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Land use regulations and the value of land and housing: An intra-metropolitan analysis

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ABSTRACT

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 within a metropolitan area – the San Francisco Bay Area. Our analysis focuses on the relationship between the regulation of urban development within different jurisdictions and land prices, while considering other factors that shape the value of land, such as topography and access to jobs. We find that cities that require a greater number of independent reviews to obtain a building permit or a zoning change have higher land prices, *ceteris paribus*. Finally, we relate the variation in land prices to the prices paid for housing in the region and show that local land use regulations are closely linked to the value of houses sold. 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.

1. Introduction

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. 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. Land use regulations can thus affect land prices directly, through the specific uses permitted, but also indirectly by creating neighborhoods and cities of a certain character.

Although much is known about the determinants of rural land values in the US (Goodwin et al., 2003; Alston, 1986), there is no comparable body of empirical evidence on the determinants of urban land values. 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. 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 (Davis and Heathcote, 2007).[1] However, this methodology does not account for variations in the land component of housing output within metropolitan regions,[2] 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).

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"

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[1] 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).

[2] 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.

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0094-1190/

parcels, and the CoStar Group collects this information on a regular basis.[3] In this paper, we use this data source in an extensive analysis of the way land use regulations shape land and housing prices in the San Francisco Bay Area in California.

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. Within the Bay Area, there is substantial variation in the economic and geographic conditions of 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. 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)[4] in the United States (Hilber and Robert-Nicoud, 2013; Saiz, 2010).

Because the power to regulate land use is wielded by city and county governments in the United States, there is significant intra-metropolitan variation in the stringency of regulation. This intra-MSA variation has received limited attention in the literature, especially in terms of its relation to land prices. Unlike at the regional level, where evidence for the impact of land use regulations on housing prices is rather strong (Green et al., 2005; Huang and Tang, 2012; Saiz, 2010), predicted city level impacts of restrictions are less clear, especially on land prices (Glaeser and Ward, 2009; 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 disaggregate the regulatory index into components in order identify those land use controls that exhibit a significant association with prices. We then 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 factors of topography, geography, and demographics are strongly related to the price of land. For example, earthquake risk reduces land prices substantially, and parcels located on hills are more expensive, not because of the intrinsic benefit of elevation, but because of population sorting and man-made amenities nearby. Of course, the primary focus of the paper is land use regulations. We document that some regulations are significantly related to land prices, and thus the value of houses sold in the region. In part this is 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.

Although our models incorporate a large number of controls related to the natural and man-made local environments of parcels, we acknowledge that our findings are not based on a randomized experiment. In an ideal randomized trial, heterogeneous owners would be randomly assigned to different parcels of land exposed to varied regulatory conditions. In such a case, OLS estimates of the impact of land use regulations would yield causal effects. In reality, of course, there is a market for land and a hedonic pricing gradient emerges as heterogeneous potential owners choose their optimal location. In Section 2 of the paper, we explicitly discuss this identification problem, the assumptions that must hold for OLS estimates to not suffer from bias due to omitted variables and self-selection issues, and some of the benefits and drawbacks from using an instrumental variable approach as an alternative specification. In the empirical analysis, we follow the identification strategy of Glaeser and Ward (2009), including a comprehensive set of demographic variables in an OLS regression to reduce the omitted variable bias and concerns about endogeneity. As a robustness check, we also use instrumental variables to estimate the models.

The remainder of this paper is organized as follows: Section 2 is a brief review of literature on land use and regulations, 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 variation in local regulation and 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. Determinants of urban land prices

2.1. Demography and topography

This paper contributes new empirical evidence on determinants of urban land prices. The key factors that determine land values within urban areas – accessibility, amenity levels, and topography – were framed almost five decades ago (Brigham, 1965); however, empirical evidence on the relative importance of these factors remains scant. As discussed in the introduction, the dearth of empirical analyses of land prices is primarily due to a lack of data on land transactions. Existing studies are limited in scope; for example, Peiser (1987) uses data on 467 transactions of vacant land, whereas Kowalski and Paraskevopoulos (1990) use data on just 56 transactions. Both studies employ models with relatively few explanatory variables.

New evidence on the determinants of urban land prices is worthwhile, though many of the hypotheses tested might seem standard in the housing price literature. Yet the market for vacant land is unusual, especially within existing urban areas. Land is "greatly differentiated; there is a notable lack of information; trading is infrequent, subject to high transaction costs and elaborate 'bargaining'" (Adams et al., 1968: 250). Additionally, the development option is an important element embedded in vacant land, which has been argued to increase land values with higher levels of uncertainty in the property market (Titman, 1985). We provide some evidence on this latter argument in Section 6.2 of the paper.

2.2. Land use regulation

Research on the role of land use regulation in property markets dates back at least to the 1970s (Ohls et al., 1974), yet it remains important, given continued disagreement over the magnitude of impacts and the challenge in identifying causality. Moreover, 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 and 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 and 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,

[3] 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.

[4] 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.

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 focused 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 of housing market effects (Glaeser and Ward, 2009; Green et al., 2005; Huang and Tang, 2012; Saiz, 2010).

Yet, the question of whether regulations affect 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 or increase density) 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 and Ward, 2009). Moreover, given that cities in metropolitan areas operate within a system, there is potential for strategic interaction that would exacerbate the role of regulations in price determination. As pointed out by Helsley and Strange (1995), restricting growth in one community will also negatively impact neighboring jurisdictions by pushing the growth onto these jurisdictions, although not all regulatory interventions will have equal impacts in this regard.

In the case of cities in Florida, Ihlanfeldt (2007) finds that more heavily regulated cities have lower land prices. 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 appears cities are close substitutes for one another.

One challenge of modeling the effects of land use regulation on land and housing prices is well documented: the potential for an endogenous relationship between regulation and prices. Some have used instruments to address this concern, such as historic density and other demographic variables (Ihlanfeldt, 2007), or the nontraditional Christian share of the population in 1970 and public expenditures 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 in an OLS regression. Any historical measure of demographics or urban form is likely to be correlated with contemporary measures, and thus will not satisfy the exclusion restriction. Glaeser and Ward (2009) argue that controlling for factors such as demographic make-up and city characteristics reduces the threat of endogeneity through the endogenous sorting process and opt for a non-instrumental variable approach. In this paper, we follow the identification strategy of Glaeser and Ward, including a comprehensive set of demographic variables in an OLS regression, but we also report results from a two-stage least squares model as a robustness check in the Appendix A.

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 and Tang, 2012; Saiz, 2010).

Other studies use cities as the unit of analysis, as this is where the power to regulate is concentrated. Some of these studies include cities from a number of metropolitan areas. Kahn (2011), like Quigley and Raphael (2005), uses all cities in California. 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 the larger geographical units reduces the power of these controls. The work by Glaeser and Ward (2009) on the relationship between regulations, housing construction, and house prices in the Boston metropolitan area is closest to our paper in its scope. That study, however, does not address land prices. Moreover, the results documented in the paper are substantially different, suggesting that intra-metropolitan relationships between regulation and prices differ across places.

3. Data on land prices and their determinants

3.1. 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.[5] The file includes the address of each parcel, its size in square feet, and its selling price. The data consist of 7419 observations on land sales in the San Francisco Bay Area between 1990 and 2010.[6] We exclude sales in cities with less than ten observations (14 cities), reducing the sample to 7358 land transactions. Fig. 1 reports the geographic distribution of our sample of land sales in the nine counties of the San Francisco Bay Area. The dark gray areas denote incorporated cities.

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 facilities[7]"). 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 able to identify the current condition and expected use of the land parcels for about 84% of the sales.

3.2. Job access

We measure the most important geographical determinant of urban land value, its location relative to jobs in the region, in two distinct ways. We first calculate a simple and widely

[5] 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."

[6] 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).

[7] "Public space" includes land for parks and recreation while "public facilities" includes land used for government buildings, parking lots, and so forth.

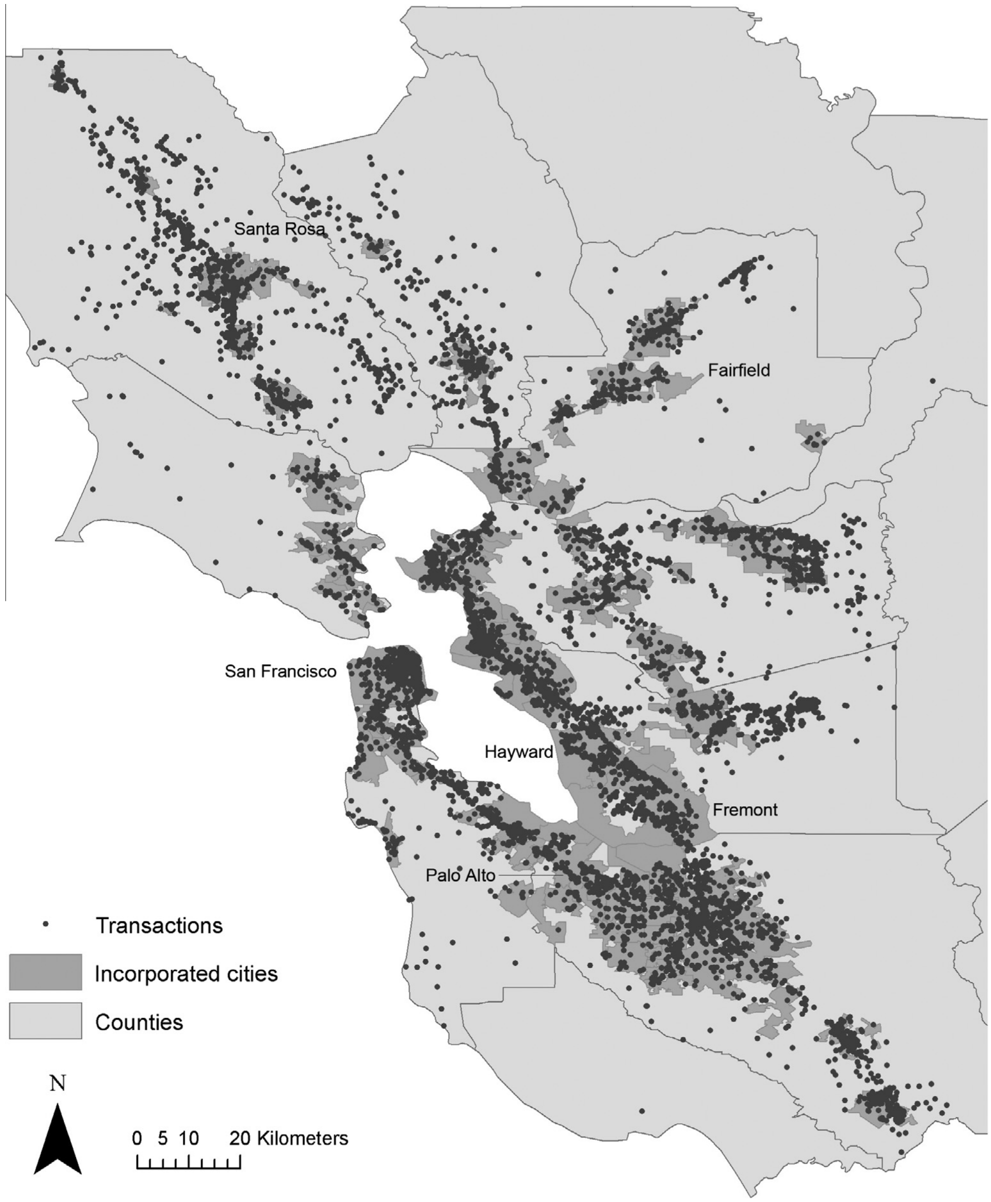

Fig. 1. Location of land sales, 1990–2010 San Francisco Bay Area.

recognized measure of employment access: the proximity of a parcel to the central business district (CBD). Given the argument that decentralization of workplaces in US cities over time has rendered this measure less meaningful (Heikkila et al., 1989), 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:

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

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.[8]

[8] See Handy and Niemeier (1997) for a discussion of measuring accessibility.

3.3. Topography and natural geography

One of the hallmarks 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 environment of each parcel. Hills and elevation are known to increase development costs, but of course they may also provide aesthetic amenities (Boyle and Kiel, 2001). Brigham (1965) develops a clear argument about how apart from views, parcels on hills might be less valuable given that slopes increase construction costs and reduce usable area. He also documents that properties located in some Los Angeles hills had a lower value. However, his measurement of topography is quite imprecise. 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.[9]

[9] 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.

Table 1
Land price, land use, economic geography, and demographic characteristics(7358 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% (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

We also measure two geographic features that are often ignored in intra-metropolitan analyses; coastal location and risk from natural disasters. We measure the first with a variable indicating the fraction of land that is underwater in circle of 1-mile radius centered on each parcel.[10] Having water nearby a parcel indicates either 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.[11]

3.4. Demographics and local public services

In addition to natural geography, we also measure local demographics and public service quality. We 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. 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.[12] The API score varies between 200 and 1000. It purports to measure student performance levels, based on the results of statewide testing. We also measure proximity to parks, specifically the percent of land within a 1-mile radius that is federal, state or local parkland.[13]

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% of parcels is unknown.

About 22% of the lots were purchased for inventory or speculation ("hold for development"), and 59% 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% 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

[10] 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.

[11] This measurement relies upon data available from the National Atlas project of the Earthquake Hazards Program, available at: http://nationalatlas.gov.

[12] 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.

[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.

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***	−0.479***	−0.496***	−0.466***
	[0.008]	[0.008]	[0.008]	[0.008]
Distance to CBD (in km)	−0.024***	−0.024***		
	[0.002]	[0.002]		
Distance to CBD^2 (in km)	0.000***	0.000***		
	[0.000]	[0.000]		
Job gravity			0.005***	0.005***
			[0.000]	[0.000]
Presence of BART station (1 = within 500 m)	0.213***	0.146***	0.145***	0.095**
	[0.051]	[0.048]	[0.049]	[0.046]
Current land condition (raw land = omitted)				
Unknown (1 = yes)		0.266***		0.277***
		[0.036]		[0.035]
Rough graded (1 = yes)		0.081*		0.064
		[0.048]		[0.046]
Fully improved (1 = yes)		0.384***		0.338***
		[0.027]		[0.026]
Previously developed (1 = yes)		0.470***		0.405***
		[0.029]		[0.029]
Proposed land use (single family = omitted)				
Unknown (1 = yes)		−0.070		−0.102**
		[0.044]		[0.043]
Hold for development (1 = yes)		−0.055		−0.086***
		[0.034]		[0.032]
Commercial (1 = yes)		0.310***		0.287***
		[0.033]		[0.031]
Industrial (1 = yes)		0.044		−0.012
		[0.037]		[0.035]
Multifamily (1 = yes)		0.428***		0.355***
		[0.040]		[0.038]
Mixed use (1 = yes)		0.486***		0.486***
		[0.070]		[0.063]
Public space (1 = yes)		−0.219*		−0.256**
		[0.129]		[0.122]
Public facilities (1 = yes)		0.159**		0.128**
		[0.066]		[0.064]
Constant	9.130***	8.294***	7.843***	7.179***
	[0.085]	[0.101]	[0.102]	[0.111]
Observations	7358	7358	7358	7358
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 level.
** Significance at the 0.05 level.
*** Significance at the 0.01 level.

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.

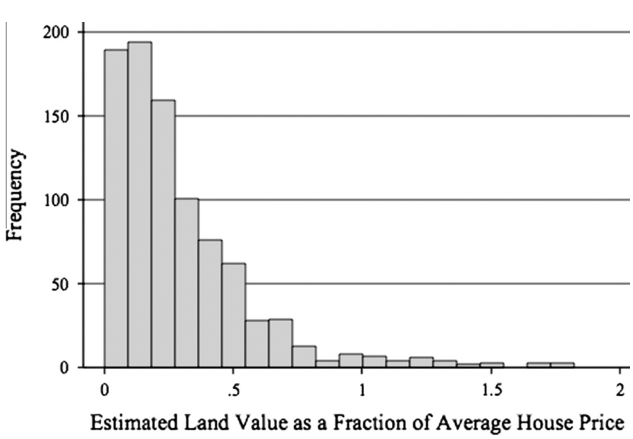

Fig. 2. Land values and house prices single family housing transactions, 1990I–2010I.

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 Fig. 3, see Section 6 for further discussion).

Lot size, distance to CBD and proximity to 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% 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

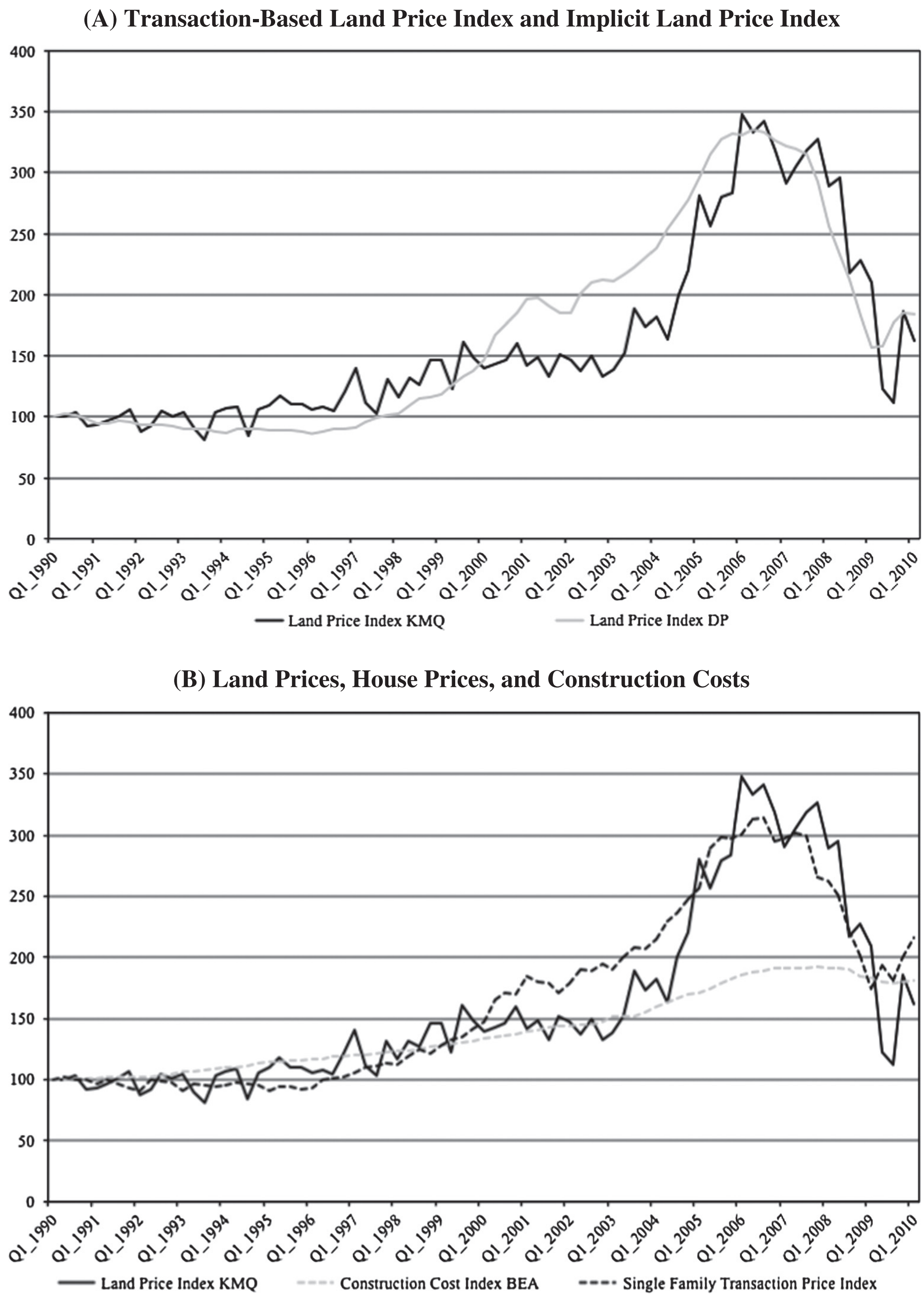

Fig. 3. Land prices, house prices and construction costs.

(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 is very strongly associated with land prices.

Columns (1) and (2) include one measure of job access – the distance to the CBD and a squared term. Distance to the CBD matters: with every kilometer increase in distance, the price of land drops by 2.4%. 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 only very slightly. This is notable in light of arguments during past decades that the monocentric model has lost relevance (Heikkila et al., 1989). The coefficients on current condition and proposed land use do not significantly change when the alternative job measure is used.

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***	−0.461***	−0.462***	−0.458***
	[0.008]	[0.008]	[0.008]	[0.008]
Jobs gravity	0.005***	0.005***	0.005***	0.005***
	[0.000]	[0.000]	[0.000]	[0.000]
Geography and topography				
Elevation (thousands of ft.)	0.851***	1.000***	0.508*	0.084
	[0.251]	[0.261]	[0.268]	[0.270]
Percentage hilliness larger than 5% (within 1 mile)	0.107*	0.130**	0.105*	0.043
	[0.060]	[0.062]	[0.062]	[0.061]
Elevation ∗ hilliness larger than 5%	−2.247***	−2.299***	−1.639***	−1.201***
	[0.438]	[0.449]	[0.446]	[0.449]
Distance to fault line (miles)		0.022***	0.020***	0.013***
		[0.005]	[0.005]	[0.005]
Distance to fault line^2 (miles)		−0.001***	−0.001***	−0.001***
		[0.000]	[0.000]	[0.000]
Percentage of land in park (within 1 mile)		0.266**	0.239*	0.231*
		[0.134]	[0.134]	[0.133]
Percentage of land underwater (within 1 mile)		0.295**	0.318**	0.326**
		[0.140]	[0.141]	[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 1000)				1.017***
				[0.097]
Distance to nearest school (miles)				−0.049***
				[0.006]
Constant	7.136***	7.098***	7.192***	6.515***
	[0.112]	[0.116]	[0.139]	[0.129]
Observations	7358	7358	7358	7369
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 level.
** Significance at the 0.05 level.
*** Significance at the 0.01 level.

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 strong correlation between the measures of topography and land prices: lots at higher elevations and on hilly terrain sell for higher prices (an anticipated result, see Mahan et al., 2000 and Brigham, 1965). However, the interaction term between elevation and hilliness is negative and significant. Construction is considerably more expensive when (parts of) lots at higher elevation must be graded, and parcels on hillsides will have less usable space, notwithstanding the amenity of a nicer view at these higher elevations.

Of course, it is possible that much of the impact of hillside location on land prices is due to population sorting effects. The results in columns (3) and (4) indeed show that topography is correlated with socioeconomic characteristics. Once these characteristics are included in the model, the positive relationship between price, elevation, and hilliness is no longer significant.

Land further away from major earthquake fault lines is more valuable; a 1-mile increase in distance to the fault line is associated with a decrease in the value of land by about two percent, *ceteris paribus* (although the relationship becomes less pronounced when the distance becomes larger). Land in close proximity to parkland is more valuable, reflecting both the amenity value associated with public parks and consequent population sorting based on these amenities. Proximity to water is also related to the price of land; coastal parcels have a significantly higher price.

The results in Table 3 also confirm the importance of local demographics in shaping 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). 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 may of course be due to population sorting effects, 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

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	0.074***			
	[0.011]			
Zoning changes		0.040***		
		[0.010]		
Restrictiveness			0.030***	
			[0.006]	
Hospitality				−0.010***
				[0.002]
Unincorporated areas (1 = yes)	−0.367***	−0.362***	−0.326***	−0.348***
	[0.031]	[0.031]	[0.028]	[0.028]
Constant	7.149***	7.160***	6.956***	7.267***
	[0.146]	[0.147]	[0.142]	[0.151]
Observations	6298	6298	6645	6634
R^2	0.664	0.662	0.656	0.656
Adj R^2	0.658	0.657	0.650	0.651

Notes: Regressions also include fixed effects by quarter year, 1990I–2010I, as well as the geography, topography, and demographic measures reported in Table 3 (column 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 level.
** Significance at the 0.05 level.
*** Significance at the 0.01 level.

et al. (2008) and the surveys have been used to estimate the restrictiveness of land-use regulation in U.S. metropolitan areas.[14]

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.[15] 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").

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.

We match our dataset of 7358 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.[16] 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).

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.[17] 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 assess the relationship between land use regulations on land prices using a simple OLS model. This estimation strategy assumes that regulation is exogenous, which is admittedly contentious. To reduce the omitted variable bias and concerns about endogeneity, we include a comprehensive set of control variables in the analysis, such as demographic characteristics of the area.

As a robustness check, we also use instrumental variables to estimate the models in Table 4. As instruments we use the popular vote on California's Proposition 13 (in favor of a substantial property tax rollback) in the 1978 state election, by precinct, and the popular vote for Ronald Reagan (against President Jimmy Carter) in the 1980 national election, also by precinct. On average, 65% of Bay Area voters favored Proposition 13 in 1978, and 46% favored Reagan in the 1980 election. In addition, we include the date of incorporation for each registered city and the fraction of the building stock constructed before 1940.

The results of the OLS estimation in Table 4 show that the stringency of regulations is positively related to the price of vacant land in the San Francisco Bay Area, even when controlling for locational, geographic and demographic 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.

[14] 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).

[15] 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).

[16] 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.

[17] 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 are available upon request.

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

The results from the IV models, presented in Appendix Table A2, marginally differ from the OLS models. Coefficients on three of the four regulation measures have the same sign and are actually larger than those from the OLS model. The coefficient on the measure of the number of approvals required to make zoning changes is no longer statistically significant.

These findings provide important evidence on the role of land use regulation in property markets within metropolitan areas. The results are consistent with 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 are associated with higher housing prices across California. The results are especially noteworthy when compared to those of Glaeser and Ward (2009), who document that the statistical association between regulations and housing prices become insignificant after controlling for contemporary local conditions such as density and demographic make-up. Of course, Glaeser and Ward were measuring the relationship to housing prices rather than land prices. Nonetheless, the fact that the sizable coefficients remain significant in the San Francisco Bay Area, even when controlling for demographics, suggests that there is an influence of regulation on land prices beyond a population sorting mechanism.

Our results also contrast with the only other recent study of land use regulations that examines land prices (Ihlanfeldt, 2007). Unlike Florida, in the San Francisco Bay Area, it is likely 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 more regulation is associated with higher land prices makes relationship to the housing market even more substantial. It adds a new channel through which regulations relate to housing prices, beyond direct costs or supply constraints.

6. Regulation, land prices and housing prices

6.1. 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. 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 how regulation might be related to prices. As noted in Table 4, we find substantial differences *within* a metropolitan housing market in the relationship between economic geography, public services, land use regulation, and 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) [10] [10] 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):

$$V_i = p_k K_i + p_l L_i \tag{2}$$

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.[18] 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 Eq. (2), we compute the average value of the housing capital transacted by simply subtracting the predicted value of land.

Fig. 2 reports the frequency distribution of land values in the San Francisco Bay Area as a fraction of average house sales.[19] For the average house sale in the region, the underlying land value represents about 32% 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% of house values; for sales during the 2005–2010 period, land values averaged 43% 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.[20] Thorsnes (1997) finds that land values are about 20% of housing values in Oregon.

The regressions linking geography, demography, and land-use regulation to land values support the argument that they influence housing prices in the region. In order to get a sense of the magnitude, 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 Eq. (2).

Table 5 summarizes a set of counterfactual estimates,[21] for the city of San Francisco and suburban jurisdictions that are identified in Fig. 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 Eq. (1)), under different 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 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.

[18] Data were obtained from DataQuick in August 2010.

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

[20] 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% in 1984 and 89% in 2004.

[21] 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).

Table 5
Estimated effects of changed geographic and economic conditions on house values in the San Francisco Bay Area.

	Fairfield	Fremont	Hayward	Palo Alto	San Francisco	Santa Rosa
Average house price	$260,090	$329,361	$270,641	$699,934	$348,830	$367,283
Median year of transaction	2001	1994	1995	1996	1993	2000
Average land value	$92,430	$114,662	$101,824	$392,549	$130,239	$157,093
Change in average house values, in percent, arising from:						
Change in topography[a]						
"Away From Fault Line"	−0.81	1.35	2.73	−0.51	−0.40	−6.17
Change in Demography[b]						
"Improve Schools"	2.67	2.40	4.05	3.26	2.26	2.67
Change in Economic Conditions[c]						
"Suburbanization of Jobs"	6.48	−2.83	−3.00	−4.45	−5.22	6.12
Reform Regulation of Land Use[d]						
Project approval	−6.02	−3.95	−7.64	−4.96	−5.34	−4.78
Zoning changes	−1.22	−0.82	−1.53	−0.89	−1.04	−0.97
Restrictiveness	−0.76	−1.02	−1.93	−1.18	−1.17	−1.21
Hospitality	0.79	1.08	1.89	1.37	1.12	1.20

Notes: Locations of cities are identified in Fig. 1.
[a] Fault lines moved one standard deviation further away.
[b] Improve all school API scores by one standard deviation.
[c] Equalize job density throughout the region.
[d] Reduce number of approvals required for a building permit or zoning change, the extent of restrictiveness, or the extent of hospitality, by one standard deviation.

The estimated effects of reductions in the current regulatory restrictiveness of land-use regulations upon housing values are also quite significant. 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 be related to a decrease in house prices of about 4–8%. The relationship to the number of independent reviews required for approval of zoning changes is much smaller, 1–2% lower housing prices are associated with a one-standard-deviation reduction in the number of reviews required.

6.2. Land prices and housing prices over time

Last, we summarize the link between land prices, house prices and capital costs over time. Fig. 3 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,[22] and the construction cost index produced by the Bureau of Economic Analysis.

Fig. 3A 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 Fig. 3B. 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. 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 uses a new source of data on urban land prices to test a number of hypotheses about the relationship between those prices and a number of factors, with a focus on city and county regulations governing land use. We document that intra-urban variations along topographic, economic, and demographic dimensions are strongly associated with land prices. Some of the findings confirm the existing understanding of property markets developed through empirical work on housing prices, yet our findings are based on land prices, providing novel insights. The distance to an earthquake fault line is found to correlate with land prices, and the distance to the CBD explains as much variation in price as a gravity measure of job accessibility, for example.

Most importantly, 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 strongly correlates with the value of land, even after controlling for a suite of demographic and other characteristics of the local environment. Higher land prices are also reflected in the transaction prices of single-family homes. Thus, this paper provides evidence on additional channel through which land use regulations influence house values. In part, this is 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.

The results contribute to the understanding of the relationship between regulations and property markets 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 are not expected to relate to prices in the same way within all MSAs (Ihlanfeldt, 2007; Glaeser and Ward, 2009), the connection is strong in the San Francisco Bay Area, one of the most important national housing markets.

[22] 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.

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Appendix A

See Tables A1 and A2.

Table A1
Descriptions of land transactions: examples reported by agents.

"Site Land Intended Use: 83 Multifamily Subsidized Units. Land Structures: Industrial Building (Tear Down)."
"Site Land Intended Use: To Construct a 10-story, 123-room hotel with subterranean parking. Land Structures: Two 1-story retail buildings."
"Site Land Intended Use: To Construct a Residential Condominium Project. Land Structures: Shell Office Building."
"Site Land Intended Use: To Construct a Condominium Complex With Commercial Space. Land Structures: Retail Building (Demolished)."
"Site Land Intended Use: To Construct a 12-unit Apartment Building. Land Structures: Duplex (Teardown)."
"Site Land Intended Use: Buyer Will Construct a 50-unit Low/Fixed Income Apartment Building. Land Structures: Two 2-story Buildings."

Table A2
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	0.162***			
	[0.030]			
Zoning changes		0.051		
		[0.034]		
Restrictiveness			0.082***	
			[0.014]	
Hospitality				−0.081***
				[0.009]
Unincorporated areas	−0.430***	−0.406***	−0.305***	−0.297***
(1 = yes)	[0.046]	[0.045]	[0.038]	[0.046]
Constant	6.378***	6.380***	6.315***	8.608***
	[0.136]	[0.137]	[0.143]	[0.263]
Observations	4,590	4,590	5,104	5,104
R^2	0.654	0.652	0.637	0.573
Adj R^2	0.646	0.644	0.629	0.564

Notes: All results are reported for 2SLS regressions using political predispositions, city characteristics and census demographics: Percent of voters favoring California's Proposition 13 (in favor of a substantial property tax rollback) in the 1978 state election, by precinct, and the popular vote for Ronald Reagan (against President Jimmy Carter) in the 1980 national election, also by precinct; Year of incorporation of the city or the founding date of the county, and percent of housing constructed before 1940; 1990 levels of the following variables: percentage of the population with at least some college education, percentage blacks, and percentage Hispanics. Regressions also include fixed effects by quarter year, 1990I–2010I, as well as the geography, topography, and demographic measures reported in Table 3 (column 3) and the land condition and proposed land use measures reported in Table 2 (coefficients are not reported).
Standard errors are in brackets.
* Significance at the 0.10 level.
** Significance at the 0.05 level.
*** Significance at the 0.01 level.

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