Land-Use Regulations, Property Values, and Rents: Decomposing the Effects of the California Coastal Act*

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Abstract

Land-use regulations can lower real estate prices by imposing costs on property owners, but may raise prices by restricting supply and generating amenities. We study the effects of the California Coastal Act, one of the nation's most stringent land-use regulations, on the price and rental income of multifamily housing. The Coastal Act applies to a narrow section of the California coast, allowing us to compare properties just on either side of the jurisdictional boundary. The setting is advantageous for the study of land-use regulation: boundary location is plausibly exogenous, which we confirm with historical data on boundary placement, and orthogonal to other jurisdictional divisions. We decompose the effects of the regulation into (i) a *neighbor effect*, the value of restrictions on adjacent properties, (ii) a *local effect*, which reflects the net effect of own-lot restrictions and the neighbor effect, and (iii) an *external effect*, the value of amenities generated by restrictions on all properties within the regulated area. Our analysis of multifamily housing prices reveals local and external effects of approximately +6% and +13%, respectively. We use data on rental income to estimate a zero neighbor effect. Together with evidence on building ages and assessed building and land values, this suggests that property owners anticipate that the Coastal Act will provide protection from undesirable development on adjacent properties, even though material differences have not yet appeared.

JEL Codes: Q24, R31, R52

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1 Introduction

The California Coastal Act, passed in 1976 and administered by the 12-member California Coastal Commission, regulates land use and coastal access along the California coast. Although the Coastal Act applies to only about 1% of land in California, the Coastal Commission has authority over some of the most valuable real estate in the world, including sections of La Jolla, Santa Monica, Malibu, and Carmel-by-the-Sea. Among other objectives, the Coastal Act is designed to "protect, maintain, and where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and artificial resources."[1] To achieve this ambitious goal, the Coastal Commission is granted permitting authority over a wide range of activities affecting land resources, the marine environment, recreation, and public access, and can levy fines and seek punitive damages. The Coastal Act has the potential to generate substantial benefits for property owners within the regulated area, referred to as the Coastal Zone, but it may also impose significant costs. Development in the Coastal Zone is subject to approval by the Coastal Commission, which can result in delays and significant modifications of proposed projects.[2]

Our study provides new results on the benefits and costs of one of the nation's most stringent and important land-use regulations. We use sale price and rental income data on multifamily housing units in Southern California to estimate the effects of the Coastal Act on property values. Our approach exploits the sharp discontinuity in regulatory regime provided by the Coastal Commission jurisdictional boundary, referred to as the Coastal Zone Boundary (CZB). We identify multiple effects of the Coastal Act operating at different spatial scales. The first, which we refer to as a *local effect*, captures the net price change due to restrictions on the subject property and restrictions on immediate neighbors of the subject property. The Coastal Act requires property owners to inform their neighbors of planned alterations to their property and provides neighbors with a mechanism for protesting these changes. This process imposes a cost on property owners (an *own-lot effect*) but also protects them from actions that their immediate neighbors may pursue (a *neighbor effect*). The local effect reflects both the own-lot and neighbor effects and can be negative or positive. We estimate the local effect by comparing sale prices for multifamily housing units just on

[1] California Public Resources Code 30001.5(a)

[2] The added costs of development in the Coastal Zone are evidenced by the highly publicized case of David Evans (also known as the Edge), the guitarist for U2. After five years of controversial hearings and significant changes to the development plan, the Coastal Commission recently granted approval to Evans's plan to build houses on a ridge in Malibu ("U2's the Edge gets state approval to build controversial homes on a Malibu ridge," *Los Angeles Times*, December 10, 2015).

either side of the CZB. Data on rental income are used to isolate the neighbor effect. In a competitive market, landlords must charge the same rent for identical apartments just on either side of the CZB. Rental market competition implies landlords just inside the Coastal Zone cannot pass along the costs of complying with the Coastal Act to renters, allowing us to separate the current neighbor effect from the local effect on prices.[3]

The Coastal Act also generates an *external effect*, the price change due to amenities resulting from the regulation of all properties within the Coastal Zone. For example, development restrictions that reduce congestion and loss of open space provide benefits to all property owners within the Coastal Zone.[4] The external effects of the regulation operate at a larger spatial scale than the local effects. We estimate the external effect by comparing price differences for multifamily units in the interior of the regulated and unregulated zones. We develop a novel spatial variant of difference-in-differences estimation to address endogeneity, as well as a plausible check on identifying assumptions that is similar to the test of parallel pre-trends. We also estimate the spillover of the external effect from the regulated to the unregulated zone, which we refer to as the *partial external effect*, by comparing properties in the interior of the unregulated area to those along the CZB but still within the unregulated zone.

We find that the Coastal Act has a local effect on prices of approximately +6%, revealing that the neighbor effect of the regulation outweighs the own-lot effect. The external effect of the Coastal Act on prices is found to range from +8% to +17%. Estimates produced with rent data reveal a similar external effect (approximately +9%), however, the neighbor effect of the Coastal Act on current rent is zero. These findings suggest that the neighbor effects of the regulation have not yet materialized but are expected to in the future, and highlight the importance of dynamic considerations when studying land-use regulation.

Previous studies on the effects of land-use regulations on real estate markets

There is a large empirical literature on the effects of land-use regulations on markets for housing and land. Quigley and Rosenthal (2005) provide a review of the literature, noting that many early studies ignore the potential endogeneity of land-use regulations. More recent analyses address this potential problem using instrumental variables or quasi-experimental

[3] The own-lot effect can raise the equilibrium *level* of the rent if it restricts the supply of housing units inside the regulated area. However, all housing units in the same market, whether regulated or not, would be affected in the same way, implying that *differences* in equilibrium rents cannot be due to the own-lot effect.

[4] The external effect is positive in this example, but it need not be. A poorly designed regulation could produce disamenities within the regulated area that have a negative effect on property prices.

methods (Cunningham 2007; Ihlanfeldt 2007; McMillen and McDonald 2002; Saiz 2010; Zhou, McMillen, and McDonald 2008). Our study builds on a recent paper by Turner, Haughwout, and Van der Klaauw (2014) who use a regression discontinuity design (RDD) to decompose the effect of regulation on property prices into own-lot, external, and supply effects. They compare parcels subject to differing degrees of regulatory stringency, as measured by the Wharton Residential Land Use Regulation Index (Gyourko, Saiz, and Summers 2008).[5] Although most earlier studies examine effects on prices, land-use regulations also have the potential to affect urban form (Shertzer, Twinam, and Walsh 2018), aggregate growth (Parkhomenko 2016), and regional convergence (Ganong and Shoag 2017).

A second group of studies focuses on the effects of spatially delineated regulations such as urban growth boundaries (UGB). These studies avoid the challenge of measuring the intensity of regulation with summary measures such as the WRLURI in favor of examining discrete changes in particular regulations.[6] Grout, Jaeger, and Plantinga (2011) use an RDD to study the effects of Portland's UGB on property values. Cunningham (2007) and Dempsey and Plantinga (2013) use a difference-in-differences approach to estimate the effects of UGBs on land development rates. Similar to our study, Kahn, Vaughn, and Zasloff (2010) use an RDD to estimate the effects of Coastal Act regulations on housing prices, household income, housing units, and population density. In an earlier study of the Coastal Act, Frech and Lafferty (1984) use housing price data from before and after the Coastal Commission began operating to measure its effect on the real estate market. They find small positive price effects of the Coastal Act, even in areas outside the Coastal Zone, which they attribute to supply constraints on the housing market.

Distinguishing features of this study

Our study is closest to previous RDD analyses of land-use regulations by Kahn, Vaughn, and Zasloff (2010) and Turner, Haughwout, and Van der Klaauw (2014). Although our study draws on Turner, Haughwout, and Van der Klaauw (2014), we extend their analysis in several ways. First, we show that what Turner, Haughwout, and Van der Klaauw (2014) call the own-

[5]The WRLURI is a municipality-level index that summarizes survey results on the parties involved in the regulatory process, local rules for residential development, and effects of the regulatory process.

[6]To account for the heterogeneity of regulation, indices like the WRLURI measure the average stringency within a municipality, but include some factors that may not be uniformly applied within a jurisdiction, such as minimum lot size requirements. In addition, the WRLURI incorporates information on the rate of land price appreciation within the municipality, which is an outcome of regulation rather than an indicator of stringency. Turner, Haughwout, and Van der Klaauw (2014) explore the use of measures created from the eleven subindexes that comprise the WRLURI.

lot effect is better characterized as a local effect that measures both the net price change due to restrictions on the subject property (a true own-lot effect) and restrictions on immediate neighbors of the subject property (a neighbor effect). Second, by analyzing price and rental income data, we distinguish effects of regulation on current rents from anticipated effects on future rents. Third, we develop a quasi-experimental identification strategy to estimate the total effect of regulation that relies on spatial difference-in-differences, rather than simple differences as in Turner, Haughwout, and Van der Klaauw (2014). Finally, we develop a combined estimator that jointly estimates local and external effects, limiting the loss of power that results from separate estimation and additionally recovers the amenity spillover from the regulated to the unregulated zone (the partial external effect). Our estimate of the total effect of regulation is similar to the estimate for single-family house prices reported in Kahn, Vaughn, and Zasloff (2010), however, we rigorously decompose this effect into its various components, provide an enhanced approach to identification, and distinguish current and future effects of the regulation.

The Coastal Act offers several unique advantages for measuring the effects of land-use regulations relative to other settings, and warrants extensive study. First, we make a strong case for the exogeneity of the boundary location. Previous studies of UGBs can be criticized on the grounds that placement of the UGB may be correlated with real estate values. The original (1972) CZB was set at 1,000 yards from mean high tide, with occasional deviations to encompass estuarine areas. Although the original boundary was determined by coastal geography, there have been some potentially endogenous changes to it since then. Using a map of the 1972 boundary, we show that our results are qualitatively unchanged using only observations for which regulatory status has not changed since 1972. Second, the CZB roughly follows the coastline, making it orthogonal to city, county, and other jurisdictional boundaries. Turner, Haughwout, and Van der Klaauw (2014) analyze properties on either side of municipal boundaries. They focus on straight-line boundaries that likely date to the 1785 Land Ordinance, arguing that these boundaries are unlikely to divide qualitatively different types of land. Nevertheless, there are difficult-to-measure factors that vary discontinuously across municipal boundaries, including school quality, city services, utility districts, and city-specific reputation effects, and the focus on undeveloped land near straight line borders may limit external validity. Finally, our estimates capture the effect of a single regulation overseen by a common authority, limiting measurement concerns.

2 Institutional setting

Coastal land-use regulation in California developed primarily in response to concerns about public access to shoreline areas and preservation of coastal resources. Threats to public access and environmental quality between the late 1950s and early 1970s prompted state regulation of the coastal area. The predecessor to the Coastal Act, the California Coastal Zone Conservation Act, was approved by ballot initiative in 1972. This legislation empowered a publicly appointed commission to protect California's marine areas in a terrestrial coastal zone extending from the mean high tide line landward to the "highest elevation of the nearest coastal mountain range." It also delineated a "permit area" wherein the commission had permitting authority consisting of roughly the first 1,000 yards inland from the mean high tide line.

The California State Legislature made coastal oversight permanent with the California Coastal Act of 1976, establishing the modern California Coastal Commission. Despite its original focus on preserving undeveloped sections within its 1.5 million acre jurisdictional area, some of the Coastal Act's largest impacts are in urban Southern California. Development that occurs in the Coastal Zone is subject not only to local city and county planning rules, but also to additional oversight by the Coastal Commission. The Commission can require alterations of proposed development activities to compensate for the loss of public access to the coast or diminished resource quality.

Several features of the Coastal Act have the potential to influence property values. The first is the permitting process. Development within the Coastal Zone requires a Coastal Development Permit, which is granted upon review by either the Coastal Commission or a local government operating as the Commission's surrogate under a carefully regulated Local Coastal Program. A permit must be obtained whenever there is proposed construction or a proposed change in land use or intensity. Second, applications for a permit must list all property owners within 100 feet of the requesting property's borders as well as all parties known to be interested in the proposed development, and permit applications must be sent in advance to these adjacent and interested parties. Furthermore, a Notice of Pending Permit must be conspicuously displayed at the development site. The Coastal Commission also provides for "citizen suits," wherein citizens can bring legal action to address perceived violations of the Coastal Act and to enforce orders issued by the Commission. This provides a means for landowners to directly challenge development on nearby properties. The ease of litigation and salience of the regulation empower interested citizens to influence and potentially obstruct nearby development.

Delineation of the Coastal Zone

The Coastal Act requires the Coastal Commission to precisely define the Coastal Zone Boundary (CZB). The Act assigns the Commission authority over the area from the state's seaward limit of jurisdiction inland to roughly 1,000 yards from the mean high tide line, with provisions for significant deviations based on coastal geography (Figure 1). Further, placement of the CZB had to satisfy three conditions: (i) avoid bisecting properties, (ii) preserve contiguity of the border, and (iii) conform to "readily identifiable natural or man-made features".[7] The constraints placed on the boundary designation are such that individual landowners have little scope for selecting into or out of regulation under the Coastal Act. The RDD we utilize in this paper is valid if landowners are unable to precisely manipulate their location relative to the demarcation of treatment (Lee 2008; Lee and Lemieux 2010). Examination of the CZB shows that there are few high-frequency abrupt changes in the boundary that would suggest that requests by individual property owners are being accommodated.[8] Rather, the boundary follows man-made features in much of the sample, such as roads that run through neighborhoods.

Since the demarcation of the Coastal Zone in 1976, requests for boundary revisions follow a standard process. Boundary amendments may be proposed to "avoid bisecting any lot or parcel, or to conform the boundary to readily identifiable natural or man-made features." The request process is costly as it requires public hearings, extensive documentation, and a significant fee (currently more than $5,000). Historically, there have been three broad types of amendment requests.[9] First, there were a few 'clean-up' amendments made initially to clarify the boundary or resolve misunderstandings or discrepancies. Second, some property owners, particularly corporate property owners, tried to receive individual exclusions. They were mostly unsuccessful, particularly when public access was threatened or properties contained important coastal resources. Finally, local governments continue to make requests for boundary adjustment. These adjustments are reflected in updated maps, and include communities that joined or left the regulated zone. Most adjustments occurred prior to 1982, and usually involved development of tract housing in rural and suburban areas. As such, these amendments have little effect on our sample, which primarily includes urbanized areas

[7]For example, the CZB can be adjusted to include marshland or exclude small water bodies unaffected by tidal action.

[8]See Appendix Figure A1 for a detail of the CZB in Santa Monica.

[9]This characterization was developed in conversations with Coastal Commission staff, and matches our reading of the historical evidence.

of Southern California.[10]

In summary, the institutional setting supports boundary exogeneity with limited scope for selection in our sample. The drawing of the boundary in 1976-77 was subject to a number of constraints that greatly limited the ability of individual properties to sort into or out of regulation. Subsequent changes to the CZB are rarely applied to individual parcels and have largely occurred in rural areas outside the scope of our analysis. In the context of our RDD, the inability of individual property owners to precisely determine treatment status is a critical feature of the Coastal Act. In Section 6.4, we use maps of the 1972 and 1976-77 boundaries to further examine boundary exogeneity.

3 Theory of property prices, rents, and effects of regulation

This section presents a simple model of property prices and rents to illustrate the effects of regulation on the market for multifamily housing units. In general, these effects will depend on market segmentation, the degree of substitutability among properties, and the development status of properties, among other factors. For this analysis, we make the following key assumptions: 1) the property market is perfectly competitive, 2) regulated and unregulated properties are exchanged in the same market, and 3) regulated and unregulated properties are close substitutes in terms of housing services, but may be differentiated by amenities and neighborhood characteristics. We present evidence that these conditions are satisfied for our empirical application in section 4.1. We consider only the market for existing multifamily housing units.[11]

In a competitive market, the price of a commercial multifamily building equals the present value of the discounted stream of rents net of management costs.[12] For a property at location

[10] Property owners may seek individual permit exceptions, or variances. Although variances are sometimes granted by the Coastal Commission for specific development activities, the process is costly and the regulated parcels are still subject to Coastal Commission oversight.

[11] Land-use regulations affect prices for developed and undeveloped land in different ways, as shown by Ihlanfeldt (2007). In the data section, below, we justify our focus on developed land only.

[12] Economists have studied the price-rent ratio in housing markets to test whether prices are determined by fundamentals, or whether there is evidence of speculative bubbles (Fairchild, Ma, and Wu 2015; Granziera and Kozicki 2015). One of the challenges in conducting these tests is that within a housing market, rental and housing units tend not to be of the same quality (Hill and Syed 2016). We do not face this problem in our data because we observe rental income and prices for the same set of properties.

x in time t; the price is given by:

$$P(x,t) = \int_t^{\infty} \{R(A(x,s), N(x,s)) - C(x,s)\} e^{-r(s-t)} ds \qquad (1)$$

where $R(A(x,s), N(x,s))$ is the rent earned from the property in time s, $C(x,s)$ is the management cost, and r is the discount rate. Because properties may be differentiated by amenities and neighborhood characteristics (but not housing characteristics), rent is a function of the amenities at location x in time s, $A(x,s)$, and restrictions on immediate neighbors of the property, $N(x,s)$, due to regulation. Rents are assumed to be weakly increasing in amenities and restrictions on neighbors: $R_A \geq 0, R_N \geq 0$. In this section, we assume that the only amenities that affect prices are due to the regulation and normalize all other amenities to zero. In the empirical application, we carefully control for confounding amenities, such as coastal proximity.

Rents in Equation (1) does not depend on management costs. In a competitive market, properties with the same amenities and neighborhood characteristics (i.e., the same values of A and N) must rent for the same amount in equilibrium. Otherwise, renters would switch to lower-priced properties, thus bidding their price up. In general, equilibrium rent differences can arise only from differences in attributes of properties that renters can observe. Management costs affect the value of owning the property, and therefore the property price in Equation (1), but differences in costs cannot produce differences in rents.

Regulation under the Coastal Act can potentially affect property prices by changing amenities, restrictions on neighbors, and management costs. Consider two properties, one inside the regulated area at location x' and one outside the regulated area at location x''. Assuming the regulation generates positive amenities, the regulated property will benefit from amenities $A(x', s)$ and from restrictions on neighbors $N(x', s)$. The property outside the regulated area will have lower amenities, $A(x'', s) \leq A(x', s)$, where $A(x'', s) > 0$ if there are amenity spillovers from the regulated area and $A(x'', s) = 0$ if the property is a sufficient distance from the regulated area. For the unregulated property, there will be no restrictions on immediate neighbors, implying $N(x'', s) = 0$. Thus, rents at time s are weakly greater for regulated properties due to larger values of A and N. On the other hand, costs are weakly greater for regulated properties, $C(x', s) \geq C(x'', s)$, because the management of these properties is constrained by regulation. If these restrictions limit the supply of housing units, regulation can result in higher prices. However, within the same market the supply reduction raises the prices of all properties and, thus, the supply effect of the regulation will not produce price differences between regulated and unregulated properties (Glaeser and

Ward 2009). In our empirical analysis, we allow for the possibility that regulation generates disamenities, but maintain the assumption that regulation weakly increases costs.

The effects of regulation on prices

We use the pricing model in Equation (1) to define three effects of the regulation, defined in all cases as the price difference between regulated and unregulated properties, $P(x',t)-P(x'',t)$. The first is the *total effect* of the regulation, given by:

$$\begin{aligned} \textit{Total effect} = \int_t^\infty \{ & R(A(x',s),N(x',s)) - R(0,0) \\ & - (C(x',s)-C(x'',s))\} e^{-r(s-t)} ds \end{aligned} \tag{2}$$

The total effect measures the present value of the relative gain in rents for the regulated property due to higher amenities and restrictions on neighbors. In defining the total effect, we assume that the unregulated property does not capture any spillovers from the regulated area, and thus amenities and rents are given by $A(x'',s)=0$ and $R(0,0)$. The total effect also reflects the higher management costs for properties in the regulated area. Therefore, the total effect can be positive or negative depending on the relative magnitudes of the rent and cost terms.

The *local effect* arises from differences in the restriction of immediate neighbors and management costs between regulated and unregulated areas. In particular, if amenities are the same for properties at x' and x'', and equal to $\bar{A}(s)$, then the local effect is given by:

$$\begin{aligned} \textit{Local effect} = \int_t^\infty \{ & R(\bar{A}(s),N(x',s)) - R(\bar{A}(s),0) \\ & - (C(x',s)-C(x'',s))\} e^{-r(s-t)} ds \end{aligned} \tag{3}$$

The first term in (3), $R(\bar{A}(s),N(x',s)) - R(\bar{A}(s),0) > 0$, measures the increase in rents in the regulated area due to restrictions on neighboring properties. We refer to the discounted stream of these rent differences as the neighbor effect. As in (2), the second term reflects the increase in management costs due to constraints imposed by the regulation. The discounted stream of these cost differences is the own-lot effect. The local effect is positive or negative depending on the relative magnitude of the neighbor and own-lot effects. In order to find properties with similar amenities levels ($A(x',s)=A(x'',s)=\bar{A}(s)$), we compare nearby properties in the empirical implementation.

The *external effect* is the price difference due solely to differences in amenities. For this effect, restrictions on neighbors are the same for properties at x' and x'', and equal to $\bar{N}(s)$. Management costs are also equal, implying that there is no difference in the cost term, and so it vanishes. The external effect is therefore given by:

$$\textit{External effect} = \int_t^\infty \{R(A(x', s), \bar{N}(s)) - R(0, \bar{N}(s))\} e^{-r(s-t)} ds \tag{4}$$

It can be shown that to a first-order approximation, the total effect is equal to the sum of the local and external effects.[13] In the empirical application, we compute the external effect as the difference between the total and local effects.

The effects of regulation on rents

To illustrate the effects of regulation on rents, we continue with the comparison of a regulated property at x' and an unregulated property at x''. The total effect on current rent is simply the rent term in Equation (2) evaluated at time t:

$$\textit{Total effect} = R(A(x', t), N(x', t)) - R(0, 0) \tag{5}$$

Under the assumption $R_A \geq 0, R_N \geq 0$, the total effect on rents is weakly positive. Rents are higher for regulated properties because of desirable amenities and restrictions on neighbors. Although we expect the neighbor effect to always be positive, it is possible that poorly-designed regulation reduces amenities, which could produce a negative total effect on rents. The local effect of regulation on the time t rent is given by:

$$\textit{Local effect} = R(\bar{A}(t), N(x', t)) - R(\bar{A}(t), 0) \tag{6}$$

Because amenities are the same for nearby properties, the local effect on rents depends only on the neighbor effect and, thus, is weakly positive. Finally, the external effect on rents is:

$$\textit{External effect} = R(A(x', t), \bar{N}(t)) - R(0, \bar{N}(t)) \tag{7}$$

The external effect depends only on amenities and will be positive (negative) as amenities are desirable (undesirable). As with prices, the external effect on rents can be approximated as the difference between the total and local effects.

The effects of regulation on rental income can differ from the effects on prices for two

[13] A derivation of this is provided in the Appendix.

reasons. First, higher management costs for regulated properties cause a difference in prices for regulated and unregulated properties, but have no effects on rents due to competition. One implication is that the local effect on rents is weakly positive but the local effect on prices can be negative if management costs for regulated properties are sufficiently high. Second, the price effects depend on the stream of future rents, and not solely on current rent. For example, the effect of regulation on the current rent could be zero, whereas the effect on price could be positive if a positive rent effect is expected to materialize in the future. In the empirical application, we exploit differences in the estimates of the local, external, and total effects for prices and for rents to further differentiate how and when regulation influences the market.

Spatial effects of regulation

Figure 2 illustrates how regulation can affect property prices at different locations. A similar graph can be constructed for rents. The solid line in Figure 2 represents the price gradient for properties at different locations, holding constant housing services and any amenities unrelated to regulation. Geographic location is represented by distance to and from the regulatory boundary at $x = 0$, where properties to the left of the boundary are regulated (inside the Coastal Zone) and properties to the right are unregulated (outside the Coastal Zone). Properties far within the unregulated area (area S_4) do not capture any benefits from the regulation ($A = 0$) or from restrictions on neighbors ($N = 0$). The price for these properties is shown as $\underline{P}$ in Figure 2.

In drawing Figure 2, we have assumed that the regulation generates positive amenities ($A > 0$), which produces a positive external effect E. Positive spillovers from the regulated to the unregulated area cause prices to rise as one moves from far in the unregulated area toward the boundary at $x = 0$. Properties right at the boundary capture only a portion of the external effect because amenities are a mixture of those in the regulated area ($A > 0$) and unregulated area ($A = 0$). The partial external effect is denoted τE where $\tau \in [0, 1]$. Thus, the price of unregulated land near the boundary (area S_3) is $\underline{P} + \overleftarrow{\tau} E$. In the regulated zone near the boundary (area S_2), the local effect of the regulation L lowers the price to $\underline{P} + \overrightarrow{\tau} E - L$ (while it is drawn as negative in Figure 2, the local effect on price could be positive, as shown above). Right at the boundary, the partial external effects are equalized, implying $\overrightarrow{\tau} = \overleftarrow{\tau} = \tau$. At the boundary, the price difference between regulated and unregulated properties equals the local effect L. Far from the boundary in the regulated zone (area S_1), prices capture the full external effect of regulation (E) and are given by $\underline{P} + E - L$.

4 Data

We use proprietary data consisting of all recent commercial multifamily real estate transactions in coastal Southern California. The data are trimmed to include multifamily housing sales that occurred in arm's-length transactions between 1989 and 2014, exclude any properties more than 10 miles away from the coast, and remove properties that appear to have mismeasured values of covariates. The database includes the precise location of each property, the date and price of sale, and property-specific characteristics such as building size, lot size, age, etc. For a large subset of these properties, the data also include gross rental income, assessed building value, and assessed land value.[14] We transform prices to price per square foot of building or lot size, and adjust to 2014 dollars using the Consumer Price Index for Urban Consumers (CPI-U). We use *R* to create measures of elevation and slope for each property with 90m digital elevation data from CGIAR.

The Coastal Commission provides a high-resolution, geo-referenced file delineating the CZB. We also use the location of the original (1972) permit area of the Proposition 20 coastal zone by geo-referencing digitized maps of the original boundary provided to us by the Coastal Commission (see Section 6.4). The location of the coastline comes from NOAA's Medium Resolution Shoreline, which we modified by hand to exclude some natural features that would introduce measurement error into distance-from-the-coast variables.[15] We use *R* to calculate distances from properties to the coastline and to the CZB, as well to determine if properties were inside or outside of the Coastal Zone.

In some specifications, we use a restricted sample focused on urban areas. This sample omits rural areas and portions of the study area where there are large parks, public lands, and similar features on one side of the boundary. While such features are uncommon given that our sample comprises multifamily housing units and thus is predominantly urban, the restricted sample allays concerns about estimation problems that could arise from an imbalanced number of properties on either side of the boundary. We denote these areas as 'restricted areas' or as the 'restricted sample'; they are marked by hatching in Figure 1. More details on the construction of the restricted sample is found in the Appendix.

[14] Another alternative is to examine vacant land prices. However, vacant land observations do not include information on rental income and are limited in our study region, which is highly urbanized and has been built out for about 50 years. There are an average of 95 multifamily observations per zip code, compared to only 16 vacant land observations. Furthermore, vacant land in our sample is highly heterogeneous in its degree of development. We do examine assessed land values in Section 7.

[15] See `http://shoreline.noaa.gov/data/datasheets/medres.html`; edited version available by request. These adjustments limit the extent to which small inlets (e.g., estuarine creeks) are treated as coastline, which inaccurately identify inland properties as beachfront properties.

4.1 Relationship of data and setting to theoretical assumptions

The data and economic environment support the assumptions that underlie our theoretical model and justify our approach. The market for multifamily commercial real estate appears to be perfectly competitive, as (i) median time on the market is 61 days for all transacted properties within 4,000 feet of the CZB and (ii) there are large numbers of buyers and sellers.[16] Further, we exclude all non-arm's length transactions to ensure that prices reflect market conditions. Regulated and unregulated properties appear to be exchanged in the same market. For every regulated property in our dataset, a corresponding unregulated property is typically close (less than one-quarter of a mile). Our estimation strategy bolsters this argument with the use of zip code fixed effects and bins in coastal distance, ensuring that comparisons between regulated and unregulated properties are made in geographically compact areas and conditioned on the coastal amenity.[17] Transacted buildings also seem to provide similar housing services. Table 1 shows the mean characteristics and standard deviations for both regulated and unregulated properties within 1,000 feet of the CZB.[18] With the exception of the distance from the coast, the regulated properties appear relatively similar on observable characteristics to unregulated properties. Notably, 11% of regulated and unregulated properties are classified as either Class A or Class B buildings.[19]

5 Methodology

We use three estimators to identify the different effects of regulation on prices and rental income. Because of the short spatial scale at which the local effect operates, we estimate it using a spatial RDD. Spatial RDD is well suited to capturing the effects of the sharp change in regulatory intensity when crossing the CZB; it compares observations just to either side of the regulatory boundary (i.e., just to the right and left of $x = 0$ in Figure 2). The second

[16] The lower quartile time on the market is 30 days, and the upper quartile is 135 days. In our full sample, we observe 5,028 observations for which the buyer is indicated; 4,041 of these are unique. There are 4,498 transactions with known seller, of which 3,834 are unique. The Herfindahl index by sale value for properties within 1,000 (4,000) feet of the CZB is 0.0014 (0.0035). In contrast, in the study by Taylor and Smith (2000) of market power in the vacation rental market in North Carolina, 40% of properties were controlled by four property management firms.

[17] In our sample, zip code areas are approximately 1 to 2.5 square miles in size. At a 1,000 (4,000) foot bandwidth around the CZB, there are 2,496 (7,799) multifamily observations in 63 (82) zip codes and 25 (29) distance bins. There are 3.3 (4.9) distance bins per zip code and 8.2 (13.8) zip codes per distance bin.

[18] A similar table for all properties within 4,000 feet of the CZB is in the Appendix.

[19] Class A buildings are well-located, have good access, and are professionally managed. Class B buildings are usually somewhat older, but otherwise similar to Class A buildings.

estimator measures the total effect of regulation using a spatial difference-in-differences (DID) design to compare parcels located in the interiors of the regulated and unregulated zones (i.e., parcels away from the boundary as illustrated by areas S_1 and S_4 in Figure 2). The external effect is the average shift in neighborhood-scale amenities that occurs because of the regulation, and is approximated by the difference between the local and total effects, as shown in Section 3. Separate estimation of the local and total effects relies on spatially delineated fixed effects, and can be underpowered because it excludes data based on spatial criteria. The third estimator overcomes this problem by combining elements of spatial RDD and spatial DID to jointly estimating the local and external effects. The combined estimator also allows us to recover an estimate of the partial external effect.

5.1 Local effect estimation: Spatial RDD

We use a spatial RDD to estimate the local effect of regulation on prices and rental income. The strength of this approach is that the identifying assumptions are straightforward and relatively weak. We need only that unobservable characteristics of properties vary continuously across the boundary and there is no endogenous sorting around the boundary. Nonetheless, there are important estimation challenges with spatial RDDs. Because we do not observe a sufficiently large number of properties right next to the boundary, we must use a sample window around the boundary and control for the price gradient within it. In a standard RDD application, this gradient is typically modeled using a flexible function of distance to the treatment threshold (e.g., Imbens and Lemieux 2008). In a spatial RDD, location is a two-dimensional variable; distance to the boundary no longer uniquely identifies a property's location. As described below, we address the identification challenges in this more complex spatial environment using a two-dimensional control polynomial in combination with additional parametric and semi-parametric controls.

Define price or rental income per square foot of built space as P_{it} for property i in time t and T_i as an indicator variable for location within the Coastal Zone. Then, the primary estimating equation for the spatial RDD is:

$$\ln(P_{it}) = \beta T_i + f(T_i, loc_i) + \sum_{m=1}^{M} 1_{i\in m}\phi_m + \sum_{z=1}^{Z} 1_{i\in z}\xi_z + x_i'\gamma + \delta_t + \varepsilon_{it} \quad (8)$$

with the sample restricted to $i \in \{\min d(loc_i, CZB) < \bar{d}\}$. The sample restriction limits analysis to those properties within some distance $\bar{d}$ of the regulatory boundary, where $d(\cdot)$ is the set of straight-line distances between the two-dimensional location of property i, loc_i, and all points on the CZB. The existing literature offers little guidance for bandwidth selection in the case of spatial RDDs. As a result, we report results for a range of bandwidths.[20]

In Equation (8), $f(T_i, loc_i)$ denotes the RDD control polynomial. For geographically complex boundaries, many studies specify a two-dimensional polynomial in latitude and longitude interacted with treatment status (Dell 2010; O'Grady 2014; Dell, Lane, and Querubin, forthcoming). For our primary specification, we follow Gelman and Imbens (2014) and consider a linear function in latitude (Lat_i) and longitude (Lon_i):

$$f(T_i, loc_i) = \zeta_0 Lat_i + \zeta_1 Lon_i + \zeta_2 Lat_i T_i + \zeta_3 Lon_i T_i \tag{9}$$

Relative to a one-dimensional distance variable used with standard RDDs, the advantage of Equation (9) is that it accommodates any boundary shape, makes use of the available information on spatial price variation (and controls for it), and avoids potential bias in effect size estimates associated with the use of higher-order polynomial control functions (Gelman and Imbens 2014).[21]

A particular concern for this application is that treatment status is correlated with proximity to the coast, which we expect to have large positive effects on property values. We assume that the level of coastal amenities is solely a function of minimum distance to the coast, but represent the shape of the amenity gradient with a flexible binning approach. In particular, Equation (8) includes M coastal distance bins, where a narrow bin of 1,000 feet is used to capture highly localized effects of coastal proximity.[22] Equation (8) also includes Z zip-code fixed effects to control for any other spatially-varying unobserved determinants of property values.[23] Our estimator thus compares properties just on either side of the CZB *within zip codes*, minimizing the effect on our estimates of any mis-specification of the control polynomial. Spatially delineated fixed effects also limit the scope for spatial unobservables to bias our results (Kuminoff, Parmeter, and Pope 2010). Our binning approach, in combination with zip-code fixed effects, is highly flexible, and removes parametric dependence on non-local observations that can occur when using more rigid parametric assumptions, as in

[20] In our primary results, the bandwidth varies from $\bar{d}$=500 feet to $\bar{d}$=4,000 feet. In graphical results and in the Appendix, we report results at a finer grid and with a minimum bandwidth $\bar{d}$=250.

[21] We report results for higher-order polynomial specifications in the Appendix.

[22] Alternative specifications use bins 500 feet in width and log-distance to coast.

[23] For example, Combes, Duranton, and Gobillon (2016) explore the relationship between housing and land prices and urban population densities. Zip code areas vary with population density and so zip code fixed effects should control for differences in urban densities within our study region.

previous studies (Frech and Lafferty 1984; Kahn, Vaughn, and Zasloff 2010).

A challenge with real estate data is heterogeneity across properties, so in most specifications of Equation (8) we include property-level controls, x_i. Multifamily commercial buildings can vary greatly in size, and there may be increasing or decreasing returns to scale in the provision of housing services. We control for this by normalizing the outcome to be price per square foot and by including measures of building and lot size, in addition to other controls, to capture heterogeneity in property types. Including these controls can influence the precision of the results (as in Turner, Haughwout, and Van der Klaauw 2014) as well as ensure that the results are not driven by variation in observable property characteristics. Finally, Equation (8) includes year-of-sale fixed effects δ_t to capture any temporal trends in the housing market. ε_{iz} is a random error, which we cluster at the zip code level.[24]

5.2 Total effect estimation: Spatial DID design

We develop a spatial DID approach to estimate the total effect of regulation. Our approach exploits variation in the distance of the CZB to the coastline to separately identify the total effect of regulation from the coastal amenity. Figure 3 illustrates the intuition behind this approach. Properties A, D, and E are regulated, properties B, C, and F are not regulated, and all properties are assumed to be far enough from the CZB so there are no spillovers from the other (regulated or unregulated) area. Simply comparing properties E and F (or A and B) might confound the effect of regulation with other spatial price gradients. Instead, we compare the *differences* in prices and rents for properties that span the CZB (e.g., E−F) with the *differences* in prices and rents for parcels that do not span the CZB (e.g., B−C). Our approach is thus a spatial analog of difference-in-difference estimation.

The primary identifying assumption is the spatial equivalent of a parallel trends assumption: in the absence of treatment, the difference in prices between a treated and control unit at different distances from the coast (e.g., E and F) would be the same as that between two units at the same distances from the coast that are either both treated or both controls (e.g., B and C). In Figure 3, this means that the price gradients along A−B−C and along D−E−F would have the same slope at each distance from the coast in the absence of treatment. This assumption is less stringent than what is required for a simple comparison of treated and control properties conditional on distance from the boundary (as in Turner, Haughwout, and

[24]We experimented with alternative methods for computing standard errors. Use of a spatially delineated, cluster robust estimator is a good substitute for parametric modeling of spatial error processes (Bester, Conley, and Hansen 2011).

Van der Klaauw (2014)). We later detail a pre-trends style test that supports the identifying assumption.

To make full use of information, we include a given property in as many comparisons as possible. Thus, in addition to using properties B and E in the comparison described above, we want to use them in a similar DID comparison between (A−B) and (D−E) (Figure 3). We achieve this with a spatial fixed effects specification. The estimator includes distance-from-the-coast fixed effects to control for coastal proximity shared by pairs (A,D), (B,E), and (C,F), as well as zip code fixed effects to control for commonalities of locations (A,B,C) and (D,E,F). The effect of treatment is the interaction between the distance-from-the-coast fixed effects and treatment:

$$\ln(P_{it}) = \sum_{m=1}^{M} 1_{i\in m}\theta_m^C + \sum_{m=1}^{M}(T_i \times 1_{i\in m})\theta_m^T + \sum_{z=1}^{Z} 1_{i\in z}\xi_z + x_i'\gamma + \delta_t + \varepsilon_{it}, \quad i \in \mathcal{I} \tag{10}$$

where $\mathcal{I}$ represents the set of points interior to either the regulated or unregulated zones (i.e., being at least a given distance away from the CZB) and other terms are as defined in Equation (8). As before, there are M distance bins, although our primary specification uses bins that are 500 feet wide.[25] The effects of interest are θ_m^T, which capture the average price differential between treated and untreated parcels at distance m from coast. To facilitate exposition, we report the weighted average of θ_m^T, estimated from

$$\ln(P_{it}) = \sum_{m=1}^{M} 1_{i\in m}\theta_m^C + T_i\bar{\theta}^T + \sum_{z=1}^{Z} 1_{i\in z}\xi_z + x_i'\gamma + \delta_t + \varepsilon_{it}, \quad i \in \mathcal{I} \tag{11}$$

where $\bar{\theta}^T$ summarizes the θ_m^T in Equation (10).[26]

We place two sample restrictions on parcels used for DID estimation to aid interpretation and boost the case for identification: excluding parcels (i) that are less than 500 feet or greater than 10,000 feet from the coastline or (ii) that are within some distance $\bar{d}$ of the the CZB. The first restriction ensures overlap between treated and control properties: there are few unregulated properties less than 500 feet from the coastline, and few regulated properties greater than 10,000 feet from the coastline. The second restriction avoids conflating the local and total effects of regulation, and overcomes remaining systematic differences in coastal proximity between treated and control groups. Along a ray pointing inland from

[25] We check that both estimators behave well with either width of coastal distance bins. We prefer narrow bins for the DID estimator, as this better controls for differences in observable covariates.

[26] Estimates of all the θ_m^T from Equation (10) are included in the Appendix.

the coastline, all regulated properties are necessarily closer to the coast than unregulated properties. In conjunction with the 500-foot wide distance bins and zip code fixed effects in Equation (10), excluding observations within a certain distance of the CZB ensures that regulated properties are being compared with unregulated properties at roughly the same distance from the coast. However, identifying variation comes from within each zip code, so these spatial exclusion restrictions may render this spatial DID estimator underpowered.

5.3 Combined spatial RDD and DID estimator

We also develop a joint estimator that combines the spatial RDD and DID approaches to estimate the local and total effects simultaneously. This combined approach excludes less data than either than the spatial RDD or DID approaches, and may be more efficient with spatially delinited fixed effects. It also allows us to recover an estimate of the partial external effect (i.e., the spillover from the regulated to the unregulated area). The identification requirements are identical to those for the separate estimators. The combined estimator regresses price or rental income on indicators for the different areas (S_1 to S_4) in Figure 2:

$$\ln(P_{it}) = \beta_0 B_i + \beta_1 T_i + \beta_2 B_i T_i + B_i f(T_i, loc_i) + \sum_{m=1}^{M} 1_{i \in m} \phi_m + \sum_{z=1}^{Z} 1_{i \in z} \xi_z + x_i' \gamma + \delta_t + \varepsilon_{it} \quad (12)$$

where $B_i = 1$ if property i is near the boundary and $T_i = 1$ if property i is on the coastal side of the boundary. As before, $f(T_i, \text{loc}_i)$ is the RDD polynomial, but is interacted with B_i and hence only 'active' when near the boundary. Our primary specification for f is as in Equation (9), however, we explore alternative specifications and report results in the Appendix and show a variant of Figure 2 estimated from the data. As before, the estimating equation also includes zip code and year-of-sale fixed effects, distance bins, and covariates.

We use Figure 2 to provide intuition for the estimator. The total effect is the price difference between the *coastal regulated* area (S_1) and the *inland unregulated* area (S_4), and is captured by β_1. Similarly, we have $\beta_0 + \beta_1 + \beta_2 = \overrightarrow{\tau} E - L$ for properties in the *boundary regulated* area (S_2) and $\beta_0 = \overleftarrow{\tau} E$ for properties in the *boundary unregulated* area (S_3). These three equations imply that the local effect ($-L$) is given by $\beta_1 + \beta_2$, the total external effect (E) is $-\beta_2$, and the partial external effect $\overleftarrow{\tau} E$ is β_0. The gray shading in Figure 2 indicates sampling areas; we use data only from these windows. We do not know *ex ante* the correct bandwidths, so we test the sensitivity of the results on different combinations of interior and exterior window sizes.

6 Primary results

For each of the estimators described in the previous section, we provide evidence related to the identifying assumptions. We then introduce the primary results for prices and rental income for each specification. Additional robustness checks are presented below and in the Appendix. Boundary exogeneity is an important assumption for all of our estimators. Tests based on historical maps are presented in subsection 6.4.

6.1 Local effect estimates

A common test for the validity of an RDD is to show that observable covariates do not jump discontinuously at the boundary; this provides assurances that unobservable covariates vary smoothly. These tests would ideally be run on ex ante covariates when assets are long lived. We provide two covariate smoothness tests on current data, as detailed real estate data prior to the Coastal Act is not available. First, we estimate Equation (8) using each covariate separately as the dependent variable (excluding all covariates as independent variables) and check whether the coefficient on regulatory status (β) is significantly different from zero. Second, we jointly test for a discontinuity in observables and sorting around the boundary by determining if the observable covariates as a group are significant predictors of a property's location (Canaan and Mouganie 2018). This test consists of sequentially estimating the following two equations on all properties within 4,000 feet of the CZB, where S_{it} is a measure of geographic location (latitude or longitude) of property i sold in year t:

$$S_{it} = \sum_{m=1}^{M} 1_{i \in m} \phi_m + \sum_{z=1}^{Z} 1_{i \in z} \xi_z + x_i' \gamma + \delta_t + \mu_{it} \tag{13}$$

$$\hat{S}_{it} = \beta T_i + f(T_i, loc_i) + \varepsilon_{it} \tag{14}$$

The right-hand side of Equation (13) uses all the non-regression discontinuity components of Equation (8) to predict location, $\hat{S}$. We then test for a discontinuity in the predicted values using several bandwidths and specifications in Equation (14). A discrete change in $\hat{S}$ at the boundary indicates the presence of unexplained factors that jointly predict location and, thus, change discontinuously with treatment status.

The first two panels of Table 2 report the results from individual covariate tests. In all cases, the linear RD polynomial in Equation (9) is used. At the smallest bandwidths, there is a discrete change in average building size across the CZB, and a marginally significant jump in lot size and slope. At larger bandwidths, there is a discrete decrease in elevation across the CZB, and a marginally significant jump in age.[27] None of the covariates is significant across the full range of bandwidths. The final panel of Table 2 presents results from the joint covariate test presented in Equations (13) and (14) for latitude and longitude. These results indicate that jointly, the covariates in conjunction with zip code and year-of-sale fixed effects have no predictive power for the location of properties with respect to the CZB.

Estimates of the local effect of regulation on price are given in Table 3 and on rental income in Table 4. Our preferred specification for the local effect of regulation on prices is given in Panel A of Table 3. These results indicate that regulation *increases* the price of a multifamily commercial building by 6% to 9% relative to a similar, but unregulated, building just across the boundary. These results are broadly consistent when limited to the restricted sample (Panel B). Specifications that include no controls still find a positive effect, but the magnitude is smaller and loses significance (Panel C). The inclusion of controls typically increases the magnitude and significance of the results; if selection on unobservables is similar to selection on observables, this implies the reported results are a lower bound (Altonji, Elder, and Taber 2005; Oster 2017).[28] Finally, in Panel A of Figure 4, we replicate our primary specification (from Panel A of Table 4) for bandwidths at 100 foot increments for the full and restricted sample. Overall, the results indicate a local effect of regulation on price in the range of 6%-8%.

Analogous results for the local effect of regulation on rental income are shown in Table 4. In contrast to the price results, the estimated effects are small and only in two cases marginally significant. Estimates using smaller bandwidths are sometimes negative. Furthermore, across the broad range of bandwidths shown in Panel B of Figure 4 (which replicates the model in Panel A of Table 4), the local effect of regulation on rental income is never significant for either the full or restricted samples. These results suggest that renters are unwilling to pay more (or less) to be just on either side of the boundary, implying that buildings are similar in terms of characteristics that matter to renters.

We perform two additional exercises to validate our use of the RDD. To allay concerns that building characteristics change discontinuously across the boundary, we estimate price

[27] The presence of a significant jump in elevation is not unexpected given the focus of the regulation on coastal properties. Regulated areas always lie seaward of unregulated areas and are typically at lower elevations. There are coastal bluffs within the study region, but a check of topographical maps indicates that they are not co-located with the CZB. Our ability to correctly interpolate elevation is also limited to linear forms due to the use of CGIAR data and *R*. The significance of the discontinuity is likely the result of curvature in the elevation surface rather than a discrete change in elevation.

[28] In particular, results in Panel D show that controlling for building size is of central importance, consistent with previous hedonic studies of housing prices (Irwin 2002; Smith, Poulos, and Kim 2002). Additional specifications are shown in the Appendix.

and rent models using only properties built before 1976. We are less likely to find discontinuous changes at the CZB in unobservable characteristics of buildings that predate the Coastal Act. Results, reported in the Appendix, are similar to those found with the full sample. We also generate three false boundaries at specified distances from the coast corresponding to quartiles of the full sample. We then run our preferred price specification using these false boundaries, with the one modification being that we use log distance to the coast to control for the coastal amenity rather than bins.[29] Results are reported in the Appendix. The local effect estimates are mostly insignificant, and when significant, are negative.

6.2 Total effect estimates

To estimate the total effect of regulation, we employ the spatial DID estimator developed in Section 5.2. While the spatial parallel trends assumption is fundamentally untestable, we develop a spatial analog to the pre-trends test used to evaluate difference-in-difference estimators. The test checks whether the slope of the coastal amenity gradient varies with the distance of the CZB from the coast; if it does not, spatial trends outside of the regulated area are similar regardless of where the CZB is located. To illustrate using Figure 3, the test compares the change in prices between O-O' with F-F' (or C-C') by interacting log coastal distance with the distance of the nearest portion of the CZB to the coast. The coefficient on the interaction term, shown in Table 5, is insignificant, supporting the identifying assumptions.[30]

Table 6 reports the total effect of regulation on prices and rental income estimated with Equation (11) using 1,000 feet as the exclusionary bandwidths.[31] Estimates of the total effect of regulation vary between 8% and 13% for prices and between 5% and 7% for rents. The total effect on rental income is smaller than on price due to differences in the local effect (recall that the total effect is the sum of the local and external effects). Together with estimates of the local effect, the estimates in Table 6 imply a positive external effect of a similar magnitude for prices and rents (from 4% to 7%). Total effect estimates are relatively consistent across

[29]The coastal distance bins are collinear with the false boundaries, which are specified at a set distance from the coast.

[30]An alternative is to test for balance between treated and control observations. This amounts to estimating Equation (11) using property characteristics as the dependent variables. Results, reported in the Appendix, show that properties in the same distance bin look relatively similar, though regulated properties tend to be at lower elevation and closer to the coast (as expected). To limit confounding effects, we include covariates in the primary specification.

[31]Additional results, in the Appendix, vary the bandwidth and report separate estimates of θ_m^T by bin. This shows that the total effect of regulation is positive and significant near the coast as well as inland, building confidence that the results are not simply driven by the coastal amenity.

specifications, although point estimates are smaller and lose significance when all covariates are excluded.[32] To ensure that any residual imbalance in the coastal amenity is not driving the estimates of the total effect, column (5) includes log coastal distance in addition to the coastal distance bins. Results are only slightly smaller than in the preferred specification. The large standard errors indicate that this test may be underpowered, motivating use of the combined estimator.

6.3 Estimates with the combined estimator

The combined estimator adopts elements from both the spatial RDD and spatial DID estimators, and produces direct estimates of the external and partial external effects, as well as the local effect. The combined estimator may or may not be preferred to the separate estimators. With narrow bandwidths, it does not use as much data as the spatial DID estimator, so estimates of the external effect may be less efficient. However, conditional on bandwidth, the combined estimator uses more data to estimate fixed effects and other controls, increasing efficiency. In our setting, we find substantial increases in power with the combined estimator.

We report the local effect, partial external effect, and external effect of regulation on price and rental income in Table 7 for different combinations of internal and external bandwidths. Estimates of the local effect are broadly consistent with findings from the two separate estimators: there is a positive and significant local effect on prices but not on rents. Estimates of the external effect from the combined estimator are larger than those obtained with the separate estimators, and are statistically significant for both prices and rents. Based on Figure 2, we expect the total and partial external effects to have the same sign and for the total external effect to be larger in absolute value than the partial external effect. For the results in Table 7, this relationship holds in almost all cases.[33] This supports our interpretation of the partial external effect as an amenity spillover from the regulated zone.

We conduct additional robustness checks for the combined estimator. As reported in the Appendix, results using the restricted sample are similar to the full sample results. Further,

[32]To test whether unobserved factors are driving our results, we also estimate a series of models that exclude single covariates. The results are relatively insensitive to the dropping of covariates, with the exception of building size. As in the case of the estimates of the local effect, this likely reflects the fact that prices do not depend linearly on building size rather than indicating the presence of confounding unobservables. Hedonic studies almost always include controls for lot and house size and find that these variables are highly significant, even when price is expressed on a per square foot basis. Two prominent examples are Irwin (2002) and Smith, Poulos, and Kim (2002).

[33]In the Appendix, we display an empirical version of Figure 2 based on the estimates in Table 7.

we experiment with alternative spatial RDD polynomials, again with fairly consistent results. As shown in Appendix Figure A2, the trend in prices over time is similar in each of the areas depicted in Figure 2. More formally, we test for the consistency of effects over time by estimating separate annual models. The same pattern emerges as in our primary results, which mitigates concerns that our results are influenced by time-varying confounders.

6.4 Using historical maps to test for boundary exogeneity

Identification of the local effect of regulation requires that agents be unable to precisely determine their location with respect to the CZB. The institutional setting (discussed in Section 2) shows that this is likely to hold; individual landowners have had little say in the precise placement of the boundary. A testable implication of this claim is that there should be little difference in the properties that changed regulatory status between 1972, when the boundary location was determined solely by coastal geography, and 1976-77, when adjustments to the boundary were made. We digitize maps from the earlier (before 1976) regulatory period and compare observable attributes of properties that changed status from unregulated to regulated and from regulated to unregulated under the modern regime. By comparing the characteristics of these two groups of properties, we can test if properties selected into or out of regulation on the basis of observable factors. Finding no appreciable differences between these groups supports the claim that, conditional on observables, assignment of treatment status is as good as random.[34]

A second way to leverage the original (1972) boundary is to estimate the spatial RDD only on properties that never switched regulatory status. We implement this test using multifamily price and rental income data and compare the estimates of the local effect with those obtained with the unrestricted sample.[35] The results are plotted for bandwidths between 500 and 4,000 feet and with bars indicating 95% confidence intervals (Appendix Figure A3). The price results confirm our finding of a positive local effect, as the results for properties whose regulatory status did not change are either identical to or larger than those for the full sample. Estimates of the local effect are significantly different from zero for most bandwidths. The rental income results also confirm our earlier finding of no local effect.

[34]Results from this exercise are presented in Appendix Table A16. These results are consistent with information obtained in interviews with Coastal Commission staff who stated that the during the 1976-1977 boundary change the scope for individual property owners to select regulatory status was limited.

[35]The unrestricted sample excludes properties in areas where the original CZB map is unavailable, which produces slightly different point estimates from those shown in Figure 4.

7 Interpretation and supporting evidence

Our results indicate the presence of localized and dispersed effects of regulation. We find (i) a *positive* local effect of regulation on prices for multifamily housing units, (ii) no corresponding local effect on rental income, and (iii) significant larger-scale external amenities reflected in both prices and rental income. We use the theoretical model from Section 3 to guide our interpretation of these results.

In theory, the price of a multifamily building is equal to the present value of the discounted stream of rents less management costs (Equation 1). The local effect on prices (Equation 3) is positive if the neighbor effect generates enough additional rental income to more than offset the higher management costs for regulated properties (the own-lot effect). Turner, Haughwout, and Van der Klaauw (2014) interpret RDD estimates as an own-lot effect, to which theory assigns a weakly negative sign. Supplementary RDD results on operating costs are not statistically significant, but suggest that costs may be weakly higher in the regulated area (Appendix Table A6). The zero local effect on rents indicates no current difference in rental income between regulated and unregulated areas due to neighbor restrictions (Equation 6). Therefore, the positive local effect on prices must be due to *anticipated* increases in rental income for regulated properties relative to nearby unregulated properties.[36]

There are several ways in which the Coastal Act might increase expected future rental income. The Coastal Act provides property owners protection against undesirable development by immediate neighbors that are unavailable to those outside the coastal zone. Property owners can use these protections to maintain (or increase) future rents (Ortalo-Magné and Prat 2014). Even if these benefits have not yet materialized, property owners may expect them to in the future. Moreover, undesirable neighboring uses can increase vacancy rates; the Coastal Act offers some insurance against such uses.[37] Finally, additional restrictions on development may lower the variability of future rents in the Coastal Zone. Even if expected future rents are the same near the CZB, investors may prefer properties with less volatile future returns. To be consistent with our findings, these advantages of the Coastal Act must be realized over a spatial scale small enough that they do not spill over into the adjacent unregulated area.

We analyze assessed land and building values to provide evidence of the capitalization of

[36] An implication of our results is that the capitalization rate (the ratio of net income to price) is lower in the regulated area. Supplementary results show that the capitalization rate decreases by approximately 0.2 percentage points at the boundary (Appendix Table A6). If the growth in future rents in the regulated area is temporary, then the capitalization rates inside and outside the Coastal Zone would converge over time.

[37] We have insufficient data on vacancy rates to test for contemporaneous differences.

future rents in land prices. We estimate the local effect separately for land and for buildings (results are reported in Appendix Table A17). Land value estimates are positive and many are significant. In contrast, building value estimates are largely insignificant. These results suggest that the positive local effect is not due to differences in building quality, which comports with our finding of no difference in current rents across the boundary. In contrast, the finding of significant local effects on the land component of property value is consistent with the capitalization of future benefits of regulation.

Further evidence comes from the age distribution of buildings near the CZB. Figure 5 plots the (smoothed) distribution of the year of construction for all sold properties within 4,000 feet of the CZB. Separate histograms are shown for properties inside and outside of the coastal zone. The largest mass of buildings were constructed in the early 1960s; these housing units are near the end of their usable lifespan by the time they show up in our sample.[38] Many property owners will need to replace or renovate these buildings in the near future. This suggests that the effects of the Coastal Act will show up in the expectation of future rents, consistent with our findings. Figure 5 also shows a drop in construction of multifamily housing units in the Coastal Zone following implementation of the Coastal Act. This is consistent with additional restrictions on development and project delays. It also indicates that more buildings inside the Coastal Zone are nearing the end of their service life, which may make the future effects of the Coastal Act more salient.

The fact that most buildings in our sample predate the implementation of the Coastal Act (vertical lines in Figure 5 are added for 1972 and 1976, the years when coastal regulations were adopted) is consistent with our finding of no discontinuity in rents or assessed building values. Additional results (in Appendix Table A15) using only properties built before 1976 are similar to previous results in Table 7. This indicates that the Coastal Act has affected the prices of properties that were built before the regulation took effect. These results reinforce the interpretation of our main results. The quality of these older properties is less likely to vary between the regulated and unregulated areas, consistent with no current differences in rents near the CZB. Higher prices for properties just inside the regulated area must then be due to expectations of future rent increases. This comports with the experience of Cambridge, Massachusetts, after rent control was repealed: uncontrolled properties experienced immediate price increases representing anticipated improvements in neighborhood quality (Autor, Palmer, and Pathak 2014).[39]

[38]The recovery period for residential rental property is 27.5 years, while for nonresidential rental property it is 39 years (United States IRS, Publication 946, How To Depreciate Property, 2015).

[39]Rent control is present in the Cities of Los Angeles and Santa Monica, although not in other coastal

We find evidence of larger scale effects of regulation. According to the theory in Section 3, amenities generated by the regulation raise the current rent and the price of properties inside the regulated area. In contrast to the local effect results suggesting that the neighbor effect is yet to materialize, the positive external effect on rental income indicate that the Coastal Act has already generated these larger scale benefits. These effects have raised property values inside the regulated area, as well as generated smaller spillover benefits for unregulated properties not too far from the CZB.

8 Conclusion

We find that the California Coastal Act raises the price and rental income of multifamily housing units located within the Coastal Zone. The total effect of regulation on prices, an increase of 13-21%, results from local benefits generated from restrictions on immediate neighbors and from amenities operating at a larger spatial scale. Our estimate of the total effect is similar to the 20% effect on single-family house prices found by Kahn, Vaughn, and Zasloff (2010). We show that the total effect on prices is the result of a local effect of approximately +6% and an external effect of about +13%. In contrast to Turner, Haughwout, and Van der Klaauw (2014), who find negative own-lot effects of land-use regulations, our estimate of a positive local effect of the Coastal Act on multifamily housing prices suggests that the positive effects of restrictions on immediate neighbors outweigh any negative effects from regulatory costs. In the case of the Coastal Act, the neighbor effect is likely to arise from provisions of the Act that require neighbors to be informed of planned developments and provide them a legal mechanism to object to such changes. Mechanisms for public participation in the land-use planning and zoning process exist in municipalities throughout the U.S. and are on the rise (Jorden and Hentrich 2003), suggesting that neighbor effects may be a widespread phenomenon.[40]

The total effect of regulation on current rental income, a smaller increase of 7-11%, is solely due to the external effect. The local effect on rental income is zero. These findings suggest that the positive local effect on prices must be due to either anticipated increases in rental income or lower management costs within the Coastal Zone. The latter possibility is

jurisdictions in Southern California. Rent control ordinances were passed in the late 1970s and apply to properties throughout the cities. Rent control only confounds estimates of the local effect if the ex ante proportion of controlled rental units varies discontinuously across the boundary, which is unlikely given the city-wide implementation of the policies.

[40]For example, in many cities in Oregon, residents vote on annexations and amendments to comprehensive plans.

unlikely, as it contradicts the logic that regulatory constraints must have a weakly positive effect on costs. Indeed, we find that current operating costs inside the Coastal Zone are weakly greater than outside. That the positive local effect is due to capitalized future rents is supported by additional evidence on building ages and assessed building and land values. Most housing units in our sample predate the Coastal Act, which explains why assessed building values and current rents do not vary across the CZB. However, pre-1976 buildings are nearing the age when they will need to be renovated or replaced. Property owners within the Coastal Zone will benefit from localized restrictions on neighbors that protect future rental income. Higher assessed land values just inside the Coastal Zone are consistent with the capitalization of future rent increases arising from anticipated positive neighbor effects. Our findings highlight the potential for land-use regulations to have time-varying effect on real estate prices, as shown in recent papers by Autor, Palmer, and Pathak (2014) and Bigelow and Plantinga (2017).

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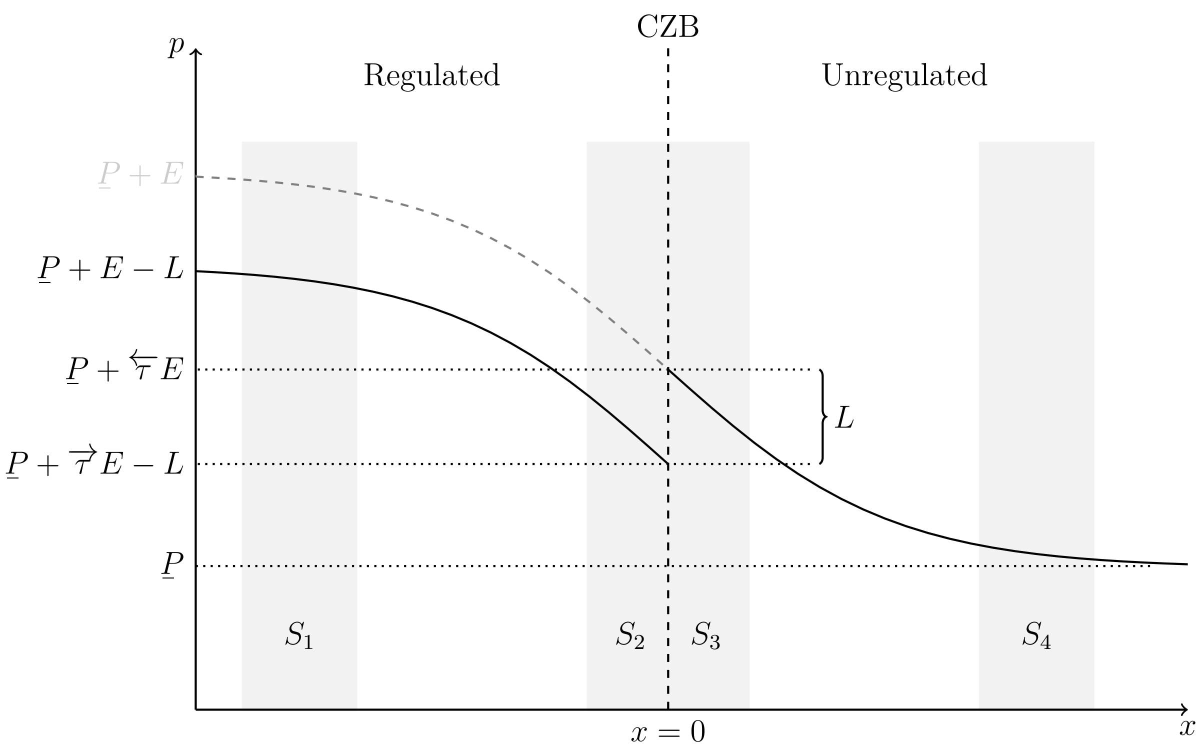
Figures and Tables

Figure 1: Coastal Zone Boundary (Current and Historical) and Restricted Sample Areas in Southern California

Figure 2: Spatial effects of regulation



	S_1: Coastal regulated	S_2: Boundary regulated	S_3: Boundary unregulated	S_4: Inland unregulated
Price or rent	$\underline{P} + E - L$	$\underline{P} + \overrightarrow{\tau} E - L$	$\underline{P} + \overleftarrow{\tau} E$	$\underline{P}$
Total effect	$E - L$	$\overrightarrow{\tau} E - L$	$\overleftarrow{\tau} E$	0
Local effect	$-L$	$-L$	0	0
External effect	E	$\overrightarrow{\tau} E$	$\overleftarrow{\tau} E$	0

Figure 3: Spatial difference-in-differences identification

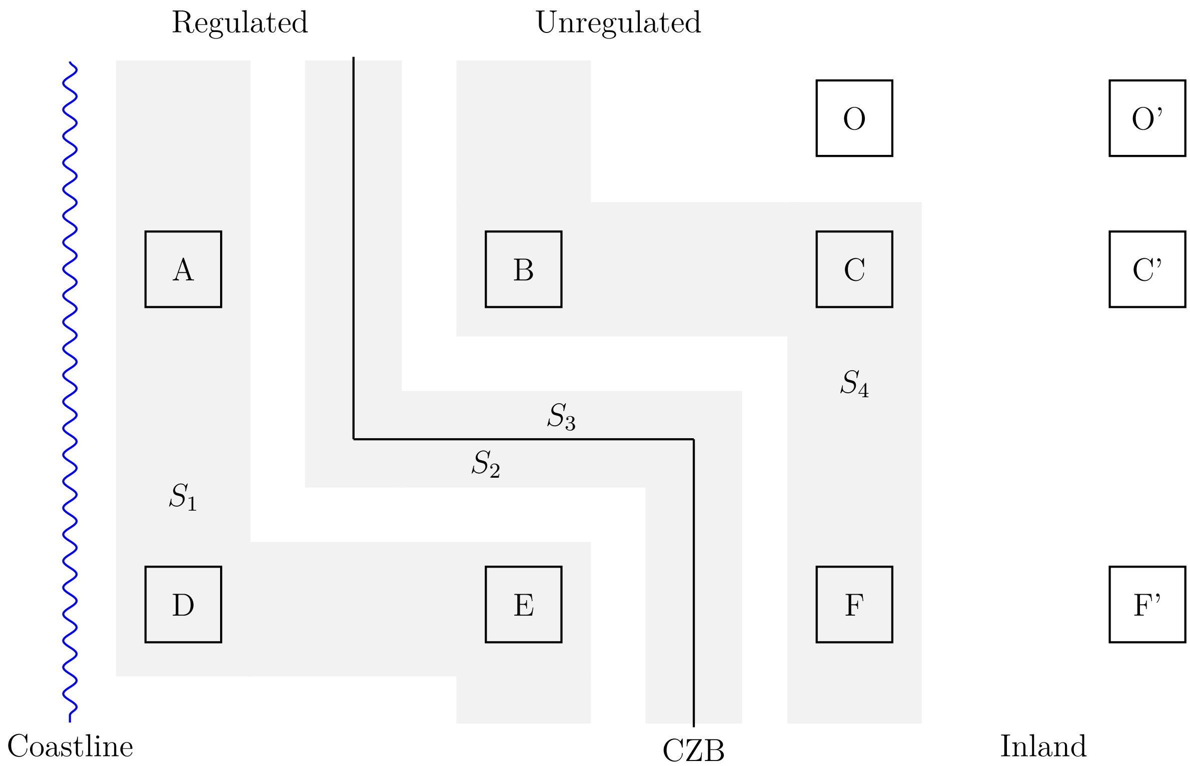


Figure 4: Local effect of regulation on price and rental income, various bandwidths

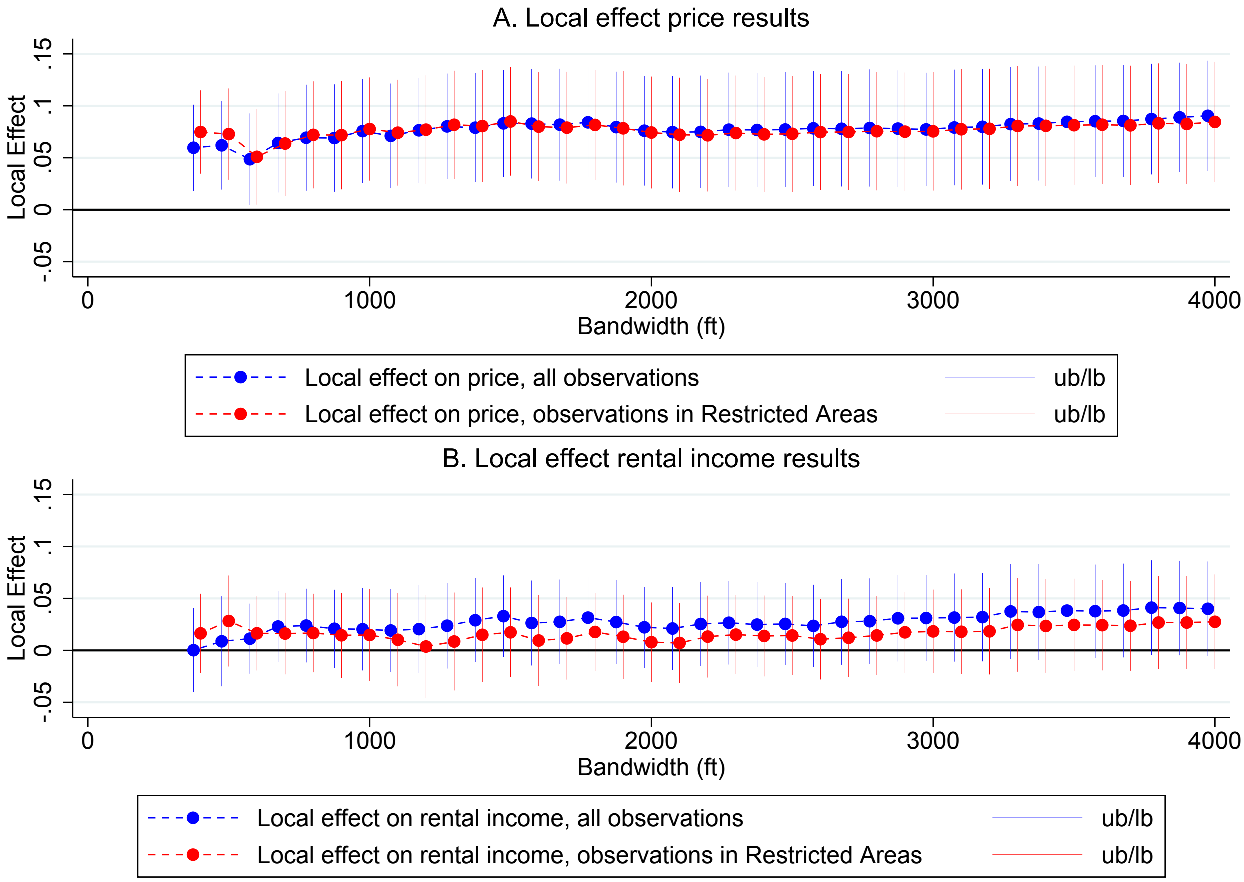


Figure 5: Histogram of year of construction for transacted properties within 4,000 ft. of CZB

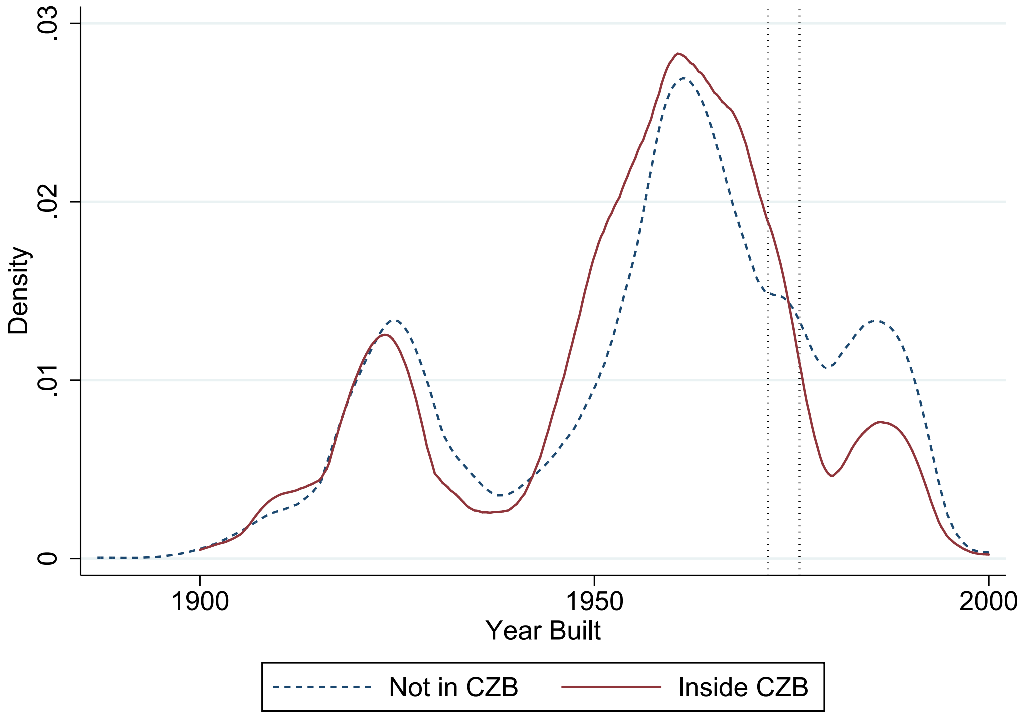


Table 1: Summary statistics on sample within 1,000 feet of CZB

	Regulated		Unregulated	
	Mean	St. Dev.	Mean	St. Dev.
Price per sqft	228.4	[131.7]	191.4	[112.9]
Distance to coast	3,329	[3,528]	5,248	[4,590]
Building sqft	12,784	[20,896]	11,155	[17,350]
Number of units	16.23	[24.90]	13.43	[18.74]
Lot size (sqft)	17,624	[42,952]	14,779	[29,667]
Age at time of sale	60.5	[21.7]	56.2	[21.0]
Elevation	24.52	[16.93]	25.18	[16.45]
Slope	1.65	[1.63]	1.53	[1.59]
% Class A or B	0.11	[0.31]	0.11	[0.31]
N	998		1,502	

Summary statistics and standard deviations [in brackets] for regulated and unregulated properties within 1,000 feet of the CZB.

Table 2: Covariate smoothness tests

	Property characteristics				Topography		Predicted coordinates	
Bandwidth	ln bldg. sqft. (1)	ln lot sqft. (2)	Age (3)	Num. units (4)	Elev. (5)	Slope (6)	Predicted Latitude (7)	Predicted Longitude (8)
500 ft.	0.207**	0.115+	1.34	4.41*	-0.58	0.337+	0.0002	-0.0011
(N=1,255)	(0.070)	(0.061)	(2.01)	(2.13)	(0.82)	(0.182)	(0.0009)	(0.0009)
1,000 ft.	0.169*	0.126+	1.81	4.00*	-2.78**	0.289+	0.0005	-0.0013
(N=2,496)	(0.074)	(0.067)	(1.77)	(1.96)	(0.99)	(0.150)	(0.0009)	(0.0010)
2,000 ft.	0.067	0.012	4.05+	2.26	-5.69**	0.217	0.0005	-0.0016
(N=4,530)	(0.078)	(0.073)	(2.13)	(2.00)	(1.35)	(0.172)	(0.0008)	(0.0010)
4,000 ft.	0.070	0.023	4.58+	2.49	-6.61**	0.241	0.0005	-0.0009
(N=7,790)	(0.072)	(0.073)	(2.46)	(1.82)	(1.62)	(0.178)	(0.0007)	(0.0011)

Each column in each panel is from a separate regression, for thirty-two total. Estimated coefficients are the effect of treatment (T_i) from the spatial RDD presented in the text with the characteristic listed as the dependent variable. All models include 1,000 ft. coastal distance bins, year of sale fixed effects, and zip code fixed effects. Outcome variables (latitude or longitude) in columns (7) and (8) are predicted (as described in the text) using covariates (log building size, log lot size, elevation, slope, age). Standard errors clustered by zip code in parentheses, $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Table 3: Local effect of coastal regulation on sales price

	(1) Price	(2) Price	(3) Price	(4) Price
Panel A: Full sample, all covariates				
Local effect	0.062**	0.076**	0.076**	0.090**
	(0.022)	(0.026)	(0.027)	(0.027)
Panel B: Restricted sample, all covariates				
Local effect	0.073**	0.078**	0.074**	0.084**
	(0.022)	(0.025)	(0.027)	(0.030)
Panel C: Full sample, no covariates				
Local effect	0.018	0.036	0.040	0.049
	(0.024)	(0.029)	(0.029)	(0.030)
Panel D: Full sample, only ln(building size)				
Local effect	0.055*	0.069**	0.052*	0.063*
	(0.023)	(0.023)	(0.025)	(0.025)
N in panel:				
A, C, D	1,255	2,496	4,530	7,790
B	1,057	2,028	3,598	6,103
Bandwidth	500 ft.	1,000 ft.	2,000 ft.	4,000 ft.

Each column in each panel is from a separate regression, for sixteen total. Dependent variable is log sale price per square foot. Sample includes all properties within the indicated bandwidth, except Panel B. All covariates: log building size, log lot size, elevation, slope, and a quadratic in age. Specifications include 1,000 ft. coastal distance bins, year of sale fixed effects, zip code fixed effects, and a linear RDD polynomial in latitude and longitude. Standard errors clustered by zip code in parentheses, $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Table 4: Local effect of coastal regulation on rental income

	(1) Rent	(2) Rent	(3) Rent	(4) Rent
Panel A: Full sample, all covariates				
Local effect	0.009	0.020	0.022	0.040^{+}
	(0.022)	(0.020)	(0.020)	(0.023)
Panel B: Restricted sample, all covariates				
Local effect	0.028	0.015	0.008	0.028
	(0.022)	(0.022)	(0.020)	(0.023)
Panel C: Full sample, no covariates				
Local effect	-0.031^{+}	-0.004	0.005	0.018
	(0.018)	(0.019)	(0.019)	(0.021)
Panel D: Full sample, only ln(building size)				
Local effect	-0.010	0.009	0.009	0.024
	(0.016)	(0.016)	(0.015)	(0.017)
N in panel:				
A, C, D	803	1,650	2,991	5,088
B	674	1,321	2,340	3,903
Bandwidth	500 ft.	1,000 ft.	2,000 ft.	4,000 ft.

Each column in each panel is from a separate regression, for sixteen total. Dependent variable is log gross rental income per square foot. Sample includes all properties within the indicated bandwidth, except Panel B. All covariates: log building size, log lot size, elevation, slope, and a quadratic in age. Specifications include 1,000 ft. coastal distance bins, year of sale fixed effects, zip code fixed effects, and a linear RDD polynomial in latitude and longitude. Standard errors clustered by zip code in parentheses, $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Table 5: Pre-trends test for spatial DiD

	(1) Price	(2) Price	(3) Rent	(4) Rent
ln(Coastal dist.)	-0.060	-0.130*	-0.013	-0.059
	(0.049)	(0.051)	(0.037)	(0.042)
CZB dist. to coast	0.035	0.024	-0.014	-0.035
(all $\times 10^{-5}$)	(0.071)	(0.062)	(0.030)	(0.040)
N	20,192	20,192	13,553	13,553
Covariates	-	All	-	All

The dependent variable is log price or log gross rental income per square foot. Sample includes all observations that are (i) inland from the CZB and (ii) more than 1,000 feet away from the CZB. All specifications include year of sale and zip code fixed effects. Standard errors clustered by zip code in parentheses, $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Table 6: Total effect of regulation on prices and rents

	(1)	(2)	(3)	(4)	(5)
	Panel A. Log price per square foot				
Total effect	0.083	0.100	0.134*	0.082	0.129*
	(0.066)	(0.062)	(0.062)	(0.056)	(0.062)
N	6,339	6,339	6,339	5,124	6,339
	Panel B. Log rental income per square foot				
Total effect	0.050	0.054	0.069+	0.065+	0.065
	(0.063)	(0.062)	(0.038)	(0.035)	(0.039)
N	4,031	4,031	4,031	3,228	4,031
Covariates	-	Size	All	All	All
Sample	Full	Full	Full	Rstrd	Full
Coastal Amenity	Bins	Bins	Bins	Bins	Bins/Dist

Each column in each panel is a separate regression, for ten total. The dependent variable is log price or log gross rental income per square foot. Sample includes all observations that are (i) within 500 and 10,000 feet of the coast and (ii) more than 1,000 feet away from the CZB. All specifications include 500 ft. coastal distance bins, year of sale fixed effects and zip code fixed effects. All covariates indicates: log building size, log lot size, elevation, slope, and a quadratic in age. Standard errors clustered by zip code in parentheses, $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Table 7: Combined estimator, full sample, simple linear bins

	(1)	(2)	(3)
Panel A: Log price per square foot			
Local effect ($\beta_1 + \beta_2$)	0.054*	0.060*	0.075**
	(0.024)	(0.024)	(0.025)
Partial external effect (β_0)	0.068**	0.091**	0.070*
	(0.025)	(0.027)	(0.029)
External effect ($-\beta_2$)	0.125**	0.152**	0.174**
	(0.043)	(0.052)	(0.058)
N	3,288	6,550	5,753
Panel B: Log rental income per square foot			
Local effect ($\beta_1 + \beta_2$)	0.008	0.014	0.019
	(0.021)	(0.022)	(0.019)
Partial external effect (β_0)	0.066*	0.093**	0.064+
	(0.027)	(0.024)	(0.033)
External effect ($-\beta_2$)	0.087+	0.103*	0.064
	(0.047)	(0.046)	(0.058)
N	2,145	4,244	3,748
Bandwidth			
Interior	0-500 ft.	0-500 ft.	0-1k ft.
Exterior	1k-2k ft.	1k-4k ft.	2k-4k ft.

Each column in each panel is a separate regression (for six total) and reports three effect estimates. Sample includes all data within either the internal or external bandwidths in absolute distance from the CZB. Outcome is indicated in panel titles, and regressions include covariates (log building size, log lot size, elevation, slope, and a quadratic in age), indicators for distance to the coast in 1,000 foot wide bins, year of sale fixed effects, and zip code fixed effects. Standard errors clustered by zip code in parentheses, $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.