Partial Equilibrium Change in Total Surplus from Reducing Project Scale from 1000 to 900 Units, by Region (in $1,000s)

	Elasticity=-1		Elasticity=-10		Parameters	
Region	H_a	H_0	H_a	H_0	Price	P-MC
Corona	-$4,670	-$1,570	-$3,260	-$160	$310	$31
E. San Gabriel Valley	-$16,450	-$2,920	-$13,820	-$290	$580	$135
Elsinore Valley	-$6,410	-$1,360	-$5,190	-$140	$270	$50
Hemet-San Jacinto	-$2,480	-$960	-$1,620	-$100	$190	$15
Jurupa	-$5,720	-$1,180	-$4,660	-$120	$240	$45
Lake Mathews	-$4,190	-$1,520	-$2,820	-$150	$300	$27
Murrieta	-$5,300	-$1,400	-$4,050	-$140	$280	$39
Norco	-$10,990	-$2,330	-$8,890	-$230	$470	$87
Ontario	-$10,730	-$1,750	-$9,160	-$170	$350	$90
Perris Valley	-$4,540	-$1,090	-$3,560	-$110	$220	$35
Riverside	-$5,980	-$1,290	-$4,810	-$130	$260	$47
San Bernardino	-$4,340	-$1,180	-$3,280	-$120	$240	$32
San Gorgonio Pass	-$4,930	-$1,030	-$4,000	-$100	$210	$39
Yucaipa	-$7,650	-$1,370	-$6,410	-$140	$270	$63