

**Land Use Regulations and the Value of Land and Housing:
An Intra-Metropolitan Analysis**

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Inferences about the determinants of land prices in urban areas are typically based on housing transactions which combine payments for land and long-lived improvements. In contrast, we investigate directly the determinants of urban land prices, and we analyze the link between the physical access of sites, the topographical and demographic characteristics of their local environment, and the prices of vacant land on those sites. Most importantly, our analysis documents the powerful link between variation in the regulatory environment within a metropolitan area and the prices commanded by raw land as an input to development. We then relate the variation in land prices to the prices paid by consumers for housing in the region, documenting that local land use regulations have quite large effects on the value of houses sold in the region. This is in part because regulations are so pervasive, and also because land values represent such a large fraction of house values in the San Francisco Bay Area.

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1. Introduction

Land use regulations in urban areas are crucial determinants of the form of cities, their spatial patterns of physical development and occupancy, the housing and transport costs of residents, and their economic well-being. These impacts depend on the magnitude and extent of the restrictions in affecting the supply and price of urban land. More generally, the price of land is a basic indicator of the attractiveness and the economic value of a specific site and of the amenities available at that location. These amenities include a diverse collection of attributes, ranging from the productivity of a site in agriculture to the quality of an urban neighborhood surrounding a given location. In urban areas, variations in the price of land reflect the locational and geographical advantages of a particular site, as well as local externalities and governmental policies regulating its use.

There is a large and impressive literature on the determinants of rural land values in the US (*e.g.*, Goodwin et al., 2003, Alston, 1986), and this has elicited detailed economic consideration of the link between the fertility of the land, government regulation (*e.g.*, agricultural price supports), and the value of farmland.¹ Yet there is no comparable body of empirical evidence on the determinants of urban land values. For the most part, land values are estimated from variations in the selling prices of housing by making assumptions about the production function for housing.² (See Davis and Heathcote, 2007, for a particularly careful and important application of this reasoning.) However, this methodology does not account for variations in the land component of

¹ This research has been facilitated by the availability of land price data through the National Agricultural Statistics Service of the US Department of Agriculture and more recently its Agricultural Resource Management Survey.

² There are also a few analyses of small samples of teardowns (*i.e.*, redevelopment parcels) to investigate the value of land in built-up urban areas. See Rosenthal and Helsley (1994) and Dyer and McMillen (2007).

housing output within metropolitan regions,³ and it does not account for factors which may distinguish the value of land at the intensive margin from the value of land at the extensive margin, *i.e.*, the difference between the value of an additional unit of land for a built-up property and the value of marginal land in lots of newly-constructed housing. (See Glaeser and Gyourko, 2003, for a discussion.)

The most important reason why measuring the value of urban land has been problematic is the dearth of direct observations on sales of urban land. However, a new source of data on the price of land in urban areas has recently become available. City and county assessors record the sales prices of parcels of vacant land and “teardown” parcels, and the CoStar Group collects this information on a regular basis.⁴ In this paper, we use this data source in an extensive analysis of the determinants of land prices in the San Francisco Bay Area in California, with a focus on the role of land use regulations.

The San Francisco Bay Area has historically had the highest housing prices in the US, and the rate of increase in housing prices has been among the highest experienced by any large US metropolitan area, at least until the recent collapse in the US housing market. Importantly, the Bay Area is also infamous for a restrictive pattern of land use regulation and for containing some of the most land constrained Metropolitan Statistical Areas (MSAs)⁵ in the United States (Hilber & Robert-Nicoud, 2013; Saiz, 2010). Yet within the Bay Area, there is substantial variation in the economic and geographical

³ For example, Davis and Palumbo (2008) estimate land values over time for 46 US cities using indices of aggregate house prices, assumptions about production relationships, and the creative measurement of residential capital.

⁴ Data from CoStar on the hedonic and financial characteristics of commercial office buildings have formed the basis for several recent microeconomic analyses of US property markets (*e.g.*, Eichholtz et al., 2010, Fuerst and McAllister, 2011); Nichols et al. (2013) use these data to create land price indexes for 23 MSAs; a subset of the CoStar data was exploited by Haughwout et al. (2008) in their analysis of land prices in New York.

⁵ The nine-county San Francisco Bay Area includes the MSAs of San Francisco-Oakland-Fremont, San Jose-Sunnyvale-Santa Clara, Santa Rosa-Petaluma, Vallejo-Fairfield, and Napa.

conditions affecting land parcels, not only proximity to jobs and economic conditions, but also wide variations in topography – in elevation and proximity to water, open space, and natural amenities, as well as exposure to earthquake risk. Moreover, because the power to regulate land use is wielded by city and county governments, there is significant intra-metropolitan variation in regulation. This intra-MSA variation has received limited attention in the literature. Unlike at the regional level, where evidence for the impact of land use regulations on land and housing prices is rather strong (Green et al., 2005; Huang & Tang, 2012; Saiz, 2010), predicted city level impacts of restrictions are less clear (Glaeser & Ward, 2009), especially the impact on land prices (Ihlanfeldt, 2007; Ohls et al., 1974).

In the empirical analysis below, we utilize detailed survey data on land use regulations in the 110 independent jurisdictions in the Bay Area (for more detail, see Quigley et al., 2009) to investigate the linkage between these regulations and land prices. We also link land values to house values, using a large sample of sales of single-family housing in the San Francisco Bay Area. We find that in addition to topography, geography, and demographics, local land use regulations have a significant effect on the value of houses sold in the region, in part because regulations are so pervasive, and in part because land values represent such a large fraction of house values in the San Francisco Bay Area.

The remainder of this paper is organized as follows: Section 2 is a brief review of literature on land use regulation, land prices, and housing prices. Section 3 describes the key sources of land price data and the measures of physical and economic geography used in the analysis. Section 4 relates variation in land prices to our intra-urban measures

of economic geography, and Section 5 investigates the impact of variations in local regulation to variation in land prices within the metropolitan region. In Section 6, which analyzes the relation between housing values and land values, we make the linkage to the work by Saiz (2010) and Davis and Palumbo (2008) more explicit, and we note the complementarity in approaches. Section 7 is a brief conclusion.

2. Literature review

Research on the impact of land use regulation on the property market dates back at least to the 1970s (Ohls et al., 1974), yet it remains an important topic of discussion. Regulations governing the use of land have become more numerous and more onerous in recent decades and housing has become more costly in some metropolitan areas (Glaeser & Ward, 2009; Quigley et al., 2007). Although there has been some recent work on the motivations behind the adoption of stringent land use regulations (Hilber & Robert-Nicoud, 2013; Kahn, 2011), these new explanations provide nuance to rather than supplanting the basic insights of decades earlier. As Hamilton (1978) and Fischel (1980) posit in what came to be called the homevoter hypothesis, municipalities, responding to voter preferences, restrict the supply of housing in order to maintain a community's high prices for single-family homes.

Although much of the early research on urban land use regulations was focused on their impact on land prices (Ohls et al., 1974; Rose, 1986), the impact of regulations on housing prices has received more attention in recent decades. Importantly, access to more detailed data and use of better empirical methods have enabled researchers to carry

out more convincing empirical analyses (Glaeser & Ward, 2009; Green et al., 2005; Huang & Tang, 2012; Saiz, 2010)

Yet, disagreement about the impact of regulations on land prices within metropolitan areas remains unresolved. On the one hand, as Ohls et al. (1974) argue, municipalities that restrict the use of land (*e.g.*, the ability to build multifamily properties) within their boundaries will effectively reduce the price of land by limiting the potential for developer profits. On the other, land use regulations might also increase prices of land through a positive amenity effect (Brueckner, 1998) if the regulated jurisdictions do not have close substitutes in the same metropolitan area (Glaeser & Ward, 2009).

In the case of cities in Florida, Ihlanfeldt (2007) finds a negative impact of regulations on the price of land. He interprets this as evidence of regulation increasing construction costs and reducing development potential, alluding to an argument later made more explicit by Glaeser and Ward (2009); the ultimate impact of supply restrictions on land prices in cities within a metropolitan area depends on how close cities are to being substitutes. In Florida, it seems cities are close substitutes for one another.

One challenge of modeling the effects of land use regulation on land and housing prices is well known: the potential for an endogenous relationship between regulation and prices. Some efforts to address this endogeneity have used instruments, such as historic density and other demographic variables (Ihlanfeldt, 2007), or the nontraditional Christian share of the population in 1970 and the local public expenditure share in protective inspection (Saiz, 2010). Other researchers have opted not to use instrumental variable strategies, given the poor quality of instruments proposed thus far, instead using measures of regulation directly. Any historical measures of, for example, demographics

or urban form, are likely to be correlated with contemporary measures and thus most instruments will not satisfy the exclusion restriction (Glaeser & Ward, 2009).

An additional challenge that has received less attention in the literature is the fact that housing markets are regional, but regulation is local (at least in most US states). Rose (1986) first introduced this issue in some of the early work considering natural (water and mountains) and man-made constraints to urban land supply. Quigley and Swoboda (2007) provide a theoretical model showing that the major impacts of regulations that restricting land supply are regional rather than local. Studies at the metropolitan level generally use weighted averages of measures of regulation for a number of cities within the MSA (Green et al., 2005; Huang & Tang, 2012; Saiz, 2010).

Other studies use cities as the unit of analysis. Some of these studies include cities from a number of metropolitan areas. Kahn (2011), like Quigley and Raphael (2005), uses all cities in California, and Ihlanfeldt (2007) includes cities from 25 of Florida's 67 counties. Although these studies control for county or MSA-fixed-effects, the limited number of these larger geographical units reduces the power of these controls. The study by Glaeser and Ward (2009) is closest to our paper in its scope, as the authors assess the impact of regulations on house prices within the Boston metropolitan area, although the study does not address the impact of regulations on land prices.

3. Data on Land Prices and Their Determinants

A. Land Prices

We utilize a proprietary file of land sales for the nine-county San Francisco Bay Area as of January 1, 2010. Most of these land sales are reported by brokers and other

market participants. They are widely used by commercial real estate agents throughout the US in keeping abreast of market developments and assisting clients in negotiating leases.⁶ The file includes the address of each parcel, its size in square feet, and its selling price. The data consist of 7,419 observations on land sales in the San Francisco Bay Area between 1990 and 2010.⁷ We exclude sales in cities with less than ten observations (14 cities), reducing the sample to 7,358 land transactions.

Figure 1 reports the geographic distribution of our sample of land sales in the nine counties of the San Francisco Bay Area. The dark grey areas denote incorporated cities; this distinction will be exploited further in the analysis below.

The correspondents reporting information on land sales are encouraged to submit descriptions of the land transactions. A sample of these descriptions is included in Appendix A. From these unstructured narratives, we classified the current condition of these parcels into four categories (*i.e.*, “raw,” “rough graded,” “fully improved,” and “previously developed” land). The proposed use of these parcels is classified into eight categories (*i.e.*, “hold for development,” “single family,” “commercial,” “industrial,” “multifamily,” “mixed use,” “public space,” and “public facilities⁸”). These categories, current condition and anticipated use, are presumably important determinants of the cross-sectional variation in land prices. Due to non-responses and ambiguities, we were

⁶ The complete database includes information on about 2.4 million commercial land parcels and properties, their locations and their hedonic characteristics, as well as the current tenancy and rental terms, and the recent sales prices for these properties. About eleven percent of these commercial parcels are classified as “land.” In addition, purchases of other properties are identified as “land” when the buyer is primarily interested in development or redevelopment of the parcel and any unoccupied structures it contains. Sales of these latter parcels are called “teardowns.”

⁷ Specifically, the data include all sales of less than 1,000,000 square feet of land which could be matched to the topographical, census, and regulatory data. The overwhelming majority of the observations excluded from analysis consist of sales of vineyards or farmlands at the periphery of the nine-county region (according to the narrative descriptions reported at the time of sale).

⁸ “Public space” includes land for parks and recreation while “public facilities” includes land used for government buildings, parking lots, and so forth.

able to identify the current condition and expected use of the land parcels for about 84 percent of the sales.

B. Job Access, Topography and Demography

From the coordinates of the street address for each parcel, we match each site to the most important geographical determinant of urban land value, namely its location relative to jobs in the region. The employment access of each parcel is measured in two distinct ways. We first calculate a simple and widely recognized measure of employment access: the proximity of a parcel to the central business district (CBD). Given that decentralization of workplaces in US cities over time has rendered this measure less meaningful, we also use a gravity-based measure of employment access. The gravity-based measure is an estimate, for each land parcel, of access to all jobs in the metropolitan area, which are discounted using a distance-decay function. It is calculated using the following model:

$$(1) \quad A_i = \sum_{j=1}^N E_j / d_{ij}^2$$

where A_i is the accessibility index of parcel i , E_j is the number of jobs of in center j , and d_{ij} is the Manhattan distance between parcel i and job center j , which we square as per convention. Thus, the closer the job center to a site, the more it contributes to accessibility, and the larger the opportunity, the higher the accessibility measure.⁹

A hallmark of the San Francisco Bay Area is its geographic diversity. Some of these attributes are surely reflected in land prices. Using geographic information system (GIS) techniques, we measure a variety of geographic characteristics of the local

⁹ See Handy and Niemeier (1997) for a discussion of measuring accessibility.

environment of each parcel. Hills and elevation are known to increase development costs, but of course they may also provide aesthetic amenities. We measure the elevation of each parcel, and we calculate the share of land within a one-mile radius of each parcel with a slope that exceeds five percent.¹⁰

We also measure the fraction of the area within a one-mile radius of each parcel of land that is underwater.¹¹ Having water nearby a parcel may indicate proximity to the San Francisco Bay or inland water bodies. A final element of natural geography that is presumably important to land prices in California is proximity to earthquake fault lines. The distance of each parcel to the Hayward or San Andreas Fault is also calculated.¹²

In addition to natural geography, we also measure proximity to parks, specifically the percent of land within a one-mile radius that is federal, state or local parkland.¹³ We also identify the census tract in which each land parcel is located and record the demographic characteristics of that tract in 1990, including the percentage of blacks and Hispanics, and the fraction of adults with at least some college education.

Last, we match each land sale to the high school servicing that site and measure the quality of this school with the Academic Performance Index (API) score, first reported in 2000.¹⁴ The API score varies between 200 and 1000. It purports to measure student performance levels, based on the results of statewide testing.

¹⁰ These calculations exploit slope maps generated from the Digital Elevation Model (DEM) of the United States Geographic Service (USGS), available at: <http://ned.usgs.gov>.

¹¹ The computations are based on a GIS layer of all water bodies produced by the Earth Resources and Observation Center, available at: <http://edc.usgs.gov>.

¹² This measurement relies upon data available from the National Atlas project of the Earthquake Hazards Program, available at: <http://nationalatlas.gov>.

¹³ The fraction of parkland is calculated from a land use cover map developed for the California Resources Agency's Legacy Project, available at: <http://legacy.ca.gov>.

¹⁴ The API is required by California's Public School Accountability Act of 1999 and is widely distributed to the public. Data are available at: <http://www.cde.ca.gov/ta/ac/ap>.

Table 1 summarizes the land sales and the matches to the geographical, topographical, and demographic information associated with their locations. The average selling price of the land parcels was about \$27 per square foot, and the average transaction was for a parcel of about 150 thousand square feet. But there is considerable variation in the data, and there are a number of large parcels. Note that the median parcel transaction involves a 65 thousand square foot lot.

About half of the transactions are for raw land, and another twenty percent are for rough-graded or improved lots. About one in eight of the transactions are previously developed lots, where “previously developed” includes land uses such as parking lots as well as “teardowns” for redevelopment. Information about the current condition of the remaining 16 percent of parcels is unknown.

About 22 percent of the lots were purchased for inventory or speculation (“hold for development”), and 59 percent were intended for single family, commercial, industrial, or multifamily construction. Mixed use, public space, and public facilities were the intended use for another six percent of sales, and the intended use of the remaining parcels is unknown.

The variation in topography and economic geography within this metropolitan region is substantial. The average elevation of the parcels is only about 45 feet above sea level, but about 11 percent of the land area within a one mile radius of the average lot has a slope greater than five percent. The land sales are, on average, seven and a half miles from the Hayward Fault (which last ruptured violently in 1987) or the San Andreas Fault (the epicenter of the great 1906 earthquake). On average, about three percent of land

located within a mile of these land sales lies within state or local parkland; only a small fraction of nearby surface area is underwater.

4. Land Prices and Economic Geography

Table 2 reports the relationships between land prices and the two accessibility measures. The table also relates the logarithm of land prices per square foot to lot size and the most straightforward measures of access - access to jobs and proximity to the main form of public transportation, the Bay Area Rapid Transport (BART) system - as well as the current land condition and the proposed usage. These regressions also include fixed effects for each quarter year, from 1990:I through 2010:I (fixed effects are reported in Figure 4, see Section 6 for further discussion).

Lot size, distance to CBD and public transport (as well as the indicators for each quarter year) explain more than half of the variation in vacant land prices per square foot. The current land condition and the proposed land use are also important; when the estimates of current land condition and expected usage are taken into account, the simple model explains 60 percent of the variation in land prices.

Not surprisingly, fully improved lots sell at a significant premium relative to raw land (the omitted category). *Ceteris paribus*, previously developed lots sell at a nine percent premium over fully improved lots. Compared to the single family category (omitted), lots purchased for unknown inventories are sold at a slight discount, while land parcels intended for specific development activities are sold for a greater premium, especially those intended for commercial, multifamily, or mixed use. Parcels intended for use as public open space (*i.e.*, parks) are sold at a considerable discount, albeit

insignificantly. Assuming the intended use indicates the zoning of a given parcel, this result suggests that regulation affects land prices very strongly.

Columns (1) and (2) include one measure of job access - the distance to the Central Business District (CBD) and a squared term. Distance to the CBD matters: with every kilometer increase in distance, the price of land drops by 2.4 percent. The relationship is concave, such that an increase in distance becomes less relevant for areas that are far away from the City of San Francisco.

In Columns (3) and (4), we substitute the traditional accessibility measure for the gravity-based variation. Inclusion of this measure, which incorporates not just proximity to the CBD, but the distance and importance of other job centers as well, improves the fit of the model. Quite clearly, it is important to control for the increase in job centers outside of San Francisco. The coefficients on current condition and proposed land use do not significantly change when the alternative job measure is used.

Table 3 reports the analysis of the relationship between land prices and the topographic and demographic measures described above. The regressions also include fixed effects for each quarter, 1990-2010, and the indicators of land condition and proposed use as reported in Table 2. The results in Table 3 show the substantial impact of the topography measures on land prices: lots at higher elevations sell for higher prices (an anticipated result, see Mahan et al., 2000). Similarly, lots on hilly terrain sell for a considerable premium. However, the interaction term between elevation and hilliness is negative and significant: presumably, construction is considerably more expensive when (parts of) lots at higher elevation must be graded, notwithstanding the amenity of a nicer view at these higher elevations. The results in columns (3) and (4) show that the

topography amenity is correlated with socioeconomic characteristics. Once these characteristics are included in the model, the positive impact and the value from elevation and hilliness is no longer significant.

Land further from major earthquake fault lines is more valuable; a one-mile increase in distance to the fault line increases the value of land by about two percent, *ceteris paribus* (although this effect becomes less pronounced when the distance becomes larger). Land in close proximity to parkland is more valuable, reflecting the amenity value associated with public parks. Proximity of water also affects the price of land: if some part of the lot is underwater, the value increases significantly.

The results in Table 3 also confirm the importance of local demographics in affecting land values. Areas with a greater share of black residents have lower land prices. Cities with a high proportion of college-educated residents have higher prices (albeit insignificantly). These correlations are in line with, for example, Ihlanfeldt (2007).

Column (4) shows that land parcels serviced by a better local school (as measured by the API) are considerably more valuable, as are parcels located close to a school. These findings about schools and land prices are consistent with the well-documented relationship between school quality, test scores, and house prices (see for example Black, 1999, and Figlio and Lucas, 2004).

5. Land Prices and Land Use Regulations

In many states, cities are afforded great freedom to regulate land use and to award or deny developers the right to build at any location. Several studies have attempted to characterize these regulations and to develop quantitative measures of the stringency of

land-use regulation from the many details specified in land-use statutes and in practice. A series of surveys designed by economists at Wharton have been used to create a taxonomy of restrictive regulatory practices in US cities. These efforts are summarized in Gyourko et al. (2008) and the surveys have been used to estimate the restrictiveness of land-use regulation in U.S. metropolitan areas.¹⁵

In California, prior studies by Glickfeld and Levine (1992) elicited a series of procedural and attitudinal responses to questions about local development and regulation from the Planning Director or a comparable official in each California city.¹⁶ In subsequent work, Quigley et al. (2004) used statistical techniques to aggregate the detailed responses documented by Glickfeld and Levine to two indexes: one measuring the “restrictiveness” of each jurisdiction (including, for example, restrictions on the numbers of building permits issued); and one measuring the “hospitality” of each jurisdiction to development (including, for example, the implementation of regulatory “fast tracking”). These indexes were used in an analysis of demographic trends in cities in Southern California.

More recently, the MacArthur Foundation sponsored a detailed investigation of the regulatory structure of the San Francisco Bay Area conducted at Berkeley in 2007. This analysis included surveys of developers and market intermediaries as well as interviews and surveys of Planning Directors and other officials in the cities within the nine-county San Francisco Bay Area.¹⁷

¹⁵ By the Wharton calculations, the San Francisco metropolitan area ranks sixth among 47 US metropolitan areas in terms of the restrictiveness of land use (Gyourko et al., 2008, p. 713).

¹⁶ The survey was administered by the League of California Cities, which insured a high response rate. Details of this survey and a complete set of survey responses may be found in Glickfeld and Levine (1992).

¹⁷ These data were used in a recent comparative analysis of land use regulation and economic development (see Glaeser and Quigley, 2009, Quigley and Raphael, 2005, Quigley et al., 2009).

We match our dataset of 7,358 sales of land parcels to the attributes of local regulation measured by Glickfeld and Levine in 1992 for the cities in which these parcels were located and to the two most salient measures of land-use restrictiveness derived from the analysis of the San Francisco Bay Area conducted in 2007 (Quigley et al. 2007; 2009). These two measures are the number of independent reviews and approvals required by a locality before issuance of a building permit and the number of separate reviews by local authorities required to approve a zoning change.¹⁸ The measures are strongly correlated with a summative index of a variety of aspects of land use regulation, but are preferred over the summative index because they are relatively simple and suffer less from endogeneity than measures such as delays or rejection rates (Quigley et al., 2009). Figure 2 shows the spatial variation in land use regulations across the Bay Area.

Table 4 presents regressions relating these measures of land-use restrictiveness to the price per square foot of vacant land, holding constant the other important determinants of land values noted previously.¹⁹ Measures of land use restrictions are normalized to a mean of zero and a standard deviation of one. In line with Glaeser and Ward (2009), we estimate the effect of land use regulations on land prices using a simple OLS model.

As the results show, the stringency of regulations has a powerful effect upon the prices of vacant land in the San Francisco Bay Area, even when controlling for locational

¹⁸ As many as eleven different reviews by municipal authorities may be required for issuance of a building permit, depending upon the jurisdiction – separate reviews by the planning commission, the architectural and design review board, the parking authorities, etc. Similarly, one or more of a large number of independent entities may be required to concur for changes in zoning; on average six concurrences are required in jurisdictions in the San Francisco Bay Area.

¹⁹ One reviewer noted that our measures of regulation are specific for the development of residential real estate, whereas our sample of land transactions includes land for residential as well as commercial developments. We estimated Table 4 using residential land transactions only, but results were not significantly different when restricting the sample. Results available upon request.

and geographic characteristics of the land site. The number of reviews and approvals required for issuance of a building permit or zoning change both contribute to higher land prices. If the number of independent reviews required for approval of a general construction project were increased by one standard deviation in each of the political jurisdictions in the Bay Area, it is estimated that average land prices in the region would further increase by eight percent. Similarly, if the number of separate reviews by municipal authorities required to approve a zoning change were increased by one standard deviation, the average land price would further increase by about four percent.

The regulatory environment proxied by the Glickfield-Levine indicators, measured at the beginning of the sample period (1992), also has a statistically significant impact on land prices. A one-standard-deviation increase in the restrictiveness index leads to a four percent increase in prices, roughly similar to the impact of the approvals needed for a zoning change. A one-standard-deviation increase in the hospitality index is associated with only a slight decrease in land prices, one percent. Growth-promoting cities have lower land prices.

These findings are an important contribution to the growing evidence about the impacts of land use regulation on property markets within metropolitan areas. They confirm early evidence by Glaeser et al. (2005), who document the impact of development restrictions on condominium prices in New York City, and Quigley and Raphael (2005), who show that stringent regulations increase housing prices across California. However, our results contrast with another study that examines land prices, in cities across Florida (Ihlanfeldt, 2007). In the San Francisco Bay Area, it appears that the amenity effects of regulations combined with a lack of close substitutes between

jurisdictions in the metropolitan area lead to an increase in land prices following more stringent regulations. The fact that regulations have an impact on land prices makes their impact on the housing market even more substantial. These effects add a new channel through which regulations impact housing prices, beyond direct costs or supply constraints.

6. Regulation, Land Prices and Housing Prices

A. Intra-Metropolitan Evidence

The empirical analyses presented in Tables 2-4 permit us to explore the relationship between the determinants of land prices within the San Francisco metropolitan area and the effects of these factors on the prices for housing paid by consumers at various locations in the region. This analysis has parallels with Saiz's (2010) aggregate analysis across 95 MSAs; both emphasize the importance of physical geography and regulation in housing market outcomes. However, Saiz's analysis is based upon stronger behavioral assumptions (*e.g.*, exogeneity in metropolitan populations across thirty years) and theoretical assumptions (*e.g.*, the forms of utility functions), as well as more aggregate measurements (*e.g.*, regulatory variables are measured at the metropolitan level of aggregation). But in return for these more heroic assumptions, Saiz is able to report estimates of house price elasticities across a national sample of housing markets.

The most important difference between this analysis and that of Saiz is the geographical level of analysis. The power to regulate land use and the variation in land-use regulation occurs at the local level, thus intra-metropolitan variation is important in

considering the impacts of regulation on prices. As noted in Table 4, we find substantial differences *within* a metropolitan housing market in the effects of economic geography, public services, and especially land use regulation upon land prices.

In order to explore the link between individual house values and land, prices we use the simple framework emphasized by Davis and Palumbo (2008) in which the value of any house (V_i) is simply the sum of the physical capital embedded in that house (K_i) and the land it occupies (L_i), where stocks of capital and land are valued at current prices (p_k, p_l):

$$(2) \quad V_i = p_k K_i + p_l L_i$$

For each of the 110 cities in the nine-county Bay Area region during the period 1990-2010, we obtain data on the number of single-family house sales, the average selling price and lot size, by quarter year.²⁰ We estimate predicted land prices for each city and quarter year from the regressions reported in Table 4 and then compute the average land values of single-family house sales by multiplying the average lot size with the corresponding predicted land price in the same city and quarter year. From equation (2), we compute the average value of the housing capital transacted by simply subtracting the predicted value of land.

Figure 3 reports the frequency distribution of land values in the San Francisco Bay Area as a fraction of average house sales.²¹ For the average house sale in the region, the underlying land value represents about 32 percent of the selling price, and this fraction has been increasing over time. Further analysis shows that for sales during the 1990-1995 period, land values averaged about 31 percent of house values; for sales

²⁰ Data were obtained from DataQuick in August 2010.

²¹ House values and land values are weighted by the number of sales reported, by city and quarter year.

during the 2005-2010 period, land values averaged 43 percent of house values. Presumably, this increase in land values reflects increases in population and incomes in the region, combined with the constraints imposed by topography and local regulation documented here. The reported fractions are in line with recent findings of Albouy and Ehrlich (2011): land shares of homes values the San Francisco Bay Area are large as compared to other parts of the country.²² Indeed, Thornes (1997) finds that land values are only about 20 percent of housing values in Oregon.

The regressions linking geography, demography, and land-use regulation to land values support an analysis of the importance of these factors in affecting housing values in the region. We use the regression results reported in Tables 2-4 to estimate changes in the land prices for each of the residential parcels in the sample under hypothetical economic conditions. These changes in land prices are then used to estimate changes in house values employing the identity reported in equation (2).

Table 5 summarizes a set of counterfactual estimates,²³ for the city of San Francisco and a number of specific suburban jurisdictions which are identified in Figure 1. The first three rows present the average house prices and the average corresponding land values. Land sales are not uniformly distributed over the 1990-2010 time period. The median year of sale is reported for the transactions in each of the cities noted in the table.

The lower part of the table reports the average percentage change of house values attributable to the change in the value of the land input (from equation 1), under different

²² Using less precise data on residential capital, Davis and Palumbo (2008) estimate land's average share of home values within the city of San Francisco to be even larger: about 75 percent in 1984 and 89 percent in 2004.

²³ Note that these counterfactual estimates assume an "open" economy with free mobility, consistent with the results reported in Tables 2-4 and also with the model developed by Saiz (2010).

scenarios. If the threat of earthquakes were reduced, average house values in the region would change by about minus six to three percent. These increments to housing values vary across the region with the underlying topography, reaching three percent, or about \$8,000, in the City of Hayward, epicenter of the Hayward fault.

If the quality of the Bay Area's public schools were increased by one standard deviation, or 16 percent (as proxied by the 2000 API score for each school), average house values are estimated to increase significantly. This effect is strongest in Hayward, and weakest in San Francisco, as schools in that city are among the highest quality.

If job locations were completely decentralized throughout the region, the aggregate effect upon house values would be significant. Of course, there is a great deal of variation across cities. Housing prices in cities like Palo Alto and San Francisco, close to current concentrations of workplaces, would decline substantially while housing prices in more rural suburbs currently far from job concentrations, such as Santa Rosa and Fairfield, would increase markedly. Job access matters for housing prices.

The estimated effects of reductions in the current regulatory restrictiveness of land-use regulations upon housing values are also quite large. A one-standard-deviation reduction in the number of independent reviews required for approval of a general construction project in Bay Area communities (about three independent public reviews) would decrease house prices by about 4-8 percent. The impact of the number of independent reviews required for approval of zoning changes is much smaller, with housing prices decreasing by 1-2 percent following a one-standard-deviation reduction in the number of reviews required. Changes in the Glickfield-Levine measures also affect housing prices: less restrictiveness decreases housing prices, whereas more hospitality

towards new developments increases prices. Restrictive land use regulations have a significant impact on housing prices through the land price mechanism (disregarding the direct costs of fees and additional physical investments required by regulations).

B. Land Prices and Housing Prices Over Time

Last, we summarize the link between land prices, house prices and capital costs over time. Figure 4 reports an aggregate index of land prices derived by holding constant the economic geography and the condition of the individual land parcels, and compares this to the index published by Davis and Palumbo (2008). We also compare the land price index to the home price index produced by Case-Shiller for the Bay Area, using repeat sales of single-family housing,²⁴ and the construction cost index produced by the Bureau of Economic Analysis.

Figure 4A shows that the transactions-based land index behaves differently when compared to the Davis-Palumbo (DP) index based on inferred land prices. In particular, the transactions-based land price index lags behind the DP index in the early years of the recent price boom. This difference is due to the dependence of the DP index on housing prices, which is evident when compared with the Case-Shiller house price index presented in Figure 4B. The transactions-based land index fluctuates around the Case-Shiller house price index, until the start of the recent housing bubble. Even though home prices increased substantially, the price of transacted land remained relatively stable for several years before catching up at the end of 2004. This lag possibly reflects the effect of the rapid increase in availability of financing at very low cost for housing purchases only.

²⁴ Our own estimates, based on a simple hedonic price index (calculated using DataQuick transactions data by city by quarter year) for the nine counties in the Bay Area, are indistinguishable from the Case-Shiller repeat sales index.

Alternatively, it may reflect the real time necessary to obtain building permits to develop otherwise raw land.

Importantly, the DP index displays a lower volatility. In the short run, this lower volatility may be explained by the fact that the transaction-based index is based on a relatively small number of observations on land sales, whereas the DP index relies upon changes in capital costs, which move slowly over time, and changes in the house price index, which is fairly smooth (on a quarterly basis). In the longer run, the price swings are also substantially larger for land prices than for home prices, which is in line with recent findings of Nichols et al. (2013). Home price indexes cover a bundle of land and structures, and our results confirm that residential land prices have been more variable than the prices of housing structures.

7. Conclusion

This paper documents that intra-urban variations along topographic, economic, and demographic dimensions are important determinants of land prices. Topography (*e.g.*, hilliness, elevation, earthquake fault lines, etc.) has a significant influence on land prices; access to jobs, demographics, and school quality are strongly and positively related to the price of land. We also find that the variation in land prices has a large effect upon regional housing prices.

Moreover, the geographic variation in the restrictiveness of the legal and regulatory environment, measured by the number of approvals needed to obtain permits or zoning changes greatly affects the value of land, and this is reflected in the transaction prices of single-family homes. These are large effects on house values, in part because

local land-use regulation is so pervasive and in part because land values represent such a large fraction of house values in the San Francisco Bay Area. Thus, regulations increase house prices not only by raising direct costs but also through land values.

The results contribute to the understanding of how regulations impact property markets within metropolitan areas and the paper illustrates the complementarity between intra- and inter-metropolitan analyses. Within a single metropolitan area – and across regional markets – land and housing prices vary quite substantially in response to natural constraints *and* localized regulation of land use. Although regulations do not appear to have impacts at the local level in all MSAs (Ihlanfeldt, 2007; Glaeser and Ward, 2009), the impacts are substantial in the San Francisco Bay Area, one of the most important national housing markets.

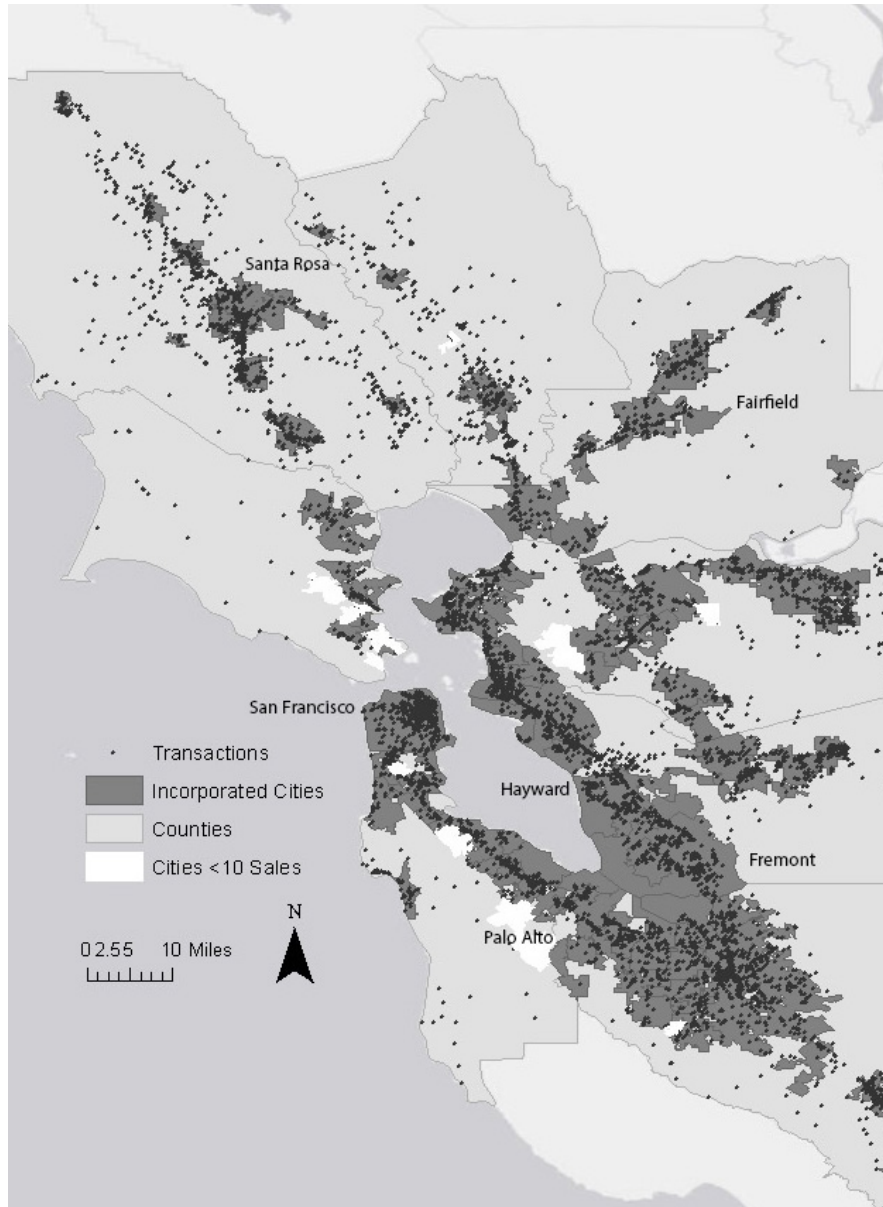
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Figure 1
Location of Land Sales, 1990 – 2010
San Francisco Bay Area

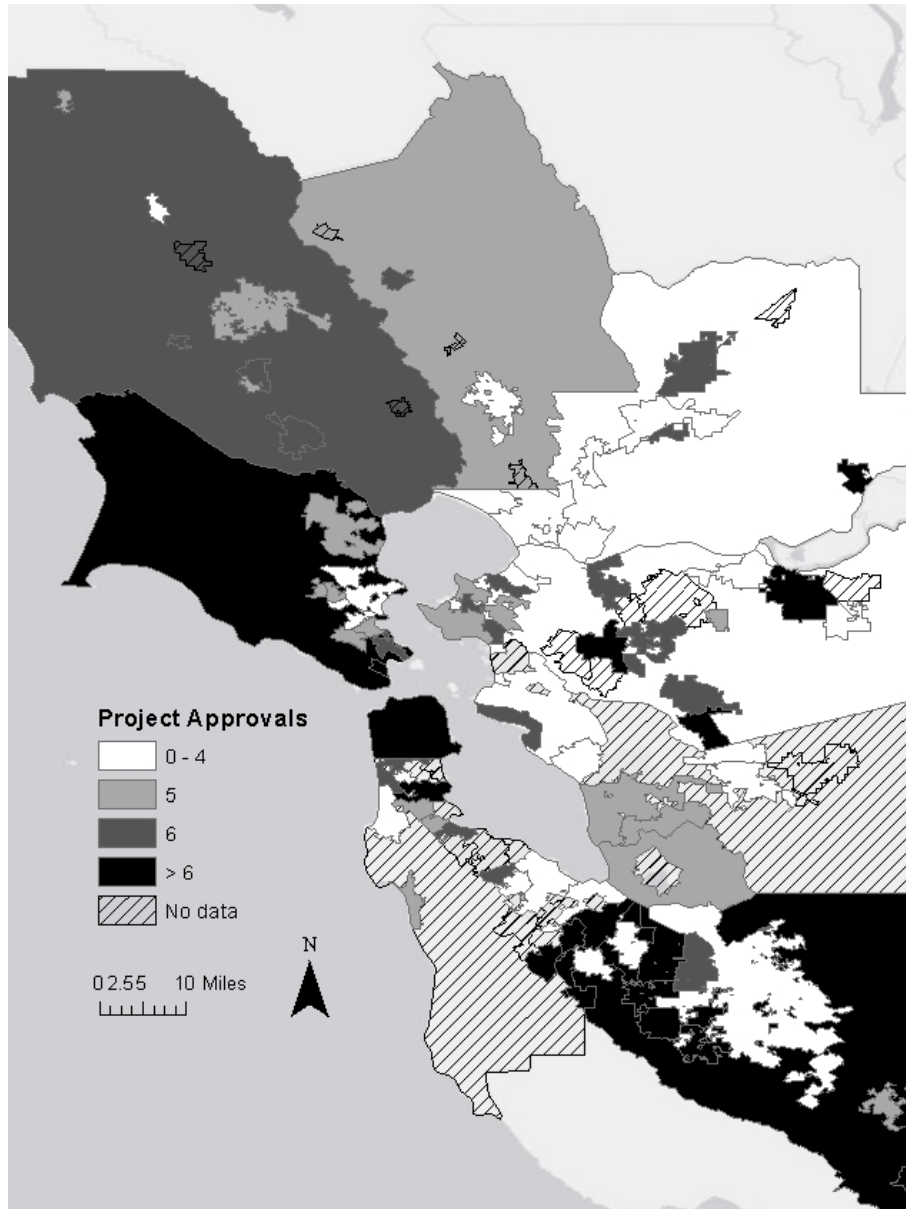


Notes:

Excludes the observations in cities with less than ten sales transactions.

Figure 2
The Geography of Land Use Regulations
(Based on Quigley et al. 2007)

A. Number of Independent Reviews and Approvals Required for Building Permit



B. Number of Independent Reviews and Approvals Required for Zoning Changes

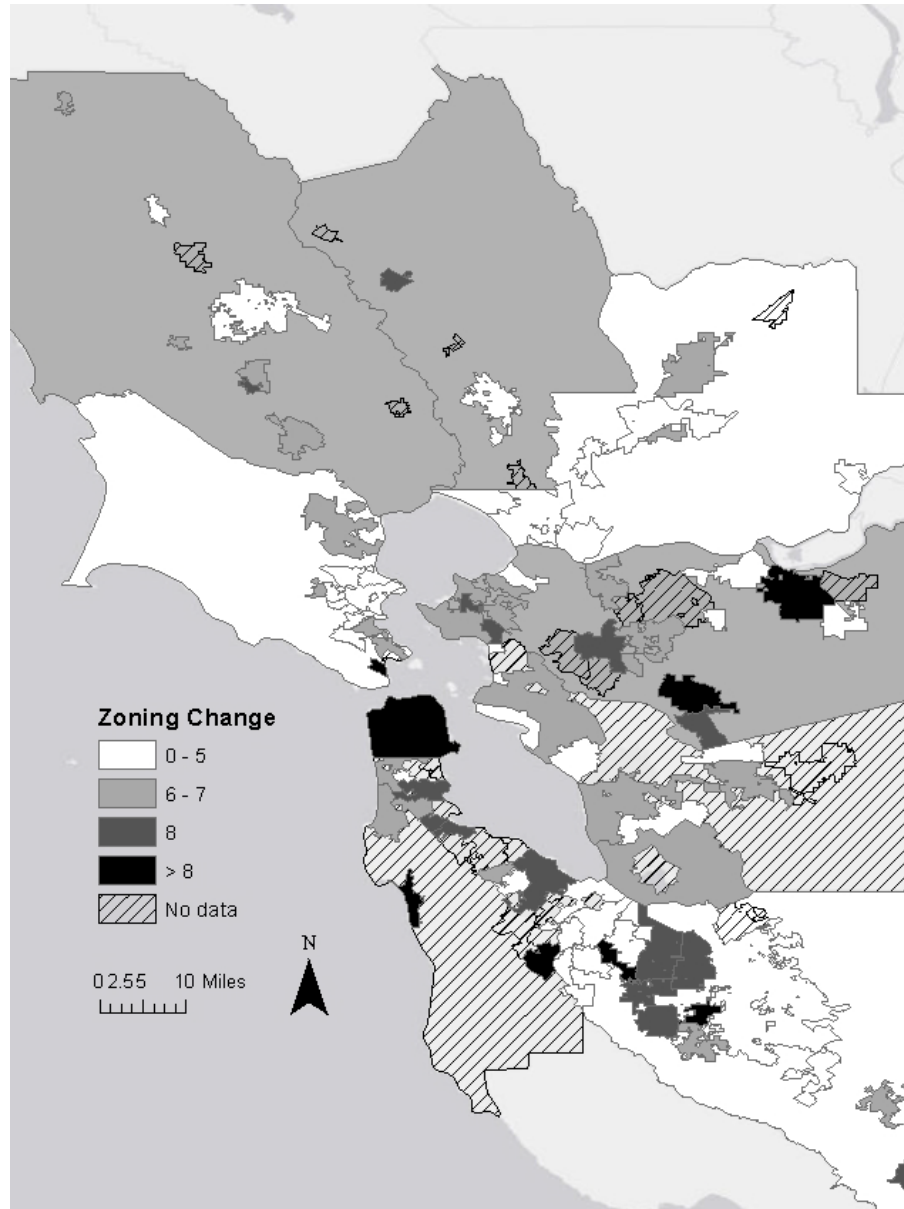


Figure 3
Land Values and House Prices
Single Family Housing Transactions, 1990I - 2010I

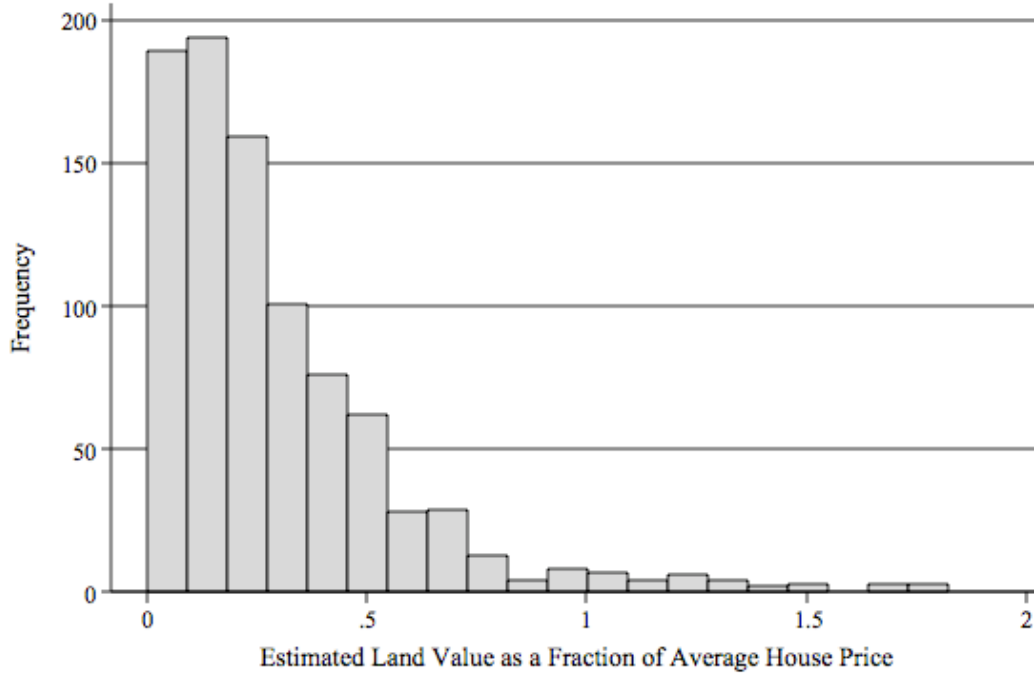
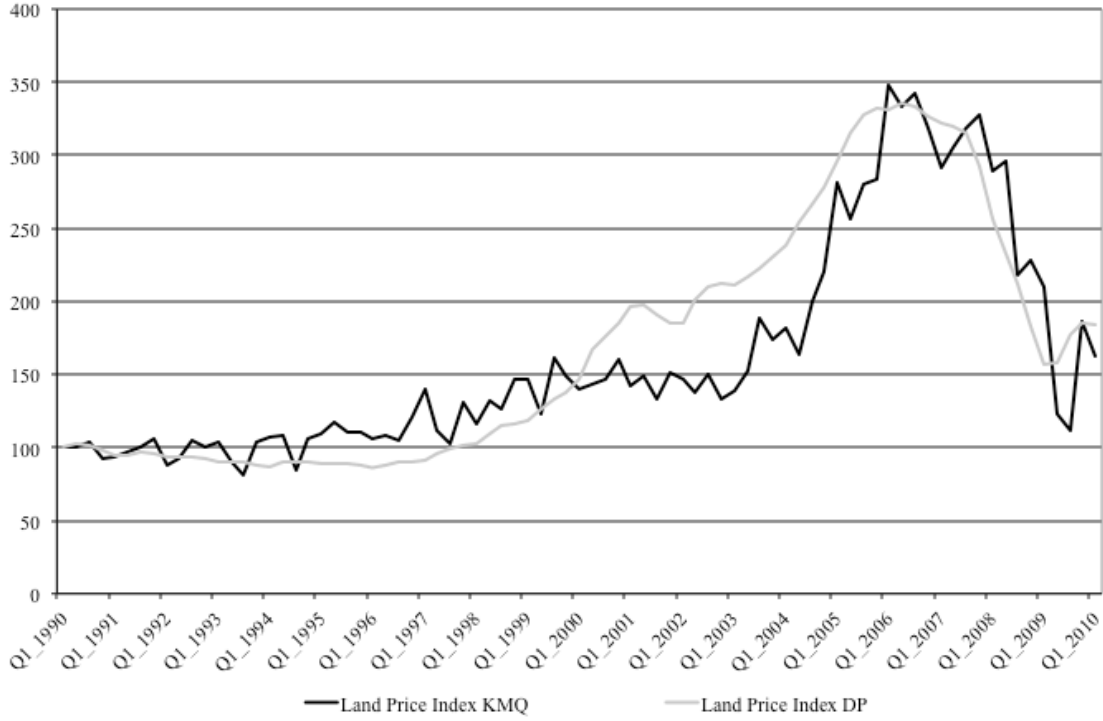


Figure 4
Land Prices, House Prices and Construction Costs

A. Transaction-Based Land Price Index and Implicit Land Price Index



B. Land Prices, House Prices, and Construction Costs



Table 1
Land Price, Land Use, Economic Geography, and Demographic Characteristics
(7,358 observations on land sales, 1990 – 2010)

	Mean	Median	St. Dev	Min	Max
Land Transactions					
Lot Price (dollars per sq.ft.)	27.49	13.21	38.97	0.01	293.63
Lot Size (thousands of sq.ft.)	151.75	65.34	203.26	0.26	998.40
Current Land Condition					
Raw Land (1 = yes)	0.48	0	0.50	0	1
Rough Graded (1 = yes)	0.05	0	0.21	0	1
Fully Improved (1 = yes)	0.17	0	0.38	0	1
Previously Developed (1 = yes)	0.14	0	0.34	0	1
Proposed Land Use					
Hold for Development (1 = yes)	0.22	0	0.42	0	1
Single Family (1 = yes)	0.12	0	0.32	0	1
Commercial (1 = yes)	0.24	0	0.43	0	1
Industrial (1 = yes)	0.12	0	0.33	0	1
Multifamily (1 = yes)	0.11	0	0.31	0	1
Mixed Use (1 = yes)	0.02	0	0.13	0	1
Public Space (1 = yes)	0.01	0	0.09	0	1
Public Facilities (1 = yes)	0.03	0	0.16	0	1
Geography and Topography (from GIS files)					
Distance to CBD (in km)	28.75	13.21	39.02	0.1	293.63
Job Gravity	109.64	102.26	65.37	21.91	779.99
Elevation (ft.)	44.68	25.00	55.16	-2.00	824.00
Percentage Hilliness Larger Than 5 percent (within 1 mile)	11.07	0.00	21.93	0	100.00
Distance to Fault Line (in km)	7.41	5.61	6.16	0	30.18
Percentage of Land in Park (within 1 mile)	3.04	0.00	7.28	0	96.00
Percentage of Land Underwater (within 1 mile)	1.28	0.00	5.55	0	76.72
Demographics (from US Census)					
Percentage Blacks (1990)	8.94	3.02	16.44	0	94.11
Percentage Hispanics (1990)	17.48	12.39	14.62	0	100
Percentage With Some College Education (1990)	20.78	21.38	4.83	0	43.60
Academic Performance Index (API, 2000)	656.30	663.00	104.32	383.00	933
Distance to Nearest School (in km)	1.72	1.31	1.68	0.03	26.05

Table 2
Job Access, Current and Proposed Use, and Land Prices
(dependent variable: logarithm of lot price per square foot)

	(1)	(2)	(3)	(4)
Lot Size (log)	-0.516*** [0.008]	-0.479*** [0.008]	-0.496*** [0.008]	-0.466*** [0.008]
Distance to CBD (in km)	-0.024*** [0.002]	-0.024*** [0.002]		
Distance to CBD ² (in km)	0.000*** [0.000]	0.000*** [0.000]		
Job Gravity			0.005*** [0.000]	0.005*** [0.000]
Presence of BART Station (1 = within 500 meter)	0.213*** [0.051]	0.146*** [0.048]	0.145*** [0.049]	0.095** [0.046]
Current Land Condition				
Unknown (1 = yes)		0.266*** [0.036]		0.277*** [0.035]
Rough Graded (1 = yes)		0.081* [0.048]		0.064 [0.046]
Fully Improved (1 = yes)		0.384*** [0.027]		0.338*** [0.026]
Previously Developed (1 = yes)		0.470*** [0.029]		0.405*** [0.029]
Proposed Land Use				
Unknown (1 = yes)		-0.070 [0.044]		-0.102** [0.043]
Hold for Development (1 = yes)		-0.055 [0.034]		-0.086*** [0.032]
Commercial (1 = yes)		0.310*** [0.033]		0.287*** [0.031]
Industrial (1 = yes)		0.044 [0.037]		-0.012 [0.035]
Multifamily (1 = yes)		0.428*** [0.040]		0.355*** [0.038]
Mixed Use (1 = yes)		0.486*** [0.070]		0.486*** [0.063]
Public Space (1 = yes)		-0.219* [0.129]		-0.256** [0.122]
Public Facilities (1 = yes)		0.159** [0.066]		0.128** [0.064]
Constant	9.130*** [0.085]	8.294*** [0.101]	7.843*** [0.102]	7.179*** [0.111]
Observations	7,358	7,358	7,358	7,358
R ²	0.561	0.605	0.596	0.634
Adj R ²	0.556	0.600	0.591	0.630

Notes:

Regressions include fixed effects by quarter year, 1990I – 2010I. (Coefficients are not reported.)

Robust standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

Table 3
Geography and Topography, Demographics, and Land Prices
(dependent variable: logarithm of lot price per square foot)

	(1)	(2)	(3) [#]	(4) ^{##}
Lot Size (log)	-0.465*** [0.008]	-0.461*** [0.008]	-0.462*** [0.008]	-0.458*** [0.008]
Jobs Gravity	0.005*** [0.000]	0.005*** [0.000]	0.005*** [0.000]	0.005*** [0.000]
Geography and Topography				
Elevation (thousands of ft.)	0.851*** [0.251]	1.000*** [0.261]	0.508* [0.268]	0.084 [0.270]
Percentage Hilliness Larger Than 5 Percent (within 1 mile)	0.107* [0.060]	0.130** [0.062]	0.105* [0.062]	0.043 [0.061]
Elevation*Hilliness Larger Than 5 Percent	-2.247*** [0.438]	-2.299*** [0.449]	-1.639*** [0.446]	-1.201*** [0.449]
Distance to Fault Line (miles)		0.022*** [0.005]	0.020*** [0.005]	0.013*** [0.005]
Distance to Fault Line ² (miles)		-0.001*** [0.000]	-0.001*** [0.000]	-0.001*** [0.000]
Percentage of Land in Park (within 1 mile)		0.266** [0.134]	0.239* [0.134]	0.231* [0.133]
Percentage of Land Underwater (within 1 mile)		0.295** [0.140]	0.318** [0.141]	0.326** [0.139]
Demographics				
City Area (square miles)			-0.000*** [0.000]	
Percentage Some College Education (in 1990)			0.158 [0.258]	
Percentage Blacks (in 1990)			-0.427*** [0.062]	
Percentage Hispanics (in 1990)			-0.038 [0.084]	
API Score ^{###} (times 1,000)				1.017*** [0.097]
Distance to Nearest School (miles)				-0.049*** [0.006]
Constant	7.136*** [0.112]	7.098*** [0.116]	7.192*** [0.139]	6.515*** [0.129]
Observations	7,358	7,358	7,358	7,369
R ²	0.636	0.640	0.646	0.649
Adj R ²	0.631	0.635	0.640	0.644

Notes:

Regressions include fixed effects by quarter year, 1990I – 2010I, as well as the land condition and proposed use measures reported in Table 2. (Coefficients are not reported.)

Robust standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

Table 4
Local Land Use Regulation and Land Prices
(dependent variable: logarithm of lot price per square foot)

	(1)	(2)	(3)	(4)
Land Regulation Measures				
Project Approvals	0.082*** [0.011]			
Zoning Changes		0.044*** [0.010]		
Restrictiveness			0.032*** [0.006]	
Hospitality				-0.010*** [0.002]
Unincorporated Areas (1 = yes)	-0.363*** [0.031]	-0.358*** [0.031]	-0.311*** [0.028]	-0.337*** [0.028]
Constant	6.934*** [0.125]	6.918*** [0.125]	6.908*** [0.121]	7.273*** [0.131]
Observations	6,304	6,304	6,655	6,644
R ²	0.662	0.659	0.652	0.652
Adj R ²	0.656	0.654	0.646	0.646

Notes:

Regressions also include fixed effects by quarter year, 1990I-2010I, as well as the geography and topography measures reported in Table 3, and the land condition and proposed land use measures reported in Table 2. (Coefficients are not reported.)

Robust standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.