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The Determinants of Non-residential Real Estate Values with Special Reference to Local Environmental Goods

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Abstract

This paper presents the results of an empirical study of the determinants of non-residential real estate values in Los Angeles County. The data base consists of 13, 370 property transactions from 1996 to 2005. Separate spatial econometric models are developed for industrial, commercial, retail and office properties. The study focus on the impact on property values of local amenities.

Our analytical results provide insights on how amenities may affect non-residential properties values and how the impact may differ across property types. Our empirical results offer evidence that explicitly modeling spatial dependence is necessary for hedonic non-residential property models where there is interest in local amenities. We also show that it is also important to account for the temporal dimension since ignoring it can lead to misinterpretation of the real measure of spatial dependence over time. Moreover, we find that in general amenities that are jointly valuable to firms and household, such as parks or air quality have either weak or non-robust effects on nonresidential values. However, the fact that the joint amenities coastal access and crime appear to have stable correlations across specifications would be consistent with a higher firm than household valuation. In contrast, those amenities that are likely only valued by firms, such as transportation access and proximity to concentrations of skilled workers have robust and significant correlations with non-residential values.

JEL Codes: R52, H23.

Keywords: Non-residential Property Values, Local Environmental Amenities, Spatial Econometrics

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1. Introduction

The economic literature has exhaustively studied the influence on housing prices of environmental goods including air quality (Bayer et al. 2009, Kim et al. 2003, Chay and Greenstone 2005, Bockstael and McConnell 2007), views (Rodriguez and Sirmans 1994, Seiler et al. 2001, Bond et al. 2002), crime (Pope 2008, Grove 2008), urban forests (Tyrvainem and Miettinen 2000, Mansfield et al. 2005), water quality (Leggett and Bockstael 2000), proximity to hazards (Bin and Polasky 2004), and many other factors. By decomposing residential prices into their relevant components, this literature is able to reveal the amount by which households value the environmental amenities and disamenities being studied.

The commercial real estate sector is also a large part of the national economy, with an estimated $11 trillion value as of the end of 2009 (Florance et al. 2010). However, there are very few studies that have estimated the influence of amenities or disamenities on the value of non-residential properties. This is quite surprising because it is likely that these two markets are strongly linked. Offices, commercial and industrial properties compete for space with residential properties, and the wages firms can offer are influenced by this competition. Diamond (2012) suggests that firms seek to locate in metropolitan areas that have high concentrations of skilled workers. If that is a factor driving inter-metropolitan firm location, should it also not be a factor driving intra-metropolitan migration?

Moreover, temperature, humidity, wind, cloud cover and precipitation also determine how much energy it takes to keep interior spaces lit and at comfortable temperatures and therefore, impact firms' cost structure. If in fact, firms observe and capitalize these types of amenities, hedonic methods can be used to measure the price premium for such attributes, representing the valuation of the marginal buyer. However, it is unclear how these amenities will be valued in equilibrium where both firms and households compete for desirable locations. One goal of this paper is to develop such a model.

While there is already valuable work that identifies appropriate environmental indicators for built non-residential assets, these studies focus on the design and building construction (see for example Eichholtz et al. 2013) and lesser consideration has been given to the impacts of local public goods such as crime, presence of skilled workers, weather, air pollution or alternative forms of open space on rents and selling prices of non-residential properties.

The goal of this paper is therefore to understand how non-residential property values correlate to local amenities using data on office, commercial, industrial and retail property sales from Los Angeles County.

The theoretical urban equilibrium model we develop shows that amenities that influence either commercial or residential property prices will influence the prices and development of both types of property. In addition, it provides a rigorous theoretical foundation for variable choice and for the control of spatial and temporal dependence in properties valuations in our empirical model of non-residential property prices.

The empirical portion of this paper seeks to test the predictions of the theoretical model by measuring how key neighborhood or geographical characteristics are related to non-residential property prices. In addition, it also investigates whether spatial and temporal dependences should be accounted for in all sub-sectors of the non-residential market, namely retail, office and industrial. Spatial dependence implies that high (low) priced real estate assets tend to cluster in some locations (Anselin and Bera 1998).[3] This is particular relevant since not accounting for spatial autocorrelation (or spatial dependence) in presence of spatial interactions in the non-residential real estate market may lead to mispricing of not only building attributes but also of local amenities. The degree of cross section dependence is usually calibrated by means of a weighting matrix, where weights can be based on alternatives forms of contiguity, distance, square distance or the number of nearest neighbors. The spatial weight matrix captures how two properties are spatially connected to one another at one point in time. However, the values for each property are also likely to be correlated with each other over time.

While it is likely that spatially close past property values influence current property values, it is unlikely that spatially close future and unknown property values influence present values. Therefore, the spatial weights matrix needs to be adjusted for potential temporal influence on the spatial spillover impacts in a temporal context. Ignoring such temporal dimension in constructing the weights matrix could lead to misinterpretations on the real measure of spatial dependence over time, which in turn has implications for the influence of local amenities on property values (Dube and Legros 2013, 2015).

We first run a hedonic model as a benchmark against which we will compare the subsequent model specifications. Then we employ spatial econometric models that employ spatial and spatio-temporal weights matrices. These models are applied to 13, 370 non-residential property transactions in Los Angeles County from 1996 to 2005. Given its multimodal structure, heterogeneity across nodes, surrounding jurisdictions and environmental amenities, Los Angeles County provides an appropriate spatial setting to illustrate the theory developed in our theoretical session.

Sivitanidou (1995) and Sivitanidou and Sivitanides (1995) are the most complete papers in the non-residential rents literature. These papers include a number of geographic and workforce attributes. However, the less-advanced geographical software of the time did not allow those authors to be as

[3] In real estate markets, due to herd behavior of buyers and sellers, the value of a property generally guides price expectations in a neighborhood (Hott and Monnin 2008, Hott 2012). Furthermore, neighborhoods tend to develop at the same time and may have similar structural characteristics, such as dwelling size, vintage, interior and exterior design features (Basu and Thibodeau 1998). Nearby buildings tend also to share the same local amenities like accessibility, environmental characteristics, and have similar access to labor markets and public facilities.

geographically specific as our paper. In addition, we include many green and infrastructure amenities that those authors likely lacked. Finally, we use a spatial econometric estimator to capture spatial correlation in both the dependent variable (property prices) as well as in unobservables (residuals). We also construct a spatio-temporal weights matrix, following Dube and Legros (2013, 2015) methodology, to evaluate spatial dependence in a context of spatial data (cross-section) pooled over time.[4]

The sources of non-residential real estate value are interesting in their own right, but our research also sheds light on the literature on quality of life and intra-city productivity divergence. The current work on quality of life and city productivity divergence (Diamond 2012, Albouy 2012) tends to assume that metropolitan areas (MSAs) are spatially uniform and stresses differences between MSAs. However, MSAs can be quite large and there is likely to be significant intra-MSA differences in productivity and quality of life. Diamond 2012, especially, posits a dynamic cycle where skill agglomeration increases productivity, attracting business, which attracts more skilled employees and increases productivity further. Also, the critical mass of skilled employees creates a market for shopping and entertainment that also draws more skilled workers. This story contains the hypothesis that firms should locate near concentrations of skilled workers, which we test in the empirical portion of our paper. We also test whether firms value proximity to restaurants and shopping.

Our empirical results indicate the importance of controlling for spatial dependence in estimating the determinants of non-residential values. Spatial parameters are generally statistically significant, and our simulations indicate that non-spatial estimates of amenity elasticities vary from those generated by spatial regressions. However, similar to Dube and Legros (2013, 2015), we also find that ignoring the temporal dimension in constructing the weights matrix leads to misinterpretations on the real measure of spatial dependence over time. In particular, our results suggest that, for the Los Angeles market, accounting for spatial-temporal dependence in the lagged dependent variable (sale prices), does not seem to attenuate the effects of hedonic attributes statistically or economically.

Regarding the impacts of local amenities, we find that in general amenities that are jointly valuable to firms and household, such as parks or air quality have either weak or non-robust effects on non-residential values. However, the fact that the joint amenities coastal access and crime appear to have

[4] Note that panel data consists of the same unit observed over time, while pooled cross-section data consists of a different unit observed over time, so that a unit is only observed once or very infrequently. Spatial, or cross-sectional, databases pooled over time can represent for example real estate sale prices, business opening (or)/closings, crime location or innovation. For these databases, the panel procedures cannot be applied because a given spatial observation (located at a point) is only observed once over time. However, Dube and Legros (2013, 2015) clearly show that neglecting the temporal dimension of the data generating process of spatial data pooled over time can generate biases on the autoregressive coefficient as well as on the coefficient related to the independent variable which can lead to erroneous interpretation of the indirect and total marginal effect related to spatial characterization.

stable correlations across specifications would be consistent with a higher firm than household valuation. In contrast, those amenities that are likely only valued by firms, such as transportation access and proximity to concentrations of skilled workers have robust and significant correlations with non-residential values. Our results are thus aligned with those of Gabriel and Rosenthal (2004), suggesting that households and firms value differently local amenities. For this reason, cities or MSAs that are attractive to firms may be unattractive to households, and vice-versa.

We begin the remaining portion of our paper by examining the literature concerning the determinants of non-residential rents and values and the related quality of life and quality of the business environment literature. In section 3 we develop a model of the joint determination of non-residential and residential rents and values that include the role of amenities and herding behavior by the market participants followed by comparative static analysis in section 4. Section 5 describes the empirical framework and the econometric model of non-residential values that includes amenities and spatial and temporal dependences and auto-correlation. It also discusses the data, which represents a unique combination of non-residential property transaction data with detailed information on building attributes and local natural and man-made environmental and urban amenities. Section 6 provides the main empirical results and finally, section 7 offers conclusions.

2. Literature Review

Application of the hedonic method to the non-residential property (office, commercial, office) market is recent compared to the housing market and, as a result, references are much fewer. This is primarily explained by the difficulty of collecting the necessary databases, as description of properties by their characteristics is generally less reliable for retail, office-commercial and industrial real estate and warehouses than for housing. However, the improvement in information quality since the 1990s has encouraged development of this type of work, which for the time being still covers only a limited number of geographical markets and has focused mostly on office-commercial real estate properties.

The most comprehensive studies of urban spatial variations in non-residential rents are by Sivitanidou (1995) and Sivitanidou and Sivitanides (1995). Both studies provide a framework for empirically analyzing location demand and supply-side influences on non-residential rents within multimodal MSAs. Coupled with a set of firm amenities reflecting traditional demand-side influences (access to CBD, freeway and airport) and a set of worker amenities (education, crime, access to shopping opportunities and distance to the ocean), supply-side factors such as local institutional controls were found in Sivitanidou (1995) to play an important role in shaping variations across space in office-commercial rents in Greater Los Angeles. A similar conclusion was also reached in Sivitanidou and Sivitanides (1995). In particular, the study concluded that although firm amenities induced the strongest price effect, worker amenities and zoning constraints also played an important role in industrial pricing in Greater Los Angeles. While these studies provide important insights of the role these factors play in shaping intra-urban variations in business rents, they lack hedonic spatial techniques in their estimations and therefore, do not account for spatial heterogeneity and spatial autocorrelation.

In general, existing empirical studies on the determinants of office-commercial rents have provided consistent results on the contribution of various locational (distance from city center or distance from nearest highway interchange) and structural (such as total building square feet, age, height, occupancy, parking) variables to the spatial variation of office rents. Examples include Brennan et al. (1984) and Mills (1992) for Chicago, Sivitanidou (1995) for Los Angeles, Bollinger et al. (1998) for Atlanta, Dunse and Jones (1998) on the market in Glasgow and Nagai et al. (2000) for central Tokyo.

Some studies focus on a specific aspect of rent determinants: architectural features of the buildings (Doiron et al. 1992, Hough and Kratz 1983), vacancy rate (Frew and Jud 1988; Wheaton and Torto 1988; Sivitanides 1997), access to main and secondary CBD centers (Bollinger et al. 1998, Sivitanidou 1995), or proximity to light rail transit and highway systems (Ryan 2005). More recently, studies have measured the effect of environmental certification on office-commercial (Eichholtz et al. 2010, Miller et al. 2008, Fuerst and McAllister 2011a,b,c) and industrial warehouse (Harrison and Seiler 2011) rents. Recognition of the adverse effects of urban sprawl and a heightened awareness of environmental concerns has contributed to the growth of the green building design and construction movement in the United States.

Yet, none of the previous studies have examined the relative contribution of urban green spaces and environmental quality (such as levels of air pollution) to the spatial variation in non-residential rents within multimodal metropolises. It is nevertheless possible that the observed ripple effect of nearby open space, landscape scenery and air pollution on residential properties may also apply to retail and office sites.

The hedonic price approach has long been used to quantify the impact of open space on residential property value, including urban parks and golf courses (Bolitzer and Netusil 2000, Lutzenhiser and Netusil 2001). A common finding in these studies is that green spaces of these types have positive impacts on residential property values up to a distance of one-quarter to one-half mile. As much as 3% of the value of properties could be attributed to park proximity, while proximity to golf courses increased surrounding property values as much as 21%. There is also empirical evidence that increasing the amount of water and grassy land covers in views result in increased home sale prices (Sander and Polasky 2009). For a review on published articles that have attempted to estimate the value of different types of open space see McConnell and Walls (2005). Bockstael and McConnell (2007), in a review of wage studies, also find clear evidence that households are willing to give up wages to live in cleaner locations. Thus higher residential rents and lower wages do not represent a higher "cost of living" in the nice locations but rather a higher "benefit of living" there.

In fact, when amenities have little or no effect on firm costs, either real-estate prices or incomes can be used as an indicator of quality of life from the households' point of view. Several studies have computed quality-of-life rankings for cities, urban counties and metropolitan areas by running two hedonic equations: one relating housing prices to different amenity variables (such as precipitation, temperature measures, sunshine, coastal access, crime, air and water pollution) as well as to housing characteristics; and the other relating incomes for individual households to the amenity levels and workers' characteristics. Examples of such studies include Hoehn et al (1987), Blomquist et al. (1988), Gabriel and Rosenthal (2004), Albouy (2012). However, since the connections between quality of life and real-estate prices and incomes can be ambiguous when firms costs are strongly linked to amenities, neither of these variables can be generally used with confidence as an unambiguous indicator of quality of life. Given all the interdependencies between amenities and households, firms and real-estate developers decisions, it is possible that both hedonic price and wage regressions yield reverse results even if these effects are theoretical possible.[5]

On the other hand, since amenities also affect firms, the empirical procedure used in quality-of-life studies can also be used to rank cities, counties or metropolitan areas from the perspective of firms. For example, Rosenthal and Gabriel (2004) have performed an empirical exercise similar to the procedure used in papers generating quality-of-life rankings. Their study found that the ranking of cities by firms is very different from the ranking by households, consistent with the different goals of the two groups, suggesting that the effects of amenities on consumer utilities and firm profits are often not in the same direction. This in turn suggests that firms and households may also not value environmental amenities and/or environmental quality the same way. Yet, no studies so far have examined the impact of alternative environmental amenities and environmental quality on non-residential real estate values and rents.

3. The Model

This section develops the theoretical underpinnings of the paper. Our framework builds on the model developed by Sivitanidou (1995) and Hott (2012) in order to analyze the effects of local amenities on

[5] For example, in the housing-price regression of Blomquist et al. (1988), better public safety leads to lower rather than higher housing prices and in the hedonic wage regression higher particulate pollution reduces rather than increases income.

non-residential real estate values.[6] By accounting for firm, worker, floor-space and land market equilibriums, our modeling scheme justifies the inclusion in the non-residential hedonic price function of not only productivity-enhancing firm amenities, but also utility-bearing worker amenities and land supply restrictions. In addition, by accounting for herd behavior of the market participants in the sense that the value of a property generally signals or guides price expectations in a neighborhood, our theoretical model justifies the inclusion of a spatial lag in our model specification. Finally, because neighborhood and accessibility attributes of a property are not always directly observable and sources of spatial autocorrelation in property prices also include measurement errors, unsuitable functional form and model misspecification, spatially correlated errors in hedonic model may result, which in turn require a specific statistical approach.

3.1. Assumptions

Let's assume our county contains many cities, indexed by j. Cities differ in two types of attributes: natural and artificial amenities and land-use regulations.

Some amenities (e.g. costal proximity) directly affect households' utility, while others (good transportation access facilitating trips within or out of the city or agglomeration economies) directly affect firms' productivity or transportation costs. Other amenities (e.g. climate conditions and public safety) may affect both the location of firms and households. Let A_{Hj} represent a vector of amenities in city j that directly affect households' utility and A_{Fj} is a vector of amenities in city j affecting firms' productivity and production.

Each city has two zoning methods to control land use: a restriction on the quantity of land available for a certain use and a set of regulations on office-commercial construction.

Land within each city is homogenous. Capital is costless mobile across cities, and is paid the price i everywhere. Office-floor space is owned by absentee landlords who rent the space to local firms. Land is owned by absentee landowners who rent the land to local residents and local developers. Households are perfectly mobile, have identical tastes and skills, and each supply a single unit of labor. Office-commercial firms are also perfectly mobile and identical. All factors are fully employed and both output and input markets are competitive.

A long-run equilibrium requires that land, labor, and floor space markets be cleared simultaneously through appropriate rent and wage adjustments. Residential land rents (P_{Hj}), office-commercial land

[6] Hott (2012) model takes into account that a house can be seen as an asset which price should reflect a risk-return tradeoff but also as a good which price should reflect the utility gain from owning it.

rents (P_{Fj}), firm floor space rents (R_{Fj}), labor wages (w_j), number of households/workers demanded by each firm (N_j) and number of firms (F_j), are endogenous. The equilibrium conditions in the model's various markets are discussed below.

3.2. Households Equilibrium

Households have preferences over residential land, h, a numeraire nonland good, z, and a set of households' amenities A_{Hj}.[7] At each city, a household solves the following utility maximization problem:

$$\begin{aligned} V(w_j, P_{Hj}; A_{Hj}) &= \max_{h,z} U(h,z) + A_{Hj} \\ s.t. \quad & P_{Hj} h + z = w_j + w_0 \end{aligned} \tag{1}$$

where $U(\cdot)$ is concave over h and z and increasing in A_{Hj}, P_{Hj} is the rental expenses on residential land per unit of land and w_j is wage in city j. The nonlabor income w_0 is assumed to be independent of location and will be suppressed in the model henceforth. For simplicity, we assume that the price of the numeraire good is set to 1. The solution of (1) yields the demand functions for residential land and the nonhousing good as

$$h^d(w_j, P_{Hj}) \tag{2}$$

$$z(w_j) \tag{3}$$

where $h^d_{w_j} > 0$, $h^d_{P_{Hj}} < 0$.[8]

The indirect utility function $V(w_j, P_{Hj}; A_{Hj})$ gives the maximum utility achieved in city j given the wage, the residential land price and the level of households' amenities. Households choose residential locations to maximize $V(w_j, P_{Hj}; A_{Hj})$ by considering the trade-offs between wage, residential land rents and households' amenities. Since households are fully mobile, their utility must be the same across all the cities that they inhabit. Therefore, equilibrium for households requires that wages and residential land rents adjust to equalize utility in all cities:

$$V(w_j, P_{Hj}; A_{Hj}) = \theta(w_j, P_{Hj}) + A_{Hj} = \overline{V} \tag{4}$$

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[7] Spatial variations in nonhousing costs, which are smaller than spatial variations in housing costs, are ignored in this analysis.

[8] Note that because A_{Hj} is separable in the utility function, (2) and (3) do not depend directly on the city's households' amenities.

where $\overline{V}$ is the exogenous uniform utility level and $\theta(.)$ is a function that satisfies $\theta_{wj} > 0$ and $\theta_{P_{Hj}} < 0$. Therefore, $V_{wj} > 0$, $V_{A_{Hj}} > 0$ and $V_{P_{Hj}} < 0$.

If there are N_j^S households/workers in city j , then total demand for residential land is given by

$$N_j^S h^d(w_j, P_{Hj}) \ . \tag{5}$$

3.3. Office-Commercial Firms Equilibrium

Office-Commercial firms produce output with a constant returns production function involving the use of office-commercial space (S_j) and labor (N_j). In addition, the production function in city j incorporates external effects represented by a Hicks-neutral technical change A_{Fj} . Output is exported at a uniform exogenous price, which we set equal to 1. At any given city, a firm takes as given input prices and production amenities and chooses the best combination of labor and office-commercial space to minimize the total production cost:

$$\begin{aligned} C(w_j, R_j; A_{Fj}) = \min_{N_j, S_j} \ & w_j N_j + R_j S_j \\ s.t. \quad & A_{Fj} Q(N_j, S_j) = \overline{Q} \end{aligned} \tag{6}$$

where $\overline{Q}$ is the optimal output (which is determined by the production technologies and markets and is set before the location decision is made) and R_j is the rental price of one unit of office-commercial floor space. The solution to (6) gives the firm's conditional demands for labor and office-commercial space in city j as:

$$N_j^d(w_j, R_j; \overline{Q}, A_{Fj}) \tag{7}$$

$$S_j(w_j, R_j; \overline{Q}, A_{Fj}) \tag{8}$$

where $\partial N_j^d / \partial w_j < 0$, $\partial N_j^d / \partial R_j > 0$, $\partial N_j^d / \partial A_{Fj} < 0$, $\partial S_j / \partial w_j > 0$, $\partial S_j / \partial R_j < 0$ and $\partial S_j / \partial A_{Fj} < 0$. Under Hicks-neutral technical change, it is clear that $S_j^d(w_j, R_j; \overline{Q}, A_{Fj}) / N_j^d(w_j, R_j; \overline{Q}, A_{Fj})$ is independent of the A_{Fj} . Because $\overline{Q}$ is assumed to be independent of location, for simplicity it is henceforth assumed to be equal to 1. Equilibrium for firms requires that wages and office-commercial rents adjust to equalize costs in all cities:

$$C(w_j, R_j; 1, A_{Fj}) = \overline{C} \tag{9}$$

where $\overline{C}$ is a constant determined by the existing production technologies. Moreover, because we assume A_{Fj} to be Hicks-neutral and firms produce output under constant returns to scale, the cost function in equation (9) can be written as

$$C(w_j, R_j; A_{Fj}) = \phi(w_j, R_j) / A_{Fj} \tag{10}$$

where $\phi_{w_j} > 0$ and $\phi_{R_j} > 0$. Therefore, $C_{wj} > 0$, $C_{R_j} > 0$ and $C_{A_{Fj}} < 0$. Equation (10) is a downward sloping function in the (w_j, R_j) space, that is, $\frac{dR_j}{dw_j} < 0$. This means that for a given level of firm amenities, locations with higher labor costs must have lower rental cost to equalize total cost across locations. In addition, since production has constant returns to scale, the unit cost of production (which is independent of the output level) equals the exogenous output price and as a result any non-negative output level is a solution to the profit maximization problem and generates zero profits.

Let F_j represent the number of office-commercial firms in city j. Then total demand for office-commercial floor space in city j is given by

$$F_j S_j(w_j, R_j; 1, A_{Fj}) \ . \tag{11}$$

3.4. The Office-Commercial Floor-Space Market

The office-commercial floor-space is a competitive industry, with profits at all locations equal to zero. Real estate developers supply office-commercial space under constant returns using capital and land. The production process may be subject to institutional constraints (for example impact fees or difficulties in obtaining building permits), which enter the production function as a Hicks neutral shift parameter. Based on profit optimization and given constant returns, long-run equilibrium in the office-commercial floor space market is ensured by equating the unit rental price of floor space (given by the LHS in (12)) to unit production costs (given by the RHS in (12)), as indicated by

$$R_j = \delta(i, P_{Fj}) G_j \tag{12}$$

where $\delta(\cdot)$ is an increasing function in both input prices. P_{Fj} is the endogenous price for office-commercial land and G_j is a vector of institutional constrains on office-commercial construction such that $G_j \geq 1$. Note that a $G_j > 1$ increases office-commercial construction costs. Moreover, equation (12) implicitly defines the land bid-rent of office-commercial floor-space producers as the price of land such that profits are zero. In order not to introduce further structure to the model, we assume that the number of real estate developers in city j is fixed and normalized to one.

3.5 The Land Market

To ensure equilibrium in the land market, P_{Fj} and P_{Hj} must be such that total land demanded by real estate developers and by households equals the fixed supply of land available for each use, as shown by

$$L^D(P_{Fj}, w_j, R_j; F_j, A_{Fj}, i) = \bar{L}_{Fj} \tag{13}$$

$$F_j N_j^d(w_j, R_j, 1; A_{Fj}) h^d(w_j, P_{Hj}) = \bar{L}_{Hj} \tag{14}$$

where $\bar{L}_{Fj}$ and $\bar{L}_{Hj}$ represent the total amount of land available in city j for office-commercial and residential land use, respectively. Since the production function for office-commercial space has constant returns to scale, then total demand for office-commercial land can be expressed as

$$L^D(P_{Fj}, w_j, R_j; F_j, A_{Fj}, i) = F_j S(w_j, R_j, 1, A_{Fj}) \alpha(i, P_{Fj}) \tag{15}$$

where $\alpha_i > 0$ and $\alpha_{P_{Fj}} < 0$. Note that in equilibrium total supply of office-commercial floor-space must satisfy total demand for office-commercial space in city j, which is given by (11). Therefore, $F_j S(w_j, R_j; 1, A_{Fj})$ should be the optimal amount produced and supplied in city j by real estate developers.

In addition, equilibrium condition (14) implies that the labor market must also be in equilibrium. From (7), each office-commercial firm in city j demands $N_j^d(w_j, R_j; 1, A_{Fj})$ units of labor. Since there are F_j firms in city j, total demand for labor is given by $F_j N_j^d(w, R_j, 1, A_F)$. Because we assume there is full employment and households live where they work, then t

otal demand for labor in city j equals the total number of households living in the city. From (2), a household living in city j demands $h^d(w_j, P_{Hj})$ units of residential land. Therefore, the LHS of (14) is the total demand for residential land in city j.

3.6. Office-Commercial Rent (and Wages) Equilibrium

Given the exogenous parameters of the model, equations (4), (9), (12)-(15) and (7)-(8) should determine unique equilibrium values for the model's simultaneously determined endogenous variables P_{Fj}, P_{Hj}, R_j, w_j and F_j.

Equation (14) implicitly determines P_{Hj} as a function of ($w_j, F_j, N_j^d, \bar{L}_{Hj}$). Note that the cost of office-commercial land is a function of the working population size of the city as well as of the number of firms and total amount of land available for office-commercial use. Inserting $P_{Hj}(w_j, F_j, N_j^d, \overline{L}_{Hj})$ and (7) into (4) while taking into account (12) , (13) , that the office production function has constant returns to scale and that firm's amenities enter the production function a la Hicks, yields the modified household equilibrium condition

$$V(w_j, P_{Hj}(R_j, \overline{L}_{Hj}, \overline{L}_{Fj}, G_j, i, 1), A_{Hj}) = \overline{V} \tag{16}$$

where $\partial P_{Hj} / \partial R_j > 0$, $\partial P_{Hj} / \partial L_{Hj} < 0$, $\partial P_{Hj} / \partial L_{Fj} > 0$ and $\partial P_{Hj} / \partial G_j < 0$. Equation (16) is upward sloping in the (w_j, R_j) space, that is, $\dfrac{dR_j}{dw_j} > 0$ implying that for a given level of household amenities, locations that offer higher wages must also have higher office-commercial rents and higher housing residential land prices to equalize utility in all locations.

Equation (16) and equation (9) together jointly determine the equilibrium office-commercial rent and the equilibrium wage in city j as

$$R_j(A_{Fj}, A_{Hj}, \overline{G}_j, \overline{L}_{Hj}, \overline{L}_{Fj}) \tag{17}$$

$$w_j(A_{Fj}, A_{Hj}, \overline{G}_j, \overline{L}_{Hj}, \overline{L}_{Fj}) \tag{18}$$

Omitting the spatially invariable parameters, the reduced-form office-commercial rent function (17) suggests that long-run office-commercial space rents must be a function of firm production amenities, household/worker amenities, legal restrictions on the production of office-commercial space, as well as land supply influences.

3.7. Office-Commercial Property Prices

From Rental Prices to Property Prices

If the property market works in accordance with conventional economic theory then the price of a property should be such that buyers are indifferent between renting and owing. Note however that rents are determined in the property market for space use, not in the asset market for ownership. Equation (17) captures thus the fundamental forces driving office-commercial rents and represents a central piece in determining the demand for real estate assets. The reason is because when investors acquire an asset (real estate property), they are actually acquiring a current or future income stream. Thus, in a frictionless market, rent should cover the user cost of a property, that is, the costs that arise from owing a property for one period:

$$R_{j,t}(A_{Fj,t}, A_{Hj,t}, \overline{G}_{j,t}, \overline{L}_{Hj,t}, \overline{L}_{Fj,t}) = P_{j,t}\left[i_t + m - E_t(G_{t+1})\right] \tag{19}$$

where $P_{j,t}$ is the property price j at time t, i_t is the real interest rate, m is the constant maintenance rate and $E_t(G_{t+1})$ is the expected capital gains defined as

$$E_t(G_{t+1}) = \frac{[(1-d)E_t(P_{j,t+1}) - P_{j,t}]}{P_{j,t}} \tag{20}$$

where d is the constant depreciation rate.

Inserting (20) into (19) yields, after some manipulations, the following property price equation:

$$P_{j,t} = \frac{R_{j,t} + (1-d)E_t(P_{j,t+1})}{1 + i_t + m}. \tag{21}$$

Herding Behavior

We now introduce herding behavior by assuming that rational but imperfectly informed investors learn from the decisions of the other investors. In particular, let's assume that investor j expectations regarding the future property price depends on both social and non-social signals. Informational influence affects expectations of real estate price appreciation if investors look to others in deciding whether or not their real estate purchase will generate capital appreciation. In this sense, we can write the expectation regarding future price as $E_t(P_{j,t+1} | \Omega_j)$, with Ω_j representing the information set upon which investor j bases his expected capital gains and described as follows:

$$\Omega_j = \sum_{q=1}^{Q-1} \lambda_{q,j} x_q + \lambda_{Q,j} P_{-j,t} \tag{22}$$

where $\lambda_{q,j}$ and $\lambda_{Q,j}$ are the weights placed by investor j on the information contained in the non-social signal x_q and social signal $P_{-j,t}$, respectively. It is assumed that $0 < \lambda_{q,j} < 1, \forall q$ and $\sum_{q=1}^{Q} \lambda_{q,j} = 1$.

According to (22) the information set has two different components. The first component on the right-hand-side of (22) captures all currently available objective information relating to non-social factors (x_q) such as for example maintenance rate, depreciation rate and interest rates.

The second component on the right-hand-side of (22) contains the social information regarding the willingness to pay of other owner occupiers for similar properties ($x_Q = P_{-j,t}$). In this sense, our model captures the idea that a selling price of a property at a particular location acts as a signal that guides the selling prices of its neighboring properties.

If markets are weakly efficient, social signals are ignored (that is $\lambda_Q = 0$ for all investors) and all investors respond symmetrically to non-social signals so that λ_q is constant across all investors, then the non-social information is factored into prices to give an unbiased estimate of future prices ($\overline{P}_t$). In this case the expectation of future price is represented as

$$E_t(P_{j,t+1}\big|\Omega_j = \sum_{q=1}^{Q-1}\overline{\lambda}_q x_q) = \overline{P}_t \tag{23}$$

However, when $\lambda_Q \neq 0$, social information will distort prices away from their fundamental value. The action of other investors introduces herd externalities in which the herd's judgment is biased by social information about the action of others:

$$E_t(P_{j,t+1}\big|\Omega_j = \sum_{q=1}^{Q}\overline{\lambda}_q x_q) = (1-\lambda_Q)\overline{P}_t + \lambda_Q P_{-j,t} \quad . \tag{24}$$

Representative office-commercial property price for city j at time t

Finally, inserting (24) back into (21) we get the representative office-commercial property price for city j at time t as

$$\begin{aligned} P_{j,t} &= \frac{R_{j,t} + (1-d)[(1-\lambda_Q)\overline{P}_t + \lambda_Q P_{-j,t}]}{1+i_t+m} \\ &= \frac{R_{j,t}}{1+i_t+m} + \frac{(1-d)}{1+i_t+m}[(1-\lambda_Q)\overline{P}_t + \lambda_Q P_{-j,t}] \end{aligned} \tag{25}$$

with the fundamental value of office-commercial rents, $R_{j,t}$, given by equation (17). According to (25) real estate prices can divert from their fundamental value because of a herding behavior. The fundamental value of office-commercial properties is represented by:

$$\frac{R_{j,t}}{1+i_t+m} + \frac{(1-d)}{1+i_t+m}\overline{P}_t = \frac{R_{j,t}}{1+i_t+m} + \frac{(1-d)}{1+i_t+m}E_t\left[\frac{R_{j,t+1}}{1+i_{t+1}+m}\right]. \tag{26}$$

Following (26), the fundamental price of a non-residential real estate property is driven by present and future office-commercial rents and interest rates. However, the presence of a herding behavior ($\lambda_Q > 0$) may create a positive feedback effect between the attractiveness of a real estate property and its price, $\lambda_Q[P_{-j,t} - \overline{P}_t]$. If $[P_{-j,t} - \overline{P}_t]$ is positive then the excess return from this price externality is positive, which pushes the price of a real estate property higher. On the other hand if $[P_{-j,t} - \overline{P}_t]$ is negative, the opposite effect occurs. The parameter λ_Q captures the strength of price externality. This in turn suggests that real estate markets are not fully efficient and autocorrelation in price inflation should be accounted for in studies that examine the determinants of real estate prices.

It is worth pointing out that $[P_{-j,t} - \overline{P}_t]$ captures proximity both in space and time because the social signal $P_{-j,t}$ incorporates property prices from spatial neighbors, which in turn incorporate expectations over future prices.

Equation (25) therefore sets the stage for the empirical analysis of office-commercial property values and location desirability within Los Angeles County. In section 5.3 we provide details on how we build our spatio-temporal weights matrix, which specifies the weight by using both the space and time of the nearest similar transacted property (neighbor). Each row in this matrix pertains to a transaction in our data set.

4. Comparative Statics

The equilibrium effects of land-use regulations, as well as production and household amenities, can be derived by totally differentiating (4), (9), (12)-(15) and (7)-(8) with respect to each variable of interest. Because of all the interdependencies, the comparative statics of this type of model can be fairly complex and lengthy. The steps for the case where the amenity is beneficial to households but neutral to firms are shown in the appendix, and the remaining derivations are available on request. In this section, we just indicate the signs for changes in each exogenous variable and discuss the results.

Table 1: Comparative Statics: Amenities

	R_j^*	w_j^*	P_{Fj}^*	P_{Hj}^*	F_j^*	N_j^*
A_{Fj}	+	+	+	+	+/-	+/-
A_{Hj}	+	-	+	+	+/-	+
A_j^+	+	+/-	+	+/-	+/-	+/-
A_j^-	+/-	+	+/-	+/-	+/-	+/-

Note: A "+" ("-") indicates that the sign if the derivative is positive (negative). A "+/-" indicates that the sign of the derivative may be positive or negative.

Impact of an increase in office-commercial firm amenities (A_{Fj})

For a given level of household amenities and land-use regulations, if firm amenities at city j increase, then office-commercial firms in the city must pay higher both for office-commercial rents and labor; otherwise, firms would have incentives to move to that location. On the other hand, households are willing to trade a higher wage for a higher residential land price in order to equalize utility across cities. In addition, higher office-commercial land prices are established in city j, as more firms bid higher floor-space rents. However, higher labor and rental costs together with higher productivity have an ambiguous effect on the number of demanded workers and on the amount of demanded floor space. As a result, the impact of a change in firms' amenities on the equilibrium number of workers/households in city j is ambiguous.

Impact of an increase in household amenities (A_{Hj})

If, for a given level of firm amenities and regulations, city j becomes more attractive to households, residential location demand will grow, increasing residential land rents, office commercial land rents as well as office-commercial rents. Higher office-commercial rents can be afforded by firms, as households are now willing to accept lower wages in exchange for better amenities. In equilibrium, the number of hired workers is higher in a location with better worker amenities because higher office-commercial rents compel firms to demand less floor-space while a lower wage incentives firms to hire more workers. Thus, and in contrast to the previous case, our model suggests that household amenities have a positive effect on employment. However, the impact on the equilibrium number of firms is still ambiguous.

Impact of an increase in an amenity that affects both firms and households (A_j)

Some amenities can affect both firms' costs and households' welfare. A firm located in a temperate climate may spend less on heating and cooling for its offices and factories, so that the cost function would be decreasing in A_j. On the other hand, households prefer temperate to extreme climate (too cold or too hot) so that the indirect utility function is increasing in A_j. Let's assume that amenity A_j^+ affects positively both firms and households. In this case, the equilibrium office-commercial rents and office-commercial land prices are still higher for the city with better amenity. However, wage and residential land price can be higher or lower, depending on the relative magnitude of the effects of the amenity on firms' costs and households' utility. If the cost (utility) effect dominates the utility (cost) effect then both the equilibrium wage and residential land rent are higher (lower).

Now suppose that amenity A_j^- affects positively firms but it is a disamenity for households because it may for example cause more traffic or pollution. In this case the negative effect of the amenity on households' utility reinforces the impact on wages, but offsets the effects on office-commercial rents and on housing residential land prices. If the disamenity effect dominates, then a city with high firm amenity and high household disamenity (or low household amenity) may actually have lower office-commercial rents and lower residential land prices. Conversely, if the cost amenity effect dominates, then a city may have higher office-commercial rents and higher residential land prices.[9]

Table 2: Comparative Statics: Land-Use Regulations

	R_j^*	w_j^*	P_{Fj}^*	P_{Hj}^*	F_j^*	N_j^*
G_j	+	-	-	-	+/-	+
$\overline{L}_{Fj}$	-	+	-	+	+/-	-
$\overline{L}_{Hj}$	+	-	+	-	+/-	+

Note: A "+" ("-") indicates that the sign if the derivative is positive (negative). A "+/-" indicates that the sign of the derivative may be positive or negative.

Impact of an increase in the stringency of floor-space regulations (G_j)

Let's assume a given level of household amenities and firms. First, because stringent production regulations increase production costs of office-commercial floor space, real estate developers require higher office-commercial rents in order to satisfy current demand for floor-space. However, office-commercial firms must be compensated with lower labor costs to offset their incentives to move. This in turn implies that households must be compensated with lower residential land rents in order to equalize utility across locations. Second, because office-commercial firms pay lower wages but higher rentals, the equilibrium number of workers/households is still higher in the location with more stringent regulations on office-commercial construction. Finally, the impact of an increase in G_j on the equilibrium office-commercial land price is negative as it decreases land's productivity.

[9] These results are also consistent with previous theoretical results within the housing market which have shown that in cases where an amenity affects positively households but it is detrimental to firms, the comparative static effects are ambiguous, with wages and rents rising or falling in almost all the cases (Blomquist 1988; Hoehn et al. 1987). For instance, in the housing-price regressions of Hoehn et al. (1987) and Blomquist et al. (1988), better public safety (lower crime) leads to lower rather than higher housing prices and in the hedonic wage regression higher particulate pollution reduces rather than increases income. Considering only the effect on wages or the effect on rents would thus suggest in the latter cases that public safety is a disamenity while pollution is an amenity. Yet, when the effects on wages and rents are both accounted for, then we observe that indeed public safety is an amenity while pollution is a disamenity.

Impact of an increase in the stringency of office-commercial zoning ($\overline{L}_{Fj}$)

A lower amount of land designated for office-commercial development must be associated with higher office-commercial land prices to equalize land demand to the constrained supply. This, in turn, requires higher office-commercial floor-space rents, and therefore, a lower wage to maintain firm indifference at the unit production cost. Office-commercial firms are able to pay less for labor since households are willing to trade lower wages for lower residential land rents to equalize utility to the exogenous uniform level. As a result, the number of demanded workers in city j by each office-commercial firm is higher in the new equilibrium.

Impact of an increase in the stringency of residential zoning ($\overline{L}_{Hj}$)

On the other hand, a lower amount of land designated for residential development must be associated with higher residential land prices which require higher wages to keep a current household indifferent across locations. This leads firms to trade higher labor costs for lower office-commercial rents in order not to move. The decrease in office-commercial rents then decreases the price of office-commercial land.

From the combined analysis of $\overline{L}_{Fj}$ and $\overline{L}_{Hj}$, we notice that in the absence of externalities, reducing the amount of land allowed in a certain use raises the land price of that use but decreases the land price of the remaining land uses. In addition, the floor-space output associated with the restricted land use declines while its price rises and the floor-space output price associated with the unrestricted land use drops. Therefore, allowable use zoning affects land values differently across uses. On the other hand, an institutional constraint on production raises the floor-space output price associated with the restricted land use. However, and in contrast to the allowable use zoning, it affects land values equally across land uses.

5. The Empirical Model

5.1. Hedonic Analysis

The literature for quality-of-life amenities and quality-of-business amenities estimate reduced form equations of equilibrium wage and housing prices in order to explain how prices vary with amenity levels across cities. However, our main goal is to examine the determinants of intra-metropolitan variations in non-residential prices focusing on the role of local amenities. As such, we aim to estimate the reduce form (25) which includes not only quality-of-life amenities but also productive amenities and local institutional restrictions as well as a herd behavior around neighboring property prices where price expectations are formed based on neighboring values.

Given its multimodal structure, heterogeneity across nodes, surrounding jurisdictions and environmental amenities, Los Angeles County provides an appropriate spatial setting to illustrate the theory developed in session 3. Before describing in some detail the datasets and the variables used in our empirical exercise, the specific empirical formulation, which builds on the theoretical formulation in (25) and accounts for the spatial nature of the data available, is discussed. Our model for the hedonic regressions follows

$$LP_{it} = \beta_0 + \alpha G_i + \beta N_i + \chi W_i + \delta X_i + \sum_{t=1}^{T} \gamma_t Y_t + \varepsilon_i \ . \tag{27}$$

In (27) LP_{it} represents the natural logarithm of the sale price of property i in year t, $t = 1997 - 2005$. G_i is a vector of green amenities. N_i is a vector of nearby amenities and controls. W_i is a vector of workforce characteristics. X_i is a vector of building characteristics and Y_t is a dummy variable indicating the year the property was sold. The model given by (27) is our baseline model to which we compare the spatial specifications.

5.2. Spatial Analysis of Non-Residential Property Values

Our theoretical model reveals that spatial autocorrelation of a property price may result from a herd behavior around neighboring property prices where price expectations are formed based on neighboring values. This herd effect from comparable sales prices then leads to the spatial lag model where a spatially lagged dependent variable (spatially weighted neighboring prices) helps to explain the determination of property prices.

There are nevertheless two other sources of spatially correlated property prices: common omitted explanatory variable(s) and measurement error(s). The location of a property influences its selling price but nearby properties will also be affected by the same location factors. Since the inclusion of all relevant attributes is seldom fulfilled and the effects of all omitted variables are subsumed into the error term, if the omitted variables are spatially correlated, so are the regression errors. A measurement error that affects nearby properties will result in spatially correlated errors in a similar way. Both of them lead to the specification of spatial error model.

Therefore, if property prices are spatially correlated, either in their levels or in the errors, then simple OLS regression can give spurious results. Spatial econometrics explicitly accounts for the influence of space in real estate and urban models.

5.3. Our Empirical Strategy

Our goal for this paper is to establish whether there are robust associations between various local amenities and the prices of non-residential properties. We aim to investigate whether there are durable associations or whether the amenity variables are simply capturing local unobservables. To this end we run specifications with a number of different sets of controls and combinations of variables and examine whether there are significant changes in sign and magnitude of the key coefficients.

The properties are classified into several broad property types including offices, industrial properties, and two types of retail. We hypothesize that office properties should be more sensitive to green, and neighborhood amenities because high-skill workers have been shown to have greater taste for these amenities. Production amenities are more mixed. The concentration of high skill workers should have a positive impact on office prices, but an unknown impact of industrial and retail prices. Other amenities such as rail access, freeway access, or airport proximity may have impacts on all property types. Differences in amenity value between the different property types are a signal that the regressions are capturing correlations between amenities and prices.

Studies focused on characteristics of the property or structure, such as an environmental label, can use a fixed effects strategy, however, fixed effects will eliminate the influence of the amenities we wish to examine. Nearby properties are likely to have similar unobservable characteristics and spatial regression controls for these. We use a spatial method that allows for both spatial autocorrelation and spatial lag. That is, the specification allows for the errors and the dependent variable to be correlated across nearby observations.

Spatial Models

Spatial methods have been used sparingly in the non-residential real estate literature, and to our knowledge they have never been used to examine the relationship between amenities and non-residential real estate prices. The specification is the same as in (27) except:

$$\varepsilon = \lambda W_1 LP + \rho W_2 e + u \tag{28}$$

where λ measures the degree of spatial autocorrelation, W_1 is a weighting matrix, *LP* is the vector of property prices, ρ is a scalar measuring the degree of spatial error correlation, W_2 is another (possibly distinct) weighting matrix, and e and u are i.i.d disturbances.[10]

[10] In order to test the robustness of our results to alternative specifications of our k-nearest neighbor matrix, we computed different matrices on the basis of the 8^{th}, 10^{th}, 15^{th} and 30^{th} closest neighbor criteria. While our coefficient estimates aren't much different between the runs, the spatial dependence declines with the increasing number of nearest neighbors taken into account. Our final runs are at 10 but with a mile cutoff, which only affects a few properties but avoided some clusters where properties are very far apart.

Using the weights matrix, the lag operator $W_1 LP$ captures the spatially weighted average of the variable of interest in a given location. This is analogous to our theoretical term $[P_{-j,t}]$ in equation (25). Thus, the spatial variable captures the impact of the neighboring unit valuations on the transaction price of a property. One of the innovative features of our spatial model is the construction of an integrated spatio-temporal weights matrix, following the methodology of Dube and Legros (2013, 2015). This spatio-temporal weights matrix allows us to incorporate the temporal dimension of the data generating process of spatial data pooled over time.

Spatio-Temporal Weights Matrices (W_1 and W_2)

Typical spatial econometric methods ignore the influence of time on spatial dependence. However, with data over eight years the assumption that there is no temporal dimension to spatial autocorrelation is unlikely to be true. For instance, it is unlikely to be either spatial or error correlation with a property that is sold several years in the future.

Following Dube and Legros (2013, 2015), we can obtain the spatio-temporal weights matrix (W) by separating its construction into a spatial (S) and temporal (T) weighting matrices. While S uses an inverse Euclidean distance function to determine the impact of neighboring transactions based on geographical proximity and a critical cut-off miles distance, T takes temporal dependence through an inverse function of the time elapsed between realization of two transactions with cut-offs memory effects for both future and past transactions. In particular, each element $t_{i,j}$ of the temporal matrix T is given by:

$$t_{i,j} = \begin{cases} (v_i - v_j)^{-g} \text{ if } v_i - v_j \leq \overline{v}_p ;\text{"}\ i \neq j \text{ and } v_i > v_j \\ \left| v_i - v_j \right|^{-g} \text{ if } v_i - v_j \leq \overline{v}_f ;\text{"}\ i \neq j \text{ and } v_i < v_j \\ 1 \text{ if } v_i = v_j \\ 0 \text{ otherwise} \end{cases} \tag{29}$$

where v_i and v_j are the time (quarterly values in our case) when properties i and j are sold respectively, $\overline{v}_p$ is a cut-off value for past transactions (sales), $\overline{v}_f$ is a cut-off value for future transactions, and γ is a parameter that determines how fast observations fade in importance as the distance in time increases (time fade parameter). We test different values for these parameters with our data. Since the transactions are ordered chronologically, the lower triangular matrix of T contains actual and past transactions, while the upper triangular matrix contains actual and future transactions. Finally, to incorporate the simultaneity of both spatial and temporal relations, we multiply, term by term, the two developed relations matrices S and T, resulting in our spatio-temporal matrix $W = S \otimes T$, with $\otimes$ the Hadamard matricial product. We also examined a variety of spatial and temporal weight matrices for both the error and spatial lag.

If λ is significant, then the non-spatial estimate will generally be biased. Therefore, it is important to test for spatial autocorrelation. Not accounting for spatial error correlation does not bias coefficients, but does result in inefficient estimation. We also examined results across property types and with different sets of local controls in the spatial framework. If coefficients on amenities in the spatial regressions are significant in the expected direction and differ across property types in expected ways, then that is evidence that the amenity coefficients are capturing a real association as opposed to capturing local unobservables.

5.4. Data and Variables

Parcel-level data on non-residential property sales from 1996 through 2005 over a significant portion of Los Angeles County was obtained through Costar Group, a national commercial real estate information provider (www.costar.com). After removing several types of parcels not suitable for the analysis and data with missing variables we were left with 13,370 observations.[11] The database contains the sales price of each property and a vector of structural characteristics (such as building coverage, permeable area, building square footage, and parking lot spaces, and property code).

The initial database assigned each observation as one of three general land use types: industrial, office or retail. We divide properties into 4 classes of non-residential use: (1) industrial, which includes manufacturing, warehouse, and other industrial uses; (2) Office properties; (3) service retail, which includes banks, restaurants, various services businesses such as doctor's offices, and auto related services; and, (4) mixed and shopping retail, the last includes many small shopping centers with shopping as well as some service retail storefronts (see Table 3 in the Appendix).[12]

Our variables come from many different data sets. Tables 4 and 5 in the Appendix detail the variables and show the summary statistics, respectively.

We look at several types of green amenities including air quality, proximity to parks, wilderness, and shore, weather, and shore proximity. For air quality, we found that the average level of pollutants is very similar across all areas of the county. The main difference is in the right tails of the distribution

[11] We removed several types of parcels which were not suitable for the analysis, namely parking, public facilities, residential, heavy industrial, industrial park, pleasure retail, retail-residential, retail-office, hi-rise-office. We also removed categories where there were few observations and where it was not clear how to group them with other categories. Also, we dropped observations from 1996 because there were few observations. We also dropped any repeat sales which were just a few observations to begin with.

[12] Light industrial and industrial were combined into industrial and office-residential, office-industrial and lo-rise office into the office category. Dummy variables for these subcategories are included in all specifications.

where unhealthy levels of pollutants occur. Because of this we looked at the 90th and 95th percentiles of the pollutant distribution as an indication of how often there are unhealthy levels of pollutants. We found that many of the pollution variables are highly correlated with the Ozone 1-hour measures. We use the 90th percentile of Ozone (translated to the Air Quality Index (AQI)) *Ozone1_90* as an indicator for high levels of several air pollutants. In addition, to capture measures of air pollution that may be more accessible to the public, we use the number of days above 100 AQI, the level at which air quality is unhealthy. [13]

Weather and temperature are another key green amenity. Our data includes monthly averages for six different meteorological measures (cooling degree days, heating degree days, maximum temperature, minimum temperature, precipitation, and relative humidity). We decided to use principal component analysis because of the large number of variables and the high degree of correlation. Our analysis showed that two principal components (*weathf1 weathf2)* capture almost all of the variation from these variables and so we use the two principal components as our controls for weather.

We also examine proximity to various green features including parks, wilderness, golf courses, and the shore. Manual inspection of the data indicates that only very nearby parks and wilderness are accessible or visible from the property. We use as a variable an indicator of whether parks or golf courses are within .2 miles of the property (respectively *regpars20* and *golf20*). For wilderness, there are few properties within a short distance so we use an indicator of one mile or less distance, *wild01*. Shore proximity is different as employees may value being close to shore even if it is not immediately accessible. We use a quadratic in distance to the closest shore to capture this amenity. The linear distance to the shore is *d_sea* and the *quadratic d_sea2.*

Zoning designation is thought to be important to building value (Sivitanidou 1995). We obtained zoning maps of each city and then used GIS to map each property to the cities' zoning areas. Cities use a variety of different zoning names (there were over 150 in total for all properties), however the zoning designation usually allow one or of the following uses: commercial, industrial, office, residential, mixed use, and special downtown zone.[14] We created indicator variables for each of these uses and categorized

[13] The AQI is an index that tells how clean or polluted the air is, and what associated health effects might be. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act (ground-level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide). An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy at first for certain sensitive groups of people, then for everyone as AQI values get higher.

[14] The zoning designations frequently distinguish between the types of industrial activity, but the descriptions are not adequate to distinguish types so we lumped all industrial zoning designation together. We also categorized any manufacturing as an industrial zone. In addition, there are a variety of residential zones, but we in our data there are few properties in any one zone so we grouped all residential properties together.

the zone by each permissible use in the zoning designation. So, for example, a zone whose description says that both commercial and industrial uses are permissible would get a one for each use.

Neighborhood amenities such as availability of shopping and retail, distance to highways, distance to airports, distance to business districts, crime levels and rail access are also included in our model. A property with access to these amenities might be more valuable because of its ability to attract skilled workers, customers, or boost productivity. Much of the previous literature has emphasized the value of shopping and restaurant amenities to skilled workers (see for example Diamond 2012 or Albouy 2012). Our measures of retail amenities are employment in shopping (*empl_shop*) and employment in food and drinking establishments (*empl_rest*).

Public safety is another amenity that is likely to be important. We obtained crime data from the proprietary CAP index that is used by many companies and real estate professionals to evaluate the safety of a potential real estate purchase. This index uses crime reports to estimate the crime level (likelihood of murders, robberies, burglary, aggravated assault, larceny and auto theft) in a given area relative to the nation as a whole. They work on a disaggregated level and were able to show the crime index at ½ mile grid points through all of Los Angeles County. We then matched the properties to the nearest grid point to make the *cr2000* variable.

Rail access is measured in the COSTAR data (*rail)*. Finally, we use quadratics in measures of distance to freeways and business districts to capture changing marginal effects.

We also use neighborhood controls to partially control for local unobservables. The nature of agglomeration economies makes it difficult to determine whether coefficients are biased because of correlation with the overall density of business activity in an area. For example, an area with pleasant climate and air quality could have built up a concentration of activity in, for example finance or entertainment. That concentration of activity could bias the coefficients if not controlled for. We use several variables to control for these effects. One control is *Density,* the ratio of non-residential built square feet to land in the immediate vicinity of the property. We also use total employment in the zip code as a control (*emp*). Also, the median house price in the property's zip code in the sale month (*DQhouseprice*) controls for the intrinsic desirability of the area. This variable is meant to capture other unobservables that are not in our green or neighborhood amenities.

In addition, we use the distance to key points as controls. We use Principal Components Analysis (PCA) to reduce the dimensionality of the data for the business districts of downtown Los Angeles, Century City, Sherman Oaks, and Santa Monica as well as distances to airports and ports. These districts are close to each other, and moving closer to one usually means moving farther from the others. We use four principal components that better reflect the multi-dimensional nature of the distances to these business districts (*distances1*-*distances4*).

Our workforce variable is the number of adults with college degrees in the commute area (*bachhigh*). A key idea in the urban specialization literature is that a high concentration of skilled workers leads to increasing productivity per worker because of the ability to share knowledge and ideas. We use the number of such workers within average commuting distance to measure this effect.[15] This workforce measure likely pertains more to firms that demand college-educated workers, such as offices and perhaps general retail, and less to service retail and industrial properties.

6. Empirical Results

Non-Spatial Results

We first turn to the OLS results. For the OLS model as a whole, the explanatory power is satisfactory with R squared in the .7 to .8 range.

Los Angeles County is a large market area with a wide variety of geographical areas and amenities. One striking feature of our data is that in our sample of sold properties, the industrial properties have a quite different geographical distribution than office properties. They tend to be located in the east and south of Los Angeles county, areas that are less affluent and have less pleasant weather.

Table 6 shows an OLS regression of property prices on just structural variables. It reveals that, controlling for building structural characteristics and year sold, industrial properties are worth significantly less than other properties. In this regression, the intercept and building and lot square footage are dummied out by property type.

Industrial properties are the base category and we see that the office intercept is $120,000 and, the other intercepts are large and statistically significant. Also, the coefficient on building floor area is much larger for general retail and office properties and statistically significantly different from industrial properties. Finally, the coefficients on property area are larger than that for industrial and the differences are statistically significant. For a building of 13,000 square feet (near the mean) this suggests that switching from industrial to office adds approximately $575,000.

A number of factors could account for this premium such as differences in structural characteristics that are not controlled for. However, differences in the amenities we include in this paper could also account for a portion of the value difference. This opens up the further possibility that selection effects could dampen the effect of amenities within property categories.

The rest of this section is organized as follows. Subsection 6.1 explores whether spatial methods are necessary with this data. Our results suggest that spatial methods are necessary, so we conduct the rest

[15] According to the 2010 Census, the average work commute for residents in Los Angeles County is 30 minutes. We use GIS to find all census block groups within a 30 minutes' drive of a property. Then, we calculate measures of income, education, and racial demographics within this area.

of the analysis using these methods. Section 6.2 discusses whether different property types differ in the marginal values of property characteristics and amenities. Section 6.3 explores whether neighborhood amenities appear to be significantly correlated with property prices.

We examine three main sets of specifications in order to examine the influence of amenities: (i) structural variables only; (ii) a specification with a thorough set of controls, and (iii) a specification with a parsimonious set of controls and amenity variables. Each set of specifications includes a separate regression for each property type. These specifications are difficult to parse in one large table because they have a large number of variables and it is helpful to compare different sets of regressions side-by-side. Therefore, we present portions of the regressions in the tables. Full results can, nevertheless, be obtained from the authors upon request.

Table 7 presents tests for spatial auto-correlation with both spatial and spatio-temporal weights matrices. Table 8 focuses on the spatial parameters estimates as well as on the spatial estimates of our neighborhood variables by property type. Table 9 presents the summary of the spatial estimation results for our structural characteristics. Table 10 presents elasticity estimates for important variables. Table 11 compared amenity coefficient estimates across estimators and property types.

6.1. Are Spatial Regressions Necessary?

We begin by examining the standard spatial tests (Moran's I, Likelihood ratio test, and Wald test) for autocorrelation in the observables. The results are presented in table 7 in the Appendix. We examine specifications with a basic and a full set of controls, and with just spatial and spatio-temporal weight matrices. All combinations of weight matrices, control sets, and property types show highly significant positive spatial correlation. Two findings are worth mentioning. First, it is interesting that the specifications with full sets of controls reduce the degree of spatial correlation. However, there is still substantial autocorrelation even after including all controls. Second, the Moran´s I index is lower, though still quite significant, when the spatio-temporal weight matrix is used as compared with the strictly spatial weights matrix. Thus, considering the spatial dimension alone when data have temporal dimension can lead to the overestimation of spatial dependence.

Our next goal was to examine the λ spatial autocorrelation and ρ spatial error correlation parameters (see table 7- Appendix). However, we first selected our spatio-temporal weight matrix by conducting a grid search over: the time cut-off past and future ($\overline{v}_p$ and $\overline{v}_f$) and; the time fade parameter γ, and ; the number of nearest spatial neighbors. We used the AIC as the criterion for selection. We found that a tight time window of four quarters in the past and one in the future, an quadratic inverse time fade (that is, γ set to 2), and 10 nearest neighbors resulted in minimum or close to minimum AIC values for all combinations of property types and specifications. When we present spatial (as opposed to spatio-temporal) results we use a squared inverse distance weight matrix with 10 nearest neighbors. Table 8 shows that the spatio-temporal model with a spatial error but no spatial lag has generally lower (better) AICs than OLS, OLS with fixed effects or other spatial models.[16] Also, the preferred model is preferred on AIC to the specification with a full list of variables. The exception is industrial properties with either the preferred or the full set of controls- where OLS has superior AICs.

We examine the spatial autocorrelation and spatial error correlation parameters with the spatio-temporal weight matrices in Table 9. The spatial lag coefficient is never significant at the 5% level and is in all cases quite small. Our data, with the proper spatio-temporal weight matrix, does not appear to show any spatial lag. This seems to suggest that, even though there can be theoretical reasons to include a spatial lag in hedonic pricing models for non-residential properties, they do not seem to add much value.[17]

In contrast, all of our results show very strong spatial error correlation at any conventional significance level. The degree of spatial error correlation varies across specifications and property types and is generally quite a bit lower in the specification with more controls. This indicates that the neighborhood and amenity controls do account for some of the spatially-correlated unobservables. In addition, the spatial alone (no temporal aspect) find much higher spatial error correlation-this suggests that a lack of temporal weighting can exaggerate spatial parameters.

Are the Property Types Different?

Table 10 presents the different coefficients on structural characteristics for the preferred spatial weight matrix and the structural only and preferred specification. In the next section, we examine the differences between OLS, fixed effects, and spatial econometric approaches.

We use the same specification as in Cutter and Franco (2012) where we include the interaction between the property square feet and the building square footage (*logparkxlogbldg)* in addition to the linear terms in order to capture possible complementarity between parking and building size. Examining

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[16] The exception is industrial properties with the full or preferred set of controls. OLS with fixed effects seems to perform much better than the other specifications. Further research should explore whether different sets of controls might perform better for industrial properties.

[17] Chegut et al. (2015) also find very small spatial and spatial-temporal dependence parameters for the London, Paris, Frankfurt, New York and Los Angeles office markets for 2007-2013. In the case of Los Angeles, the spatial and spatial-temporal estimates were also not statistically significant. A possible explanation, presented by the authors, for their results is the fact that their sample covered the global financial crisis period, which started in the US at end of 2007. During unstable periods such as that of the recent financial crisis, markets are more volatile and, for that reason, information spillover from nearby transactions may cease to be important in these circumstances. It should be mentioned, nevertheless, that in contrast to our study, the authors have a panel data and they apply a spatial autoregressive (SAR) and a spatial-temporal autoregressive (STAR) model with added controls for spatial dependence in the error term (AR).

the preferred specifications first, we can see that for all property types, the coefficient on *lpcsqft* and *logbldg* are significant at the 1% level and positive. The coefficients on *logpark* and *logparkxlogbldg* are significant at the 1% level for all property types except for service retail. Because of the non-linearities in the specification it is necessary to compare elasticities rather than coefficients.

Table 11 panel A shows that elasticities for building size are also quite different. Looking at the preferred specification with a spatio-temporal econometric approach (OLS or fixed-effects estimates are similar) we see that the office elasticity for building size is almost twice the service retail size. We also observe large differences in the degree of spatial auto-correlation. In the preferred controls model (almost identical in the preferred specification) the service retail properties show less than half the spatial autocorrelation as the industrial properties. These results support our decision to divide properties into different categories.[18]

OLS versus Spatial Regressions

Table 10 compares the elasticities of several amenities and key structural characteristics between five sets of predicted elasticities: OLS with the structural only, preferred specification and fixed effects and the spatial error regression with the structural only and preferred specification.[19] We use a city by zip code fixed effect (a zip code in two different cities is broken into two fixed effects).

Table 10-Panel A compares the elasticities of the key structural characteristics. One key finding across all the specification is that, with the addition of the neighborhood and amenity controls or fixed effects, the elasticity of the lot size increases substantially and that of the parcel size decreases substantially. Next, the OLS, fixed effect, and spatial error elasticities in the preferred specifications are very close. Last, the spatial error with structural only control specification has elasticities that are about midway between the OLS structural controls and the preferred specification (for either OLS or spatial). Our results thus seem to suggest that controlling for spatially-correlated unobservables controls for some of the neighborhood and amenity variables that are included in the preferred specifications. In addition, it appears that controlling for neighborhood and amenity effects corrects for biases in the structural coefficients in much the same manner as low-level fixed effects. This finding echoes that of the Kuminoff et al. (2010) analysis of econometric approaches to residential hedonics. The authors find that fixed effects do a better job of controlling for spatial factors than spatial econometric approaches. Our findings are similar, it appears that if the researcher's primary interest concerns the value of the structural

[18] In addition, in our robustness tests we include zoning classification. The coefficients on different zones differ significantly depending on the property type.

[19] These are average elasticities calculated across the sample by adding 10% to the variable, and then calculated the percentage change in the predicted price.

characteristics of the building then a fixed-effects strategy is superior to spatial econometric approaches without controls and similar to OLS or spatial approaches with controls.

The amenity coefficients across the OLS and spatio-temporal approaches are quite similar as well (see Table 10-Panel B). Seventeen out of 24 calculated elasticities are within 10% of each other, and all coefficients are the same sign. However, there are several elasticities with economically-significant differences such college workforce availability in several of the property types and freeway distance in the industrial specifications.

6.2. Do the different property types differ in the marginal values of property characteristics and amenities?

Non-residential properties serve different purposes and have different workforces. Zoning serves to partition different types of non-residential properties into distinct areas, as well. We identify our properties by the use at the time of sale, which matches up well with how the property is zoned. Our hypothesis, stemming from the theoretical analysis of sessions 3 and 4, is that the marginal effect of amenities could be a function of the property type.

Theory outlines four different types of amenities: those that affect only households, those that affect only firms, those that affect firms positively and households negatively, and vice versa. Our theory predicts that these different types of amenities have both different effects and different mechanisms for their effects. Therefore, we discuss them in different sub-sections.

The first two categories of amenities are both predicted to lead to higher non-residential real estate prices. However, household amenities lead to higher prices by increasing workforce supply. Previous literature (see for example Arora et al. 2000, Hanson et al. 2003, Florida 2004 and Shapiro 2006) indicates that amenities such as higher air quality, culture and retail diversity are highly correlated with educated and high-skill workforce. Thus, the main way we examine this hypothesis is looking at the direct mechanism. We test whether a larger supply of skilled workers increases prices. Because we are controlling for this mechanism, the coefficients on amenities such as air quality should be understood as the direct effect on property prices after controlling for workforce effects.

The division of amenities into these categories depends on spatial scale. Some amenities, such as parks, are theoretically both household and firm amenities, but, if they are measured at a very local scale as in our data, will be firm-specific amenities. A park near an office building doesn't substantially affect park availability in the areas where the firm's potential workforce lives. And, again, we control for the workforce in the area, so the effects of a park through household amenities should be captured.

Table 12 shows the coefficients for amenities in our preferred specification for OLS, spatial our and spatio-temporal runs (the sign and significance are similar for the spatial only runs).

Joint Firm and Household Amenities

We classify air quality, coastal proximity, crime, and weather as joint amenities. All of these are significantly spatially correlated, so that households that live close to a firm likely enjoy similar amenities as the firm itself. The most significant green amenity in the Los Angeles area is coastal access. Note that in our regression we are controlling for weather and pollution as well as a number of other location factors, so the coastal access should mainly reflect the desirability of being close to the ocean. This bundles both the possibility of visiting the ocean and the psychic boost many people experience by simply being close to the ocean.

The coefficients on the distance to the sea (linear and quadratic terms) are significant at the 1% significance level for all properties and economically large, with the smallest elasticities at about -.54.[20] For weather, our first component *weath1*, mainly measures the temperature gradient in Los Angeles and other associated weather variables. The coefficient is negative and significant at the 1% level for industrial and general retail, it is insignificant for the other property types. This perhaps occurs because of comparatively large cooling costs. The second component, *weath2*, is highly correlated with precipitation, it is only significant for office properties and is quite small even in that case.

We tested both linear and quadratic specifications for the 90th percentile of ozone levels, *Ozone1_90*. The linear specification does not show a significant effect. The quadratic specification shows significant effects at the 1% for all property types in the preferred regression (the squared term is significant). The turnaround point for this variable is at around AQI =80 for all properties.

As expected, the coefficient on crime (*cr2000)* has a negative effect for some property types, it is significant at the 1% level for service retail and office properties. However, the coefficient for industrial properties is positive and significant. The crime effect is economically small, the absolute values of the elasticities are at about .07. This positive coefficient for industrial properties could be due to areas with high industrial use generating crime because the geography of warehouses and parking lots is crime friendly. Another possibility is that, in Los Angeles, the high value industrial area south of downtown is adjacent to Skid Row and that is at least partly responsible for the positive coefficient.[21] In unreported runs, we used Geographically Weighted Regression (GWR) to examine if there is spatial variability of

[20] The coefficients on the quadratic imply a negative marginal effect out to about 40 miles, which is at the 99th percentile of distance for our properties.

[21] The Skid Row of Los Angeles is a portion of the area in downtown Los Angeles with a large homeless population concentrated in a densely packed area of economic disadvantage. Skid Row is located east of the Financial District and the Historic Downtown Center, partially overlaying the core of the downtown Industrial District. This area of downtown L.A. had high rates of crime and victimization, including open-air drug markets, prostitution, theft, robbery gangs, and vandalism. As an attempt to combat rising levels of crime and improve public order in the Skid Row area, the Los Angeles Police Department implemented in 2005 the Safer City Initiative.

the marginal effect of crime in industrial properties. This analysis shows that positive marginal effects are strongest in metro LA (particularly the downtown industrial district that contains Skid Row) but also show up in other areas, such as the San Gabriel valley.

However, our theoretical results from Table 1- section 4 can also offer an explanation for this counterintuitive effect of crime on industrial property values. According to our empirical results, crime seems to be an example of an amenity that affects positively industrial firms but it is a disamenity for households. As a result, the negative effect of crime on households' utility reinforces the impact on wages, but offsets the effects on industrial property rents and on residential land prices. On the other hand, for commercial, retail and office properties, crime seems to affect negatively both firms and households. In this case, our theoretical results of table 1 suggest that crime should be negatively (rather than positively) correlated with commercial-office-retail rents in areas with high crime levels.[22]

Firm Specific Amenities

The influence of a skilled workforce on firm location is the focus of related research and a key mechanism through which amenities may affect non-residential property prices. The coefficient on *bachorhigh* is positive and significant at the 1% level for office properties and insignificant for industrial properties. For offices it is economically large as well; the elasticity is .34. The effect for industrial properties is quite small, an elasticity of -.03. This accords with our reasoning, and prior literature, that a skilled workforce is likely to be particularly important for firms that locate in office properties.

We classify our various measures of open space proximity as firm-specific amenities because they are local to the firms. We only include our measure of golf course access (*golf20)* because the others are insignificant in most of our specifications. *golf20* is positive and significant at the 1% level for offices in the OLS run only. Our evidence suggests that other open space is not correlated with commercial property prices. However, our parks and open space data is crude. We measure proximity but not access. Google earth inspection of many properties that are close to parks shows that even very nearby properties can have difficult access because of highways, railroads, and other infrastructure. Therefore, further research should examine more refined data on actual park access.

We hypothesized that proximity to freeways would be positively associated with property values for ease of access. Industrial properties have significant coefficients on the linear and quadratic terms that

[22] Industrial and commercial-office-retail businesses use different types of workers. In particular lower skill labor is an input more in demand for industrial use compared to the other non-residential uses. While lower skill workers may find areas with low crime levels desirable, they may also be less willing to pay high housing costs, leading them to choose more affordable locations. If such locations overlap with industrial districts, then wages do not need to be as high to attract this type of labor. This in turn can lead to higher industrial rents and values and also higher industrial land prices within these high crime areas.

imply closer proximity is associated with higher values out to about .6 miles. This is intuitive as freeways are likely to be important for goods movement. However, coefficients on the freeway highway distance terms for office and general retail properties are positive and significant at the 1% level. Greater distance from freeways is associated with higher property values for these types of properties. Since there are clear access advantages to freeway proximity, this result is consistent with the hypothesis that freeways have a negative amenity value for some types of properties. Since freeways are largely old and therefore exogenous, this is a convincing amenity result.

Our *empl5* variable measures the concentration of entertainment option in the zip code surrounding a property. This is conceivably both a household and a firm-specific variable, but since we are measuring the variable at a small geographic scale we posit that entertainment density near a firm is not likely to be highly correlated with entertainment options in the surrounding housing market. We find a positive and significant coefficient for *empl5* across all specifications. The implied elasticities are highest for the general retail category (.16) and lower for offices (.09) and industrial (.05). This result accords and strengthens Diamonds (2012) findings that the amenities such as a strong entertainment are particularly attractive to a skilled workforce.

Robustness Tests

We use OLS to examine several different slices of the data and different sets of controls to analyze the robustness of our results. First, our comparison of various spatial and OLS results above is one robustness test. Then, we examine results with a very thorough set of controls that intend to capture the general desirability of an area (employment, density, and land value) as well as zoning measures. Next, in our preferred specification we divide the sample in half by time period (1997-2001, 2002-2005). Finally we look only at buildings in excellent condition (class A) where there is little danger that the property is being sold as a teardown or conversion to other use.

The desirability measures are intended to catch attributes of areas that are otherwise unobservable such as historical factors or transit availability that is not captured in our measures. It is likely that they overcontrol for our amenities because an area could be dense or have high residential property values particularly because of the amenities in the area. For example, zoning could well be influenced by the type of amenities in the area (industrial zones next to major transportation arteries, for example). We use density, overall employment, an indicator for the Los Angeles Downtown CBD, the estimated parking in the area, the log of commercial land value in a 1/3 of a mile radius, and the zoning classification of the properties in the extended controls robustness test. We find that the coefficients on these variables individually are significant in the expected direction. House prices, employment and density all have positive and highly significant coefficients, except employment is not significant for the two retail categories. Zoning is as expected, commercial and mixed zones have positive coefficients while industrial zones are negatively associated with property prices.

These results are too long to report in the main paper. They are included in the reviewers' appendix. Some coefficients on amenities are very robust across all of these robustness tests. The main structural variables (*lpcsqft, logpark, logbldg,* and the interaction term) are significant across most specifications. The exception is the parking variable an interaction for office properties, which has a similar sign but loses significance in the split time period and A class only runs.

The coefficients on our variables for air quality, distance from the ocean, entertainment, and freeway distance generally maintain their significance across all of these robustness checks.[23] In addition, the first weather component is robust in the sense that it is only has significance for industrial properties across all specifications.

The coefficients on our crime and workforce variables are somewhat more sensitive to specifications. The coefficient on *cr2000* maintain their significance and magnitude for industrial properties. However, for service retail and offices there is a loss of significance in the earlier period. This could be due to the crime variable coming from year 2000 data, toward the end of the earlier period. The coefficient on the workforce variable, *bachhigh*, also loses significance in the earlier period data for offices, but has the same magnitude and sign. Our result on golf course proximity is not robust. It is not significant for the best condition properties nor for the latter period.

7. Conclusions

This paper fills a gap in the literature by constructing an analytical model of the determinants of non-residential property prices and then testing that model with a spatial econometric model that includes both property characteristics and spatial amenities. In contrast to the housing literature, there are few papers that explicitly construct analytic and empirical hedonic models for non-residential properties and this paper is the first step toward closing that gap.

Our analytical framework suggests that long-run office-commercial space rents must be a function of firm production amenities, household/worker amenities, legal restrictions on the production of office-commercial space, as well as land supply influences. It also provides a rigorous theoretical foundation for variable choice in our empirical model of non-residential prices. The empirical modeling tested both the economic and statistical significance of including spatial dependence, temporal dependence, and auto-correlation in the hedonic model. We find that spatio-temporal models with a narrow time window and fast time fade perform better on AIC criteria than either OLS or other spatial models. We found that

[23] The exceptions are the freeway distance for general retail has about the same size coefficient but loses significance for the early period run.

the spatial autocorrelation parameters were significant. However, the spatial lag coefficients are not significant in our spatio-temporal models.

The theory developed in this paper discussed two different channels whereby amenities could affect non-residential property values. One is a direct channel, that amenities make a given location more productive. The other is indirect, that amenities may attract a high-skilled workforce. Our empirical results are consistent with the effects from both channels. Even after controlling for the quantity of high-skilled labor, a number of amenities such as infrastructure access, distance to the coast, weather, and air quality are correlated with non-residential property values. Property values for offices are also highly correlated with the quantity of skilled labor and is one of the larger elasticity estimates (only coastal distance has a larger magnitude).

The differences in coefficient estimates and elasticities are consistent with our estimates capturing something about the productivity of a location for a business activity, and not simply underlying land values. Skilled labor is highly correlated with office prices but small and insignificant for industrial properties, which are likely not dependent on a college-educated workforce. Freeway distance is positively correlated with office property prices and negatively correlated with industrial property prices. Distance to the sea matters most for offices, where it might attract skilled workers and please customers, and has a smaller impact in the other property categories.

The combination of these two findings suggests that the city productivity literature should consider more complex mechanisms for the spiraling productivity found in cities such as New York and San Francisco. It is not simply the aggregation of skilled labor that drives firm location. Our results suggest that amenities may also make certain locations more productive even controlling for skilled labor.

We also find that most amenity coefficients are similar between OLS and spatio-temporal models. In addition, OLS models with zip code by city fixed effects yield similar coefficients on property structural characteristics (floor space, lot size and so on.). OLS models without fixed effects or amenities variables yield very different coefficients on structural characteristics than spatial or fixed effects models. However, spatial models that do not consider temporal effects produce different coefficient estimates for the amenities. Our results suggest that if researchers are only interested in the coefficients of structural characteristics then OLS with fixed effects is the best combination of computational cost and unbiasedness. However, low-level fixed effects control for amenities and so cannot answer the questions about the importance of amenities. For researchers interested in amenities the spatio-temporal model is slightly preferred to an OLS model but both seem much better than a spatial model that does not consider temporal effects.

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Appendix

1. **Derivation of the effects of a change in A_H on non-residential and residential land rents, number of non-residential firms, wages, non-residential rental prices and number of households/workers.**

The effects of a marginal change in A_H are derived by taking the total differential of the system of equations defined by (4), (10), (12), (13) and (14) and then solving the resulting system of equations for $\frac{dR^*}{dA_H}$, $\frac{dw^*}{dA_H}$ $\frac{dP_F^*}{dA_H}$ $\frac{dP_H^*}{dA_H}$ and $\frac{dF^*}{dA_H}$. The differential system is represented as follows:

$$\theta_w \frac{dw}{dA_H} + \theta_{P_H} \frac{dP_H}{dA_H} = -1 \tag{A1}$$

$$\phi_w \frac{dw}{dA_H} + \phi_R \frac{dR}{dA_H} = 0 \tag{A2}$$

$$\frac{dR}{dA_H} = \delta_{P_F} \frac{dP_F}{dA_H} G \tag{A3}$$

$$F\alpha S_w \frac{dw}{dA_H} + F\left[\alpha S_R \delta_{P_F} G + S\alpha_{P_F}\right]\frac{dP_F}{dA_H} + S\alpha \frac{dF}{dA_H} = 0 \tag{A4}$$

$$\left[N_w h + Nh_w\right]\frac{dw}{dA_H} + FNh_{P_H} \frac{dP_H}{dA_H} + FhN_R\delta_{P_F} G \frac{dP_F}{dA_H} + Nh\frac{dF}{dA_H} = 0. \tag{A5}$$

Substituting (A3) into (A2), the system can then be written in matrix form as

$$\begin{bmatrix} a & b & 0 & 0 \\ c & 0 & d & 0 \\ e & 0 & f & g \\ t & l & m & n \end{bmatrix} \begin{bmatrix} \frac{dw}{dA_H} \\ \frac{dP_H}{dA_H} \\ \frac{dP_F}{dA_H} \\ \frac{dF}{dA_H} \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{A6}$$

where

$a = \theta_w > 0$, $b = \theta_{P_H} < 0$, $c = \phi_w > 0$, $d = \phi_R \delta_{P_F} G > 0$, $e = F\alpha S_w > 0$, $f = F(\alpha S_R \delta_{P_F} G + S\alpha_{P_F}) < 0$, $g = S\alpha$, $l = FNh_{P_H} < 0$, $m = FhN_R\delta_{P_F} G > 0$, $n = Nh$ and $t = (N_w h + Nh_w)F < 0$ if $\left|\frac{\partial N}{\partial w}\right| \frac{w}{N} < \frac{\partial h}{\partial w}\frac{w}{h}$.
Note that N represents the number of workers while h represents the quantity of land demanded by an household. Thus, $\left|\frac{\partial N}{\partial w}\right|$ captures the wage-induced effect on local labor demand while $\frac{\partial h}{\partial w}$ captures the wage-induced effect on local residential land demanded and also the wage-induced effect on local labor

supply. The reason is because in equilibrium (i) the number of households must equal $\frac{\bar{L}_R}{h}$ and (ii) unemployment is zero, which implies that $\frac{\bar{L}_R}{h} = N$ must be satisfied, that is, local labor demand must equal local labor supply.[24] The determinant of matrix A, denoted as D, is equal to

$$\begin{aligned} D = {} & \theta_w \phi_R \delta_{P_F} GFNh_{p_H} S\alpha - \theta_{P_H} \phi_w \left[F(\alpha S_R \delta_{P_F} G + S\alpha_{P_F})Nh - S\alpha FhN_R \delta_{P_F} G \right] + \\ & + \theta_{P_H} \phi_R \delta_{P_F} GF\alpha \left[h(S_w N - SN_w) - SNh_w \right] \end{aligned} . \tag{A7}$$

The determinant define by (A7) is negative if $t = (N_w h + Nh_w)F < 0$ is satisfied. In our derivations, we assume that such condition is met. Applying the Cramer rule to (A6) while taking into account the sign of (A7) yields the comparative static results for the effects of A_H on our variables of interested as

$$\frac{dP_H}{dA_H} \frac{\phi_w \left[F(\alpha S_R \delta_{P_F} G + S\alpha_{P_F})Nh - S\alpha FhN_R \delta_{P_F} G \right] - \phi_R \delta_{P_F} GF\alpha \left[h(S_w N - SN_w) - SNh_w \right]}{D} > 0 \tag{A8}$$

$$\frac{dP_F}{dA_H} = \frac{\phi_w FNh_{p_H} S\alpha}{D} > 0 \tag{A9}$$

$$\frac{dR}{dA_H} = \delta_{P_F} G \frac{dP_F}{dA_H} > 0 \tag{A10}$$

$$\frac{dW}{dA_H} = -\frac{\phi_R \delta_{P_F} GFNh_{p_H} S\alpha}{D} < 0 \tag{A11}$$

Note also that (A11) can also be re-written as:

$$\frac{dW}{dA_H} = -\frac{\phi_R \delta_{P_F} G}{\phi_w} \frac{dP_F}{dA_H} < 0 \tag{A12}$$

$$\frac{dN}{dA_H} = N_w \frac{dW}{dA_H} + N_R \frac{dR}{dA_H} > 0 \tag{A13}$$

$$\frac{dF}{dA_H} = -\frac{\phi_w F^2 Nh_{p_H} \left[\alpha S_R \delta_{P_F} G + S\alpha_{P_F} \right]}{D} + \frac{\phi_R G^2 F^2 \delta_{p_F} S_w hN_R \delta_{P_F}}{D} \substack{> \\ <} 0 \; . \tag{A14}$$

All the derivatives (A8)-(A14) and (A7) are evaluated at the optimal solution. However, for a clear exposition of the results we have omitted the use of "*" to denote optimal values.

[24] This is similar to the Walrasian stability assumption made by Hoehn et al. (1987) and Blomquist et al. (1988) to determine the sign of the determinant of the matrix associated with their comparative statics analysis. The Walrasian stability assumption requires that the slope of the local demand curve is less than the slope of the local labor supply curve.

2. Tables and results related to the empirical part of the paper

Table 3: Property Type Summary.

Property Code	Obs(1997-2005)
Industrial	4,570
Service retail	1,756
General Retail	4,450
Office	2,944
Total	13,720

Table 4: Variable Definitions

Variable name	Definition
Dependent Variable	
lprice	Log of sale price
Amenities	
Wild	Within one mile of national forest, natural area, wilderness area, wildlife area.
regparks20	Within .2 miles of city or county park.
Golf20	Within .2 miles of Golf Course.
Ozone1_90	90th percentile of location's one hour maximum ozone concentration.
d_sea	Distance to the sea (miles.)
Crime2000	Crime Level relative to nation average in 2000 CAP Index.
dist_FH	Distance to a freeway (miles).
dist_lax	Distance to LAX (miles.)
dist_aer	Minimum distance to another airport that is not LAX (miles.)
weathf1	Weather Principal Component one (max temperature)
weathf2	Weather Principal Component two.(Cooling Degree Days)
busdistrict1	Principal Component one of distance to Downtwon/Westside Business Districts
busdistrict2	Principal Component two of distance to Downtwon/Westside Business Districts
pasa_chall	Distance to Pasadena City hall (miles.)
lbeach_chall	Distance to Long Beach City hall (miles.)
rail	Indicator that property has rail access.
Neighborhood Characteristics	
dens	Total non-residential building floor area per square foot land area - one-third mile radius.
DQprice	Median house value in zip code and year of sale.
Bachorhgh	Number of residents in commute distance with college degree
Empl2	Employment in retail clothing and acessories for establishments in the zip code.
Empl5	Employment ineating and drinking establishments in the zip code.
lpksup	Logged estimated density of parking in 1/3 mile radius (own excluded).
llandval	Logged assesor estimated land value in 1/3 mile radius (own excluded). (millions)
Property Characteristics	
pcsqft	Property area (square feet)
park	Parking area (square feet)
bldg	Building floor area (square feet)
age	Age of main building on property
cnloc	Corner location
Construction indicators	Categories are: concrete (base), brick, frame, mixed, other, missing
Condition indicators	Condition categories: A (base),E,F,G,P, missing.
Property categories	indicators for industrial (base), three retail types and office, for pooled specification only
Zoning	Zoning designation of property.
Year dummies	Indicators for each year of sale (year1997-year2005)
ltind	Indicator for light industrial (industrial property specification only)
looff	Low rise office indicator (office properties specification only)
offres	Office-residential dual use indicator (office properties specification only)

Table 5: Summary Statistics

Variable name	Mean	Max	Min	Sd	N
price	1,304,412	10,000,000	30,000	1,344,105	13720
Wild	0.0036443	1	0	0.0602603	13720
regparks20	0.1779155	1	0	0.3824555	13720
Golf20	0.0145773	1	0	0.1198575	13720
Ozone1_90	76.4844	102	61	13.24492	13720
d_sea	1.296832	3.4695	0.0019	0.77875	13720
Crime2000	0.3611474	1.549	0.012	0.2566138	13720
dist_FH	0.8832012	7.45	0	0.7664743	13720
dist_lax	13.41794	40.2	0	7.791542	13720
dist_aer	4.993686	11.04	0	2.811916	13720
pasa_chall	13.93006	30.99	0.146	6.226791	13720
lbeach_chall	19.16657	40.565	0.095	7.561001	13720
rail	0.1302478	1	0	0.3365881	13720
dens	0.1169399	3.910879	0.0000648	0.167363	13720
DQprice	2.986784	29.5	0.345	1.801611	13720
Bachorhgh	1.063911	687.2608	0.3474566	5.862765	13720
Empl2	0.1915189	2.195	0	0.3003017	13720
Empl5	0.1214615	0.6066	0.00025	0.0825936	13720
pksup	0.1190023	1.885106	0	0.0995173	13720
landval	573.4644	10062.58	3.45326	653.6841	13720
pcsqft	25042.37	152460	810.216	25537.77	13720
park	6896.611	192000	0	9984.349	13720
bldgflsqft	12807.19	100000	1000	14133.08	13720
age	41.96611	176	1	22.31281	13720
cnloc	0.1879738	1	0	0.3907055	13720
ltind (Industrial only)	0.0067834	1	0	0.0820904	4570
looff (office only)	0.670856	1	0	0.4699822	2944
offres (office only)	0.0427989	1	0	0.2024379	2944
respct (office only)	0.0000757	0.0008899	0	0.000073	2944
Construction indicators					
concrete	0.3908892	1	0	0.4879674	13720
brick	0.1550292	1	0	0.3619457	13720
frame	0.3366618	1	0	0.4725854	13720
mixed	0.0522595	1	0	0.2225579	13720
other	0.0349854	1	0	0.1837496	13720
missing	0.0301749	1	0	0.1710746	13720
Condition indicators					
A	0.7847668	1	0	0.410999	13720
E	0.0990525	1	0	0.2987434	13720
F	0.0888484	1	0	0.2845352	13720
G	0.0011662	1	0	0.0341307	13720
P	0.0083819	1	0	0.0911717	13720
missing	0.0189504	1	0	0.136355	13720

Table 6: Industrial Properties are Worth Less (OLS regression of Price on minimal characteristics)

Industrial Properties are Worth Less

	Dependent Variable=	Price					
	Observations	13,720					
	R-squared	1					
VARIABLES							
	(Industrial Base Category)						
propertycode		-	**Building Square Feet**	40.02***	**Lot Square Feet**	5.69***	
				[0.000]		[0.000]	
			Interacted Property Code:	3.50	*Interacted Property C*	8.18***	
	Service Retail	160,277.83***	Service Retail	[0.556]	Service Retail	[0.001]	
		[0.000]		35.54***		5.76***	
	Shopping/Mixed Retail	39,271.49	Shopping/Mixed Retail	[0.000]	Shopping/Mixed Retail	[0.002]	
		[0.210]		36.30***		5.12**	
	Offices	74,476.12**	Offices	[0.000]	Offices	[0.014]	
		[0.012]					
(year controls suppressed)							
	Constant	668,961.01***					
		[0.000]					

Robust pval in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Spatial and Spatio-Temporal Approaches Both Show Significant Autocorrelation.

Spatial Weight Matrix (no time adjustment)

Property Code	Tests for Spatial Autocorrelation* Moran's I (std)	Likelihood Ratio	Wald
Only Property-Level Controls			
Industrial	0.45	2264.88	183924.68
Service Retail	0.35	493.43	21458.60
Shopping/Mixed Retail	0.51	2595.20	254329.71
Office	0.49	1617.61	110519.40
Preferred Specification			
Industrial	0.27	781.26	51034.52
Service Retail	0.18	127.41	2788.56
Shopping/Mixed Retail	0.32	933.51	79022.72
Office	0.25	416.82	20658.39

* All tests reject the null of zero autocorellation at the 1% critical level

Spatio-Temporal Weight Matrix**

Property Code	Tests for Spatial Autocorrelation* Moran's I (std)	Likelihood Ratio	Wald
Only Property-Level Controls			
Industrial	0.43	1076.34	77997.24
Service Retail	0.29	180.07	2331.68
Shopping/Mixed Retail	0.44	1084.02	75210.27
Office	0.47	823.95	41416.16
Full Specification With All Control Variables			
Industrial	0.28	383.15	9179.32
Service Retail	0.13	30.10	70.05
Shopping/Mixed Retail	0.25	286.99	5153.61
Office	0.24	183.66	2127.96

* All tests reject the null of zero autocorellation at the 1% critical level

** Spatio Temporal Matrix has Nearest Neighbors 4 quarters/1 quarter

Table 8: AIC Scores Show The Spatio-Temporal Specifications Outperform OLS and Spatial-Only Specifications.

	OLS	OLS	Spatio-Temporal		Spatial
		Fixed effects	Lag + Error	Spatial Error	Spatial Error
Property Type					
Only Property-Level Controls					
Industrial	3,844	1,091	344	340	1,675
Service Retail	2,464	1,405	-993	-994	-659
Shopping/Mixed Retail	6,740	3,671	-2,643	-2,645	-985
Office	3,745	1,494	-900	-902	9
Full Specification With All Control Variables					
Industrial	1,749	1,452	1,876	1,875	2,264
Service Retail	1,858	1,382	-436	-437	-347
Shopping/Mixed Retail	4,548	3,567	-1,068	-1,070	-429
Office	2,136	1,433	230	229	475
Preferred Specification					
Industrial	1,889	711	1,788	1,787	2,231
Service Retail	1,899	1,407	-480	-480	-381
Shopping/Mixed Retail	4,657	3,593	-1,152	-1,155	-475
Office	2,186	1,451	196	195	451

Table 9: Spatial Parameters and Neighborhood Controls, Spatial Hedonic Regressions (Spatial Error and Spatial Dependence) by Property Type

Property Type:	Industrial			Service Retail			Shopping/Mixed Retail			Office		
Spatial only	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Temporal-Spatial	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N
Spatial Error	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Spatial Lag	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Structural Controls Only												
Parameters												
rho (Spatial Error Correlation)	0.416***	0.418***	0.756***	0.28***	0.281***	0.618***	0.42***	0.419***	0.752***	0.443***	0.441***	0.753***
	[77.401]	[34.76]	[112.884]	[21.423]	[16.953]	[212.53]	[58.384]	[35.126]	[71.916]	[67.848]	[30.557]	[69.032]
lambda (Spatial Lag)	-	-0.002	-		-0.002		-	0			0.002	
	-	[1.355]	-		[0.559]		-	[0.077]			[0.778]	
Observations												
Preferred Controls												
rho (Spatial Error Correlation)	0.243***	0.245***	0.549***	0.112***	0.113***	0.369***	0.205	0.112***	0.113***	0.209***	0.207***	0.5***
	[29.698]	[45.955]	[112.392]	[7.835]	[156.55]	[39.523]	[0]	[7.835]	[156.55]	[35.33]	[283.38]	[79.93]
lambda (Spatial Lag)	-	0.001	-	-	0	-	-		0		0.001	
	-	[0.509]	-	-	[0.002]	-	-		[0.002]		[0.587]	

*Robust t-statistics in parentheses.

Table 10: Structural Characteristics, Spatio-Temporal Hedonic Regressions by Property Type.

	Industrial		Service Retail		General Retail		Office	
	Structural	Preferred	Structural	Preferred	Structural	Preferred	Structural	Preferred
R2	0.82	0.85	0.61	0.69	0.61	0.77	0.82	0.86
AdjR2	0.81	0.85	0.60	0.68	0.60	0.77	0.82	0.86
LL	140.43	846.28	-524.03	-285.20	-524.03	-622.75	-481.13	49.51
N	4,570	4,570	1,756	1,756	4,450	4,450	2,944	2,944
lpcsqft	0.297***	0.378***	0.348***	0.462***	0.235***	0.336***	0.192***	0.284***
	[27.404]	[35.404]	[16.592]	[22.525]	[17.471]	[24.618]	[14.723]	[20.616]
logpark	-0.092***	-0.074***	-0.025	0.014	-0.078***	-0.064***	-0.092***	-0.045***
	[9.995]	[5.754]	[1.454]	[0.627]	[5.346]	[3.895]	[6.276]	[2.657]
logbldg	0.362***	0.327***	0.231***	0.223***	0.401***	0.382***	0.457***	0.443***
	[27.49]	[23.777]	[11.239]	[9.663]	[21.364]	[21.052]	[22.527]	[22.107]
logparkxlogbldg	0.01***	0.008***	0.003	-0.002	0.009***	0.007***	0.01***	0.005***
	[10.267]	[6.044]	[1.308]	[0.906]	[5.424]	[3.749]	[6.67]	[2.84]
lage	-0.097***	-0.133***	-0.128***	-0.142***	-0.162***	-0.174***	-0.1***	-0.121***
	[12.641]	[17.898]	[7.721]	[9.301]	[17.007]	[18.528]	[8.603]	[10.569]
floors	0.098***	0.085***	0.139***	0.14***	0.011	0.012	0.049***	0.058***
	[8.19]	[7.914]	[5.625]	[6.217]	[0.795]	[0.957]	[5.894]	[7.642]

* t-statistics in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Calculated Elasticities of Key Variables.

Panel A: Structural Characteristics

	OLS			Spatio-Temporal		Spatial
	Structural	Preferred	Fixed Effects	Structural	Preferred	Preferred
Industrial						
Lot Size	0.199	0.363	0.359	0.296	0.377	0.399
Building Size	0.481	0.391	0.405	0.431	0.383	0.370
Service Retail						
Lot Size	0.260	0.452	0.469	0.347	0.460	0.468
Building Size	0.287	0.210	0.198	0.250	0.204	0.200
General Retail						
Lot Size	0.103	0.323	0.337	0.234	0.334	0.371
Building Size	0.520	0.439	0.423	0.453	0.423	0.383
Office						
Lot Size	0.064	0.272	0.275	0.191	0.282	0.289
Building Size	0.603	0.489	0.493	0.533	0.480	0.476

Panel B: Calculated Elasticities of Some Amenities.

Controls:	OLS Preferred	Spatio-Temporal Preferred	Spatial Preferred
Industrial			
Crime	0.070	0.072	0.075
Sea Distance	-0.782	-0.798	-0.805
Freeway distance	-0.039	-0.040	-0.035
College Workforce	-0.026	-0.005	-0.108
Entertainment Employme	0.053	0.049	0.059
Air Quality (Ozone)	0.350	0.340	0.360
Service Retail			
Crime	-0.064	-0.060	-0.073
Sea Distance	-0.549	-0.575	-0.644
Freeway distance	-0.005	-0.008	-0.004
College Workforce	0.0003	0.0005	0.0004
Entertainment Employme	0.111	0.107	0.090
Air Quality (Ozone)	0.341	0.342	0.338
General Retail			
Crime	0.042	0.046	0.035
Sea Distance	-0.686	-0.690	-0.769
Freeway distance	0.042	0.045	0.059
College Workforce	0.136	0.082	-0.051
Entertainment Employme	0.158	0.146	0.110
Air Quality (Ozone)	0.004	-0.026	-0.058
Office			
Crime	-0.062	-0.055	-0.062
Sea Distance	-0.892	-0.888	-0.921
Freeway distance	0.044	0.044	0.056
College Workforce	0.344	0.336	0.272
Entertainment Employme	0.087	0.082	0.069
Air Quality (Ozone)	-0.058	-0.065	-0.099

Table 11: Property Types Have Different Estimated Amenity Coefficients.

	Industrial		Service Retail		General Retail		Office	
	OLS	Spatio-Temporal	OLS	Spatio-Temporal	OLS	Spatio-Temporal	OLS	Spatio-Temporal
golf20	0.0566	0.066	-0.0621	0.061	0.0574	0.056	0.0682**	0.065
	[1.1342]	[1.331]	[-0.8225]	[1.004]	[1.2652]	[1.061]	[2.1289]	[1.627]
ozone1_90	0.0062***	0.006***	0.0081***	0.001	0.0016	0.001	0.0025*	0.003**
	[7.4979]	[8.365]	[3.7725]	[0.798]	[1.3522]	[1.323]	[1.9273]	[2.291]
ozone1_90_2	-0.0005***	0***	-0.0006***	-0.0004**	-0.0003***	-0.0003***	-0.0004***	0***
	[-6.4336]	[5.323]	[-4.3952]	[2.233]	[-3.3544]	[3.058]	[-4.1411]	[3.518]
d_sea	-0.6274***	-0.653***	-0.5308***	-0.748***	-0.6739***	-0.68***	-0.8541***	-0.864***
	[-12.7983]	[11.062]	[-6.9811]	[9.616]	[-11.6127]	[12.094]	[-13.6375]	[12.119]
d_sea_2	0.0750***	0.086***	0.1004***	0.142***	0.1392***	0.139***	0.1674***	0.176***
	[3.9497]	[4.29]	[3.6971]	[4.216]	[5.7090]	[6.043]	[6.6848]	[6.861]
cr2000	0.1759***	0.174***	-0.1938***	0.099*	0.1279***	0.13***	-0.1769***	-0.172***
	[7.3298]	[7.168]	[-2.7097]	[1.681]	[3.0467]	[3.259]	[-3.7503]	[3.781]
weathf1	-0.0137***	-0.013***	-0.0031	-0.002	-0.0054**	-0.005**	0.0038	0.003
	[-7.1424]	[6.258]	[-0.8047]	[0.54]	[-2.3585]	[2.023]	[1.5173]	[1.193]
weathf2	0.0018	0.002	0.0038	-0.003	-0.0057**	-0.006*	0.0131***	0.013***
	[0.8899]	[0.6]	[0.9469]	[0.507]	[-2.0103]	[1.808]	[4.7551]	[4.036]
distances1	0.0888***	0.089***	0.0401**	0.066***	0.0844***	0.081***	0.1122***	0.108***
	[6.5025]	[5.545]	[2.0027]	[2.919]	[5.1005]	[5.085]	[6.5963]	[5.557]
distances2	0.2583***	0.27***	0.2042***	0.345***	0.3178***	0.322***	0.3702***	0.374***
	[11.9809]	[10.687]	[5.0734]	[9.924]	[11.6100]	[12.395]	[12.8079]	[11.479]
distances3	-0.1201***	-0.125***	-0.0871***	-0.182***	-0.1664***	-0.172***	-0.1868***	-0.186***
	[-11.8028]	[10.855]	[-4.6418]	[8.745]	[-12.0388]	[12.071]	[-13.8740]	[12.074]
distances4	-0.0318**	-0.035*	-0.0096	-0.028	-0.0338*	-0.03	-0.1032***	-0.106***
	[-2.1793]	[1.85]	[-0.3528]	[0.87]	[-1.7608]	[1.408]	[-5.1453]	[4.549]
DQhouseprice	0.0876***	0.082***	0.0430***	0.036***	0.0641***	0.059***	0.0551***	0.048***
	[13.8110]	[12.395]	[2.9912]	[5.925]	[10.5838]	[10.46]	[6.4210]	[9.572]
dist_fh	-0.0768***	-0.078***	-0.0071	0.065***	0.0516***	0.054***	0.0500***	0.045***
	[-8.6362]	[7.526]	[-0.3667]	[3.547]	[4.6723]	[4.136]	[4.0426]	[3.415]
dist_fh_2	0.0330***	0.035***	-0.0003	-0.004	-0.0066	-0.006	-0.0033	0
	[3.6670]	[3.935]	[-0.0362]	[0.544]	[-1.3075]	[0.95]	[-0.5785]	[0.04]
bachorhigh	-0.004	-0.005	0.0003***	-0.051	0.1258	0.08	0.3479***	0.338***
	[-0.0443]	[0.065]	[3.1238]	[0.806]	[1.1045]	[1.222]	[2.8948]	[3.025]
empl2	-0.0432**	-0.034	-0.0299	0.043	0.0581**	0.069***	0.0228	0.028
	[-2.1604]	[1.483]	[-0.8049]	[1.315]	[2.4110]	[2.637]	[0.9497]	[1.202]
empl5	0.4903***	0.472***	0.9233***	0.839***	1.2135***	1.125***	0.6241***	0.605***
	[4.9275]	[5.241]	[5.2133]	[6.904]	[12.4754]	[11.628]	[6.8031]	[6.669]

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