The Impact of Land Use Restriction on Housing Supply and Urban Form

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Abstract

Rising home prices have led to public concern regarding housing affordability and availability. Interest in the role that land use regulations may play in reducing housing availability has been of increasing interest. While many of these regulations were initially implemented to preserve neighborhood character and promote sustainable growth, many contend that these regulations have the unintentional consequence of restricting supply and raising housing costs. Previous literature typically studies the impacts of land use regulation in individual cities or metropolitan areas, but questions remain whether these results can generalize to other cities across the country. Utilizing a two-time period panel dataset on city-level regulations across the nation, I assess whether minimum lot size, project approval delays, and impact fees cause a reduction in housing availability across cities. In most cases, increased levels of these regulations reduce housing availability in jurisdictions of medium to high population density whereas results are insignificant for jurisdictions of low population density.

JEL classification: R14; R31; R38

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1 Introduction

Housing has become increasingly unaffordable for many Americans. Real house prices, controlled for quality, are about 15% above their peak prior to the Global Financial Crisis of 2007-2009 (Glaeser & Gyourko, 2025). Various land use regulations may impose constraints on developers, resulting in a reduction in the housing supply and thereby raising prices. Thus, the role that land use regulations may play in reducing housing affordability has become a topic of significant interest in economic research (Glaeser & Gyourko, 2018). Many attribute housing affordability crises to densely populated coastal markets. While coastal housing markets tend to be the most expensive and highly regulated, housing construction has been low or falling across the United States since 2000, whether in high-density coastal markets or low-density suburbs. Thus, housing affordability is a national problem that affects metropolitan areas of all density types throughout the country (Baum-Snow, 2023).

At least one cost of increased regulation is clear: the artificial restriction of supply of homes inflates the price, preventing many potential buyers from purchasing a home (Baum-Snow, 2023). Nevertheless, potential costs of regulation go beyond the simple raise in price. For example, Hsieh and Moretti (2019) show that the spatial misallocation of labor because of artificially suppressed density has led to 36% of GDP growth in the years 1964-2009 being unrealized. Highly skilled workers are unable to access the high-productivity labor markets of cities like New York and San Francisco due to those cities' restrictions preventing the addition of new and highly dense developments.

The types of regulations that a city can implement are quite variable. For example, common regulations include minimum lot sizes, floor-to-area ratio (FAR) regulations, and general zoning requirements. Minimum lot sizes are a prominent regulation – they are nearly ubiquitous among American jurisdictions. Floor-to-area ratio regulations restrict the structure built on a given property from being above a certain percentage of the overall lot size. General zoning requirements refer to the notion that jurisdictions may only permit certain structure types from being built on certain properties. For example, single-family zoning prevents any multi-family structures such as townhomes, duplexes, and apartment buildings even though these structures could act to significantly increase density and housing supply.

A common motivation for imposing regulations is for preservation of the community's status quo. Many current residents resist the change brought on by development that may alter the character of a community. This behavior is colloquially known as NIMBYism and has extensively been studied as a source of higher regulation (Einstein et al., 2020). The causes of regulation go beyond NIMBYism, however. Jurisdictions may require buildings to adhere to certain architectural styles to receive permits, for example. Single-family zoning may protect unwanted structures from being built on nearby properties. On the extreme level, high density can also lead to reduced sunlight and greenspace (Kono & Joshi, 2019). Moreover, the congestion that can potentially arise from increased density could result in higher levels of air pollution. Thus, regulation clearly serves to produce some social benefit. Nevertheless, it remains unclear for a given policy whether the marginal social benefit of regulation offsets the marginal costs that the policy can incur via restricting housing supply.

This paper presents an analysis of how three different forms of land use restriction impact the supply of housing across American cities. The three forms of restriction I analyze are minimum lot sizes, delays in development project approvals, and whether the city imposes an impact fee.[1] I utilize a novel panel dataset that describes how regulations have changed between

[1] These are fees that developers must pay to account for the costs of adding public infrastructure, such as water and sewer, to new developments.

2006 and 2018 across 806 cities. Given that Baum-Snow (2023) describes how housing markets behave differently depending on the size and density of the market, I assess how the impacts of the three regulations differ conditional on the population density of a given city. I find that increased density controls, delays, and impact fees have statistically significant negative effects on housing supply only in jurisdictions of medium to high population densities.

The rest of the paper proceeds as follows: section 2 provides an overview of the current literature that has studied the impact of land use regulations on the housing market. Section 3 presents a brief theoretical framework that motivates my empirical analysis. Section 4 describes the data that underlies the analysis. Section 5 describes the empirical specification I employ to understand the regulations' effects. Section 6 presents results from my empirical specification, and Section 7 briefly concludes.

2 Literature Review

2. 1 Effects of Land Use Regulation on Home and Land Price

My analysis contributes to a growing literature studying the economic implications of land use regulation. A significant subsection of the literature primarily focuses on how changing regulations may affect home and property prices. For example, Turner et al. (2014) propose a framework that separates the effects of regulation on land prices due to own-lot and external-lot effects. Given a property, own-lot effects refer to the potential price effect of increased land use regulation on the given property whereas external-lot effects refer to the potential change in value of the given lot due to how increased land use regulation affects nearby lots. They hypothesize that the decreased option-value of the land due to increased regulation would result in a decrease of the property's value. To address potential endogeneity in how parcel characteristics could influence regulation, the researchers utilize a regression discontinuity approach. By focusing on parcels near the border between two municipalities, they attempt to eliminate the effects unobserved heterogeneity between municipalities may have on their estimates of price changes. They find an economically meaningful negative own-let effect whereas the external-lot effect is not statistically meaningful. In a spatial model of Beijing height restrictions, Ding (2013) finds a similar negative price effect on land due to increased restrictions.

Grout et al. (2011) employ a similar empirical approach to Turner et. al (2014) by utilizing a regression discontinuity model at the Urban Growth Boundary (UGB) in Portland, Oregon. The Urban Growth Boundary is regulatory boundary around Portland, Oregon where properties within the boundary have a larger option-set for development, such as high-density residential zoning and commercial zoning. Parcels outside the boundary are zoned for less intensive uses, such as agriculture and low-density residential development. There may be unobserved variables, such as topography and soil quality that influence property values and government decisions to implement certain regulations. The discontinuity approach at the UGB assumes a continuous change in these unobservable variables near the boundary, eliminating the bias they may create in determining the effect of regulation. The researchers find that being outside the UGB yields a negative price effect on land values ranging from $30,000 per acre to $140,000 per acre in varying areas of the city.

While the aforementioned studies focus on price effects of raw land values, other studies focus on price effects of regulation on homes. For example, Davidoff et al. (2022) further study the external-lot effects of regulation as discussed in Turner et al. (2014). The researchers exploit a change in Vancouver zoning that enabled essentially all properties zoned for single-family homes to build an accessory dwelling unit (ADU) on their property. ADUs, also referred to as laneway homes, are small units that property owners can either use themselves or rent to other households. Having a neighbor build a laneway home may result in decreased value of your own home, given that public amenities may become more crowded, and you may lose some amount of privacy given the higher density of the neighborhood. Davidoff et. al (2022) find that the negative spillover effect from a neighbor building an ADU is small and statistically insignificant for less expensive neighborhoods. For more expensive neighborhoods in Vancouver, however, the negative effect is larger in magnitude and statistically different from zero. This may suggest that wealthier residents are more willing to pay for added privacy and less crowding of public amenities.

In an analysis of how more stringent minimum lot size restrictions affect home prices in the Boston metropolitan area, Zabel and Dalton (2011) find statistically significant positive price effects from increased restriction. These positive price effects can range up to 20%. Interestingly, they also find that the magnitude of the effect increases with time, meaning that homes sold longer after the increase in minimum lot size restriction receive a larger price effect on average. To control for unobservable characteristics in districts that alter their restrictions, the researchers utilize zoning district fixed effects in a hedonic regression model. They further construct a town-level price index to control for any bias that rising or falling town prices may produce by impacting regulation implementation. Using similar hedonic regression models from 1990 and 2000 regulatory and real estate data in California, Quigley and Raphael (2005) find a positive relationship between regulatory restrictiveness and home prices. Their variable of interest accounts for general growth restrictions, not a singular policy.

In a study of how regulatory constraints affect home prices in England, Hilber and Vermeulen (2016) find that home prices would be around 35% lower in 2008 in the absence of regulation. Again, they acknowledge the presence of endogeneity, as existing home prices may influence the decision to implement regulatory change. In a novel approach to eliminate this endogeneity, Hilber and Vermeulen utilize two instrumental variables: jurisdictional responses to a nationwide regulatory reform in 2002 that affected all zoning jurisdictions in England and the Labour Party vote share in the 1983 General Election. Hilber and Vermeulen also claim omitted variable bias may exist due to topographical preferences among households; thus, they directly control for topography using satellite data. Other studies have also treated regulation as endogenous and use instrumental variables to combat this. In an analysis of cities and Florida, Ihlanfeldt (2007) uses various demographic variables as instruments for regulation and finds that increases in a general regulation index cause a decrease in land price and an increase in house prices.

The literature examining the price effects of regulation is quite rich. Other studies that conduct regression discontinuity approaches find similar price impacts: for example, in an analysis of a regulatory reform in Sao Paolo, neighborhoods that allowed for more densification saw a 0.5% decrease in home prices in the long run. Interestingly, the analysis finds that welfare overall decreases, as gains by consumers due to lower home prices are overshadowed by welfare losses for landlords and existing homeowners (Santosh Anagol et al., 2021).

2.2 Effects of Land Use Regulations on Housing Supply

The literature on the economic implications of land use regulation goes beyond the effects on land and house prices. Many articles also study the impacts that various regulations may have on the quantity of housing available. Glaeser and Ward (2009) examine various townships in the Boston metropolitan area and whether increased regulation resulted in decreased construction activity. They utilize township fixed effects to control for potential unobserved time invariant variables that could bias their estimates of the causal effect. The regulations of interest include wetland construction restrictions, septic restrictions, and minimum lot size. A one acre per lot increase in minimum lot size is associated with a 40% decrease in construction permits between 1980 and 2002. Moreover, the addition of wetland and septic restrictions each further reduces construction permits by around 10%.

Using regulatory data from US metropolitan areas between 1985 and 1986, Mayer and Sommerville (2000) find that certain restrictions have negative impacts on new construction starts at the metropolitan level. Increased impact fees do not have a statistically significant impact on construction starts; however, the authors construct an index that measures the delay of project approval and find meaningful negative effects on construction starts. To correct for any possible endogeneity between construction levels and restrictiveness, the researchers utilize instrumental variables such as educational attainment and Republican vote share in the 1984 presidential election. Several other studies in the literature have shown general negative impacts on permits and construction starts because of increased regulation (Skidmore & Peddle, 2006; Jackson, 2014)

In addition to studying direct measures of housing supply such as construction starts, other research has looked more closely into the price elasticity of housing supply. As price elasticity of housing supply increases, positive demand shocks would induce higher levels of construction. On the other hand, lower price elasticity indicates that construction may not respond sufficiently to positive demand shocks, thus further raising home prices. Since regulations may create frictions in the construction process, it's logical to expect that increased regulation may reduce housing supply elasticity. Indeed, Quigley and Raphael (2005) find that

California cities with higher levels of land use regulation are associated with a lower price elasticity of housing supply.

Similarly, Saiz (2010) finds that both geographic constraints and regulatory constraints reduce the elasticity of housing supply at the metropolitan level. Using a cross-section of regulatory data, he finds evidence that the level of regulatory restrictions is endogenous with respect to house prices and population growth but corrects for this by using an instrumental variable. Wheaton et al. (2014) utilize a time series model for 68 US metro areas and find that lower housing supply elasticity is associated with higher regulatory constraint. Other papers that utilize time series methods have found similar results (Green et al., 2005; Harter-Drieman, 2004).

2.3 Effects of Land Use Regulation on Urban Form

A smaller subset of the literature primarily focuses on how various land use regulations may affect urban form, or the built environment of the area of interest. As urban sprawl can have negative welfare effects due to commuting costs and higher home prices, understanding how land use restrictions may influence urban form is of interest (Bertaud & Brueckner, 2005). Variables of interest may include lot size, house size, homes per acre, and construction of multifamily housing relative to single family housing.

In a study that uses a similar empirical framework to Turner et al. (2014), larger minimum lot size restrictions are shown to reduce housing density by about 11% and increase house size by about 80 square feet. Like Turner et al. (2014), the use of a regression discontinuity that exploits parcels near administrative borders, the researchers can control for unobserved variables that may bias empirical estimates (McCulloch & Gyourko, 2023).

Kulka, Sood and Chiumenti (2023) also employ a discontinuity design between towns in the Boston area and find that decreasing density controls alone has an economically meaningful positive impact on the supply of multifamily housing. In their model, they also interact direct density controls with maximum height allowances and find that the pairing relaxed density controls with relaxed height restrictions further increases the supply of multifamily housing. Other studies have indicated that direct density restrictions decrease the supply of multifamily housing relative to single family housing (Pendall, 2000).

2.4 Gaps in the Literature

In terms of the literature on the effects of regulation on housing supply, many papers focus on singular regions or metropolitan areas (Glaeser & Ward, 2009; Jackson, 2014). Questions remain as to whether these results generalize to cities across the country. Furthermore, most of the supply literature focuses on construction starts and permits as the outcome of interest (Mayer & Sommerville, 2000). To directly understand potential shortages in housing availability, I plan to use number of available housing units per household as my outcome of interest. The number of housing units per household is a direct measure of housing supply shortages that could lead to increases in price. To the best of my knowledge, this outcome of interest is understudied. Additionally, I assess how the impacts of density restrictions, approval delays, and impact fees vary across population densities. Many studies in the literature do not empirically evaluate the differential effects of regulation conditional on population density.

3 Theoretical Framework

3.1 Determinants of Housing Supply

When assessing the impact of regulation on housing supply directly, I utilize the theoretical foundation presented in Hilber and Vermuelen (2014). Hilber and Vermuelen attempt to estimate the how price elasticity of housing supply varies with regulatory constraints. In doing so, they construct a relatively simplistic theoretical framework of the housing market in each local planning authority. First, for housing demand, they assume individual household utility V_h to be a function of the form

$$V_h(Y, P, A) = Y - P + A + \varepsilon(h)$$

where Y denotes local earnings, P denotes local housing prices, and A denotes local amenities. They also include an idiosyncratic factor $\varepsilon(h)$ for each household that can include personal and family ties to the local area. Local amenities may include the presence of parks, school quality, commute times to work, and preferable topography. In a sorting framework, households choose a jurisdiction in which to live that maximizes this household utility function.

On the supply side of the market, Hilber and Vermeulen assume a convex cost function of the form

$$C(Q_s, X) = \frac{1}{2} Q_s^2 X$$

where Q_s denotes the current housing supply and X captures additional supply constraints such as geographical constraints and regulatory constraints. Assuming that developers are price-takers, they will supply new housing until the marginal cost of additional housing is equal to price, or P = $Q_s X$. Thus, when assessing how regulatory constraints directly affect supply, we see that the quantity of housing supply is a function of regulatory constraints and equilibrium price in a housing market. From the consumer standpoint, this equilibrium price is also a function of potential earnings and local amenities. Thus, such variables should be accounted for in an empirical framework.

3.2 Potential for Differential Impacts Across Existing Densities

Previous findings present evidence that the impacts of restrictive regulation vary according to the existing urban form of the area of study. For example, in construction of a theoretical model of density controls, Mills (2005) estimates the welfare impacts of density controls. He shows that density controls increase urban sprawl in metropolitan areas relative to areas that lack controls. Some residents may prefer lower density, creating a benefit for these residents as the urban form becomes less dense. However, Mills shows that even with the benefit, the added housing costs and commuting times that sprawl creates reduce welfare overall. A key component of Mills' analysis is that he assumes heterogeneity in household preferences for density. Assuming households have heterogeneous preferences for density, the impacts of direct density controls may vary based on the existing urban form of the area of interest. Further, it's logical to expect that density restrictions, such as minimum lot sizes, are the most binding in typically suburban and urban areas while they may be less binding in rural areas. Thus, in my empirical analysis, I assess the impacts of restrictions across various levels of population density.

4 Data

To assess the price impacts of various land use regulations, this paper utilizes a panel dataset of two time periods that consists of 806 cities and towns. From this point onward, I refer to the cities and towns collectively as jurisdictions. I paired each jurisdiction with regulatory data from the 2018 and 2006 versions of the Wharton Residential Regulation Index dataset (see below). I also utilize 5-year American Community Survey data from IPUMS NHGIS to pair each jurisdiction with demographic and economic data.

4.1 Wharton Residential Land Use Regulatory Index

I begin construction of my dataset with the Wharton Residential Land Use Regulatory Index (WRLURI). The creators of the dataset compiled responses from jurisdictions across the United States to questions related to the jurisdiction's regulatory environment. The responses are typically from city managers or other executives in the jurisdiction's government. The survey has been conducted twice: once in 2006 and most recently in 2018. As many jurisdictions answered both surveys, the survey's creators believe this to be the first nationwide panel dataset that documents change in local regulatory environments. As most research regarding land-use regulation occurs in case studies at the local level, this new panel dataset allows for novel analysis of nationwide trends (Gyourko et al., 2021).

Questions range across different areas for land-use regulation. For example, the researchers ask whether the jurisdiction has a minimum lot size. If so, jurisdictions then specify if the largest minimum lot size falls within 4 categories: <0.5 acres, 0.5-1.0 acres, 1-2 acres, or 2+ acres. Other questions include whether there exist annual hard caps on permits and the number of committees project must receive approval from before construction. As the questions cover a large range of regulation types, the researchers construct several subindices that represent the level of restrictiveness in different regulatory categories. The researchers then compile these subindices into an overall index, the namesake WRLURI, that is intended to capture the restrictiveness of the overall regulatory environment. To compile each subindex into the overall index, the authors use factor analysis. For this paper, I am primarily concerned with the impact of density controls and project delays. Thus, I choose to utilize three subindices - the Density Restriction Index, the Approval Delay Index, and the Exactions Index – as opposed to the overall namesake WRLURI.

4.1.1 Density Restriction Index (DRI):

The DRI measures direct density controls via minimum lot size restriction. A score for a given jurisdiction can range from 0 to 5 based on the restrictiveness of minimum lot sizes in the jurisdiction. See Table 1 for a more detailed description of how the index is constructed.

Table 1. Assignment Criteria for DRI Score

Score	Criteria
0	no minimum lot size in the jurisdiction
1	largest minimum lot size is less than 0.5 acres
2	largest minimum lot size is between 0.5 and 1 acre
3	largest minimum lot size is between 1 and 2 acres
4	largest minimum lot size is greater than 2.0 acres

4.1.2 Approval Delay Index. (ADI)

The ADI index is a measure of the length of time it takes for proposed projects to receive a permit. Surveyed jurisdictions are asked about the typical length of time for projects to receive approval in the following categories:

A. How many months it typically takes for review of a by-right (currently permitted) residential project. This is asked for both single family and multifamily projects and the average is taken.
B. How many months it typically takes for a review of a not-by-right (not currently permitted by rules) residential project. This is asked for both single family and multifamily projects and the average is taken.

C. Typical amount of time (in months) between application for rezoning and issuance of permit for the following three categories: single family developments with < 50 units; single family developments with > 50 units; and multifamily developments. The average is taken.

D. Typical amount of time between application for subdivision approval and issuance of permit for the following three categories: single family developments with < 50 units; single family developments with > 50 units; and multifamily developments. The average is taken.

The ADI is then the average of the above 4 quantities.

4.1.3 Exactions Index (EI)

The exactions index (EI) is a binary indicator variable that takes a value of 1 if the jurisdiction imposes any impact fees. Impact fees are fees imposed on developers by jurisdictions that account for the cost of adding public infrastructure to new developments.

I utilize these 3 indices (the DRI, ADI, and EI) as explanatory variables. I further standardize each variable to have mean zero and variance 1. Using standardization, I can then interpret regression coefficients as the effects of a 1 standard deviation increase of each index.

Several subindices had little variation for a given city over time. (Gyourko et al., 2021). However, the ADI, the DRI, and the EI had sufficient variation across years to identify estimates of at least some statistical significance. Descriptive scatterplots show a consistent negative relationship with each higher levels of subindex and the number of housing units available per household (see Appendix Figures A1-A3). Summary statistics for each subindex and the overall index are presented in Appendix Table A1. Overall, we see an average increase in the DRI from

2006-2018. The mean for the ADI doesn't change significantly, although the standard deviation increases. The EI tends to decrease on average from 2006 to 2018.

4.2 American Community Survey

I further pair each jurisdiction with demographic and economic data from the American Community Survey (ACS) 5-year estimates. Many demographic variables are only available in the single-year estimates of the ACS for jurisdictions with populations of over 65,000. As most of the jurisdictions in the WRLURI dataset have populations of less than this threshold, I opt to use 5-year estimates instead. I pair regulatory data from the 2006 publication of the WRLURI with 2006-2010 ACS estimates. Similarly, I pair regulatory data from the 2018 publication of the WRLURI with 2018-2022 ACS estimates. For the remainder of this paper, I refer to each ACS dataset with the first year of its 5-year window. I source ACS data from IPUMS NHGIS, a data tool that compiles Census datafiles, including the ACS. I source the following data from the American Community Survey: total population, median household income, median home value, GINI coefficient of income inequality, number of households, number of housing units, average commute time to work, land area, and proportion of each race, and proportion of residents with a bachelor's degree or higher[2].

My outcome variable of interest is the number of housing units per household in each jurisdiction. From the ACS data, I divided the number of housing units in a jurisdiction by the number of total households. See Appendix Table A2 for summary statistics on the number of housing units per household by year. Again, I am looking at regulatory impacts on housing units per household across population densities. I construct a population density variable by dividing

[2] I utilize the jurisdiction's proportion of residents with a bachelor's degree or higher as a proxy for quality of education in the jurisdiction. Glaeser & Ward (2009) also utilize this proxy.

total population by land area for each jurisdiction. The distribution of population densities pooled across both 2006 and 2018 is shown in Figure 1.

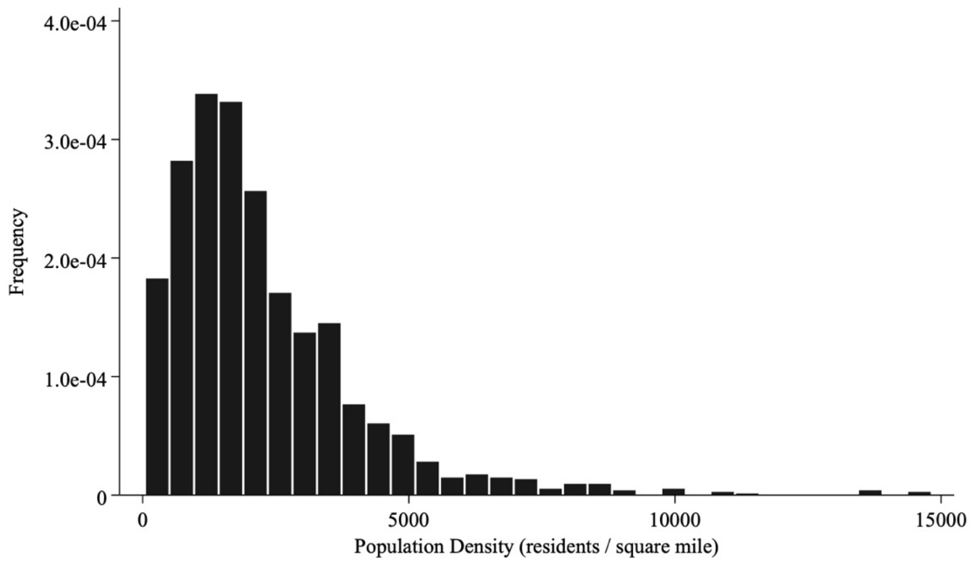


Figure 1: Distribution of Population Densities in Pooled Samples

Several control variables require separate calculations. First, for median household income and median home value, I adjust the 2006-2010 value to 2022 dollars to ensure that change in price does not simply reflect inflation.[3] Further, ACS estimates for median household income are winsorized to $250,001 for any values above this level. When I adjust for inflation, some jurisdictions in 2006 have incomes above this level. For consistency, I re-winsorize these values to back to $250,001. Similarly, the winsorization threshold changes for median home value from 2006 to 2018. In the 2006 data, home prices are winsorized at $1,000,001, whereas in 2018, home prices are winsorized at $2,000,001. After adjusting for inflation, for consistency I

[3] Dollar estimates in ACS 5-year data are adjusted for inflation to the final year of the window; hence, I adjust to 2022 since that is the final year of the 2018-2022 window. I utilize the CPI as the price index for adjustment.

winsorize both periods to have a maximum value of $1,000,001. For robustness, I re-ran my models without the winsorization adjustments and found no significant difference in my results.

For the average commute time to work, the ACS reports to number of residents that fall in various travel time intervals. To arrive at a single figure, I calculate a weighted average using the midpoint of each interval. The remaining control variables are either given directly in the ACS data or require simple proportion calculations. See appendix tables A3 for summary statistics of each control variable by year.

4.3 Sample Creation

To create the panel dataset, I began with both the 2006 and 2018 WRLURI datasets. The 2018 dataset contains responses from 2,844 jurisdictions whereas the 2006 dataset contains responses from 2,729 jurisdictions. There are 806 jurisdictions that answered at lost some component of both surveys. As housing affordability is primarily of interest in urban and suburban areas, I planned to drop jurisdictions that were not listed as part of a Core-Based Statistical Area (CBSA) as defined by the U.S. Census Bureau. Nevertheless, none of the 806 jurisdictions listed in both surveys were listed as non-members of a CSBA.

The jurisdictions in the WRLURI data are classified in ACS 5-year data as either Census-designated places (CDPs) or Census County Divisions (CCD). The 2018 ACS contains data on 32,186 CDPs and 36,016 CCDs. The 2006 ACS contains data on 29,514 CDPs and 36,165 CCDs. Using unique FIPS identifiers, I matched the 806 jurisdictions listed in both cities to their respective demographic and economic data in 2006 and 2018.

5 Empirical Framework

5.1 Baseline TWFE Model

To understand the relationship between various regulations and the quantity supplied of housing, I utilize the number of housing units available per households in each jurisdiction as my outcome variable of interest. Higher values would indicate a surplus of available housing for the jurisdiction. I utilize a two-way fixed effects model that can be expressed as

$$\ln(Q_{jt}) = \beta_0 + \beta_1 regulation_{jt} + \beta_2 \boldsymbol{X}_{jt} + \alpha_j + \lambda_t + \varepsilon_{jt} \tag{1}$$

where Q_{jt} is the number of housing units per household for jurisdiction *j* at time *t*. $regulation_{jt}$ is the level of the subindex of interest for jurisdiction *j* at time *t*. $\boldsymbol{X}_{jt}$ is a vector of control variables[4] for jurisdiction *j* at time *t*. α_j are jurisdiction fixed effects. λ_t represents a dummy variable for year to control for time fixed effects. ε_{jt} is an idiosyncratic error term.

The DRI is standardized to have mean 0 and a variance of 1. Moreover, by taking the natural log of the number of housing units per household, the interpretation of β_1 can be viewed as the impact of a 1 standard deviation increase in DRI on the quantity of housing units per household in percentage terms.

As discussed in the theoretical framework, the demand for housing, which influences supply, can be viewed as a function of certain public goods, such as the presence of parks, preferable topography, and more. Due to the difficulty of measuring such characteristics, I include jurisdictional fixed effects to yield within-jurisdiction estimates. By looking at within estimates, I control for time invariant unobservable heterogeneity across jurisdictions, such as geography, that

[4] The control variables I utilize are population density, median household income, median home value, the Gini coefficient of income inequality, the unemployment rate, average commute times to work, proportion of resident's with a bachelor's degree or higher, and proportion of white residents to control for demographic impacts.

may affect both regulation and housing supply. Similarly, the year fixed effect can account for economic conditions that affect all jurisdictions; this can include macroeconomic conditions.

Lastly, the population of each jurisdiction in 2006 is utilized as an analytic weight due to the large variation of total populations across jurisdiction. Due potential serial correlation of errors among jurisdictions, I cluster standard errors by city.

5.2 Incorporating All Policies

The previous model assesses the impact of policies within jurisdictions by including one policy in the model at a time. This may produce potential omitted variable bias, as the level of one policy may be correlated with another policy that is truly driving the effect on the quantity of housing units per household. Thus, I also regress the quantity of housing per household on each policy concurrently. This isolates the partial effect of each policy by holding the values of the other policies constant, helping to alleviate concerns about omitted variable bias. This version of the regression model is expressed as:

$$\ln(Q_{jt}) = \beta_0 + \beta_1 DRI_{jt} + \beta_2 ADI_{jt} + \beta_3 EI_{jt} + \beta_4 \boldsymbol{X}_{jt} + \alpha_j + \lambda_t + \varepsilon_{jt} \tag{2}$$

where again Q_{jt} denotes the quantity of housing units per household in jurisdiction *j* at time *t*. DRI_{jt} is the level of the Density Restriction Index in jurisdiction *j* at time *t*, ADI_{jt} is the level of the Approval Delay Index in jurisdiction *j* at time *t*, and EI_{jt} denotes a binary indicator of whether jurisdiction *j* utilizes exaction fees at time *t*. Again, I utilize both jurisdiction and year fixed effects to control for any unobserved heterogeneity that may impact the outcome of interest and the explanatory variable. I also again use total population as an analytic weight and cluster standard errors by jurisdiction.

5.3 Interactions of Policies

Since the Exactions Index is a binary indicator, it may be illuminating to note how the DRI and the ADI behave with and without the presence of exaction fees. I assess this relationship with the following model

$$\ln(Q_{jt}) = \beta_0 + \beta_1 DRI_{jt} + \beta_2 ADI_{jt} + \beta_3 EI_{jt} + \beta_4 (DRI * EI)_{jt} + \beta_5 (ADI * EI)_{jt}$$
$$+\beta_6 \boldsymbol{X}_{jt} + \alpha_j + \lambda_t + \varepsilon_{jt}. \tag{3}$$

In this model, Q_{jt} again denotes the quantity of housing units per household in jurisdiction *j* at time *t*. $(DRI * EI)$ represents the interaction between the DRI and the existence of impact fees. $(ADI * EI)$ represents the interaction between the ADI and the existence of impact fees. Thus, according to this model, β_1 denotes the impact of a 1 standard deviation increase in the DRI in jurisdictions without impact fees. If the jurisdiction has an impact fee, then the total effect of a 1 standard deviation increase in the DRI is $\beta_1 + \beta_4$. Similarly, β_2 denotes the impact of a 1 standard deviation increase in the ADI within jurisdictions without impact fees. If the jurisdiction has an impact fee, then the total effect of a 1 standard deviation increase in the ADI is $\beta_2 + \beta_5$. I again utilized jurisdiction and year fixed effects. I again use total population as an analytic weight and cluster standard errors by jurisdiction.

5.4 Endogeneity Concerns

It is important to note that there are valid endogeneity concerns with the above models. More specifically, it may be the case that cities that experience housing crises are likely to alter their levels regulations during the period of study. Many candidates for instrumental variables, such as political voting patterns and statewide policy reforms, likely do not satisfy the exclusionary requirement for IV estimation. However, since housing crises tend to manifest via home prices, by controlling for home price in the above estimates, I hope to partially remove the effect that housing crises may play in influencing quantity and regulation levels. I also regress a city's change in regulation between 2006 and 2018 on the change in housing units per household from 2000-2006 using the same control variables as the above models and find no relationship that is statistically different from 0 for any regulation I use (see Appendix Table A4). Lastly, Glaeser & Ward (2009) find evidence in a sample of Boston towns that density controls appear to be enacted quasi-randomly. Although this cannot be generalized to a nationwide sample, it does provide some reassurance.

6 Results and Discussion

Throughout my discussion of the results, the quintiles of population density remain constant. The range of the quintiles are reported in Table 2.

Table 2: Population Density Quintiles Within Sample

Quintile	Interval of Population Densities (Residents / Sq Mile)
1	[42.02, 921.11]
2	[921.36, 1500.43]
3	[1504.05, 2152.34]
4	[2152.36, 3333.46]
5	[3337.13, 14823.9]

6. 1 Baseline Model

Tables 1-3 report the output of model (1) when the Density Restriction Index, Approval Delay Index, and Exactions Index are used individually as explanatory variables. Again, I report results by quintile of population density to understand how policy impacts differ across population densities. The coefficient on the Density Restriction Index is statistically different from 0 at a 10% significance level for the 4th quintile of population density. This coefficient of -0.01338 can be interpreted as indicating that a 1 standard deviation in the DRI leads to a 1.3%

decrease in the quantity of housing units per household in the average jurisdiction. This indicates that relaxation of density controls may lead to a higher availability of housing in jurisdictions within the 4th quintile of population density. For quintiles 1,2,3, and 5, the coefficient on the DRI was not statistically different from 0. This may indicate that density controls are not binding in these regions of population density. Jurisdictions in quintiles 1,2, and 3 are more sparsely populated. Sparser population due to larger existing lot sizes and land availability, meaning that an increase in the minimum lot size may not have as strong of an effect. Jurisdictions in the 5th quintile are the most densely populated of the sample; density controls may not be binding in these jurisdictions as the higher population density may indicate that these jurisdictions are already built out, reducing the efficacy of minimum lot size on new developments. The negative result in the 4th quintile agrees with other studies in the literature that have studied density controls (Glaeser & Ward, 2009; Gyourko & McCulloch, 2023)

Table 4 reports model (1)'s result when solely using the Approval Delay Index as the explanatory variable. For the 1st, 2nd, and 3rd quintiles of population density, the coefficient on ADI is not statistically different from 0. For the 4th quintile, the coefficient takes a value of -0.00748, which is significant at the 10% level. This value indicates that a 1 standard deviation increase in the ADI leads to a 0.75% decrease in the quantity of housing per household in the average jurisdiction. Thus, jurisdictions in the 4th quintile of population density may benefit from a decrease in typical project approval delays. Interestingly, the coefficient of ADI has a positive value of 0.00720, which is significant at a 5% level. This indicates that for jurisdictions in this quintile, a 1 standard deviation increase in the ADI is associated with a 0.72% increase in the quantity of housing units per household. The theory behind this is unclear and warrants further study. This may be indicative of reverse causality: higher densely populated areas have higher construction levels which leads to longer approval delays. The lack of statistical significance for jurisdictions in quintiles 1, 2 and 3 indicates that increased approval delays may not deter development. The negative impact of ADI on housing quantity for jurisdictions in the 4th quintile is consistent with other studies in the literature (Mayer & Sommerville, 2000).

Table 5 reports the results of model (1) when solely using the Exactions Index (EI) as the explanatory variable. As a reminder, the EI is a binary indicator variable that takes a value of 1 if the jurisdiction imposes impact fees on developers and 0 if not. The coefficient on the Exactions Index is statistically significant for the 3rd and 4th quintiles of population density. For the 3rd quintile, the coefficient on the EI is -0.01279, which is significant at 10% level. This indicates that, on average, for jurisdictions in the 3rd quintile of population density, the imposition of exaction fees leads to a 1.3% decrease in the quantity of housing units per household. Similarly, for the 4th quintile, the coefficient on the EI is -0.01437, which is significant at the 5% level. This indicates that, on average, for jurisdictions in the 4th quintile of population density, the imposition of exaction fees leads to a 1.4% decrease in the quantity of housing units per household. Thus, in both the 3rd and 4th quintiles, jurisdictions may help increase housing supply by avoiding the imposition of impact fees on develops. For the 1st, 2nd, and 5th quintiles, the coefficient on the EI is not statistically different from 0. For the 1st and 2nd quintiles, ease of development due to land availability may outweigh the costs an impact fee may impose. It is interesting to note that there is disagreement among the literature on the effect of impact fees. Skidmore & Peddle (1998) find that impact fees reduce permits in DuPage, Illinois – a suburb of Chicago. On the other hand, Burge and Ihlanfeldt (2007) construct a theoretical model that shows that impact fees may boost construction by providing assurance to developers that their projects will be approved. In the 3rd and 4th quintiles, the negative coefficient agrees with the findings of Skidmore and Peddle (1998). However, while the 5th quintile's coefficient on EI is statistically insignificant, the point estimate is positive (0.106). This would support the model developed by Burge and Ihlanfeldt (2007). Perhaps in high density jurisdictions, the assurance of approval that impact fees may provide encourages development.

Table 3: The Impact of Increased Density Restriction on Household Units per Household

VARIABLES	Quintile of Population Density				
	(1)	(2)	(3)	(4)	(5)
Density Restriction	-0.00501	-0.00040	0.00167	-0.01338*	-0.00186
	(0.00572)	(0.00473)	(0.00457)	(0.00750)	(0.00337)
Population Density	-0.00003	-0.00015***	-0.00008***	-0.00002	-0.00001*
	(0.00008)	(0.00004)	(0.00002)	(0.00002)	(7.18e06)
Median HH Income	4.55e-07	4.09e-07	8.88e07*	7.23e-07***	1.34e-06***
	(2.97e-07)	(5.90e-07)	(4.70e-07)	(2.70e-07)	(4.28e-07)
Median Home Value	-2.30e-07	4.28e-08	1.62e-07*	-1.58e-07**	5.34e-08*
	(1.40e-07)	(7.68e-08)	(8.77e-08)	(6.14e-08)	(3.08e-08)
Gini Coefficient	0.00705	-0.10592	-0.22578	0.29683**	0.28424***
	(0.08698)	(0.11802)	(0.18149)	(0.13821)	(0.10908)
Average Commute Time	-0.00631	-0.00095	-0.00187	0.00147	-0.00185
	(0.00394)	(0.00202)	(0.00142)	(0.00214)	(0.00130)
Unemployment Rate	0.07995	-0.04848	0.46022***	0.64968***	0.57679***
	(0.17189)	(0.13460)	(0.17480)	(0.16662)	(0.18685)
% of Residents with	-0.04644	-0.00628	-0.12122	0.12608*	-0.15430
Bachelor +	(0.11009)	(0.10746)	(0.11514)	(0.07477)	(0.12448)
% of White Residents	-0.01925	0.05037*	0.12214	0.05626	-0.06801
	(0.06269)	(0.02796)	(0.08379)	(0.07112)	(0.07125)
Constant	0.34488**	0.29324***	0.19934	-0.16263	0.00104
	(0.14896)	(0.09751)	(0.14352)	(0.12685)	(0.07290)
Jurisdictions	178	202	208	203	181
Within R^2	0.2622	0.2738	0.2582	0.5894	0.5339

Standard errors clustered by jurisdiction in parentheses
Significance Codes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: The Impact of Increased Approval Delays on Housing Units per Household

VARIABLES	Quintile of Population Density				
	(1)	(2)	(3)	(4)	(5)
Approval Delay Index	-0.00097	0.00171	0.00096	-0.00748*	0.00720**
	(0.00380)	(0.00391)	(0.00316)	(0.00434)	(0.00354)
Population Density	-0.00004	-0.00015***	-0.00008***	-4.85e-06	-0.00002**
	(0.00007)	(0.00003)	(0.00002)	(0.00002)	(0.00001)
Median HH Income	7.50e-07**	-4.26e-07	8.03e-07*	5.52e-07**	1.06e-06***
	(3.55e-07)	(5.22e-07)	(4.60e-07)	(2.66e-07)	(3.30e-07)
Median Home Value	-2.90e-07**	5.18e-08	1.58e-07*	-1.38e-07**	2.73e-08
	(1.39e-07)	(8.10e-08)	(8.79e-08)	(6.69e-08)	(3.03e-08)
Gini Coefficient	-0.11694	-0.11597	-0.24117	0.28660*	0.34316***
	(0.09303)	(0.11435)	(0.19281)	(0.14597)	(0.10224)
Average Commute Time	-0.00714*	-0.00090	-0.00168	0.00303	-0.00099
	(0.00392)	(0.00204)	(0.00148)	(0.00299)	(0.00122)
Unemployment Rate	0.21974	-0.05393	0.43975**	0.62155***	0.57556***
	(0.15222)	(0.13356)	(0.18008)	(0.18031)	(0.16633)
% of Residents with Bachelor +	-0.09701	-0.00450	-0.11852	0.12647	-0.22620
	(0.11200)	(0.11214)	(0.12182)	(0.07824)	(0.13934)
% of White Residents	-0.05947	0.04851*	0.12023	0.10521	-0.07931
	(0.06321)	(0.02878)	(0.08348)	(0.09672)	(0.06481)
Constant	0.46169***	0.29769***	0.20407	-0.25815	0.03243
	(0.16512)	(0.09439)	(0.14438)	(0.16804)	(0.08270)
Jurisdictions	177	202	208	205	179
Within R^2	0.3084	0.2788	0.2508	0.5304	0.5705

Standard errors clustered by jurisdiction in parentheses
Significance Codes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: The Impact of Impact Fees on Housing Units per Household

VARIABLES	Quintile of Population Density				
	(1)	(2)	(3)	(4)	(5)
Exactions Index	0.00326	-0.01112	-0.01279*	-0.01437**	0.01061
	(0.00788)	(0.00759)	(0.00684)	(0.00592)	(0.00945)
Population Density	-0.00005	-0.00014***	-0.00007***	-0.00001	-0.00001
	(0.00008)	(0.00004)	(0.00002)	(0.00002)	(0.00001)
Median HH Income	5.25e-07*	6.79e-07	6.97e-07	6.35e-07**	1.23e-06***
	(3.04e-07)	(5.90e-07)	(4.46e-07)	(2.63e-07)	(3.49e-07)
Median Home Value	-2.12e-07	3.47e-08	1.31e-07	-1.62e-07**	5.19e-08
	(1.42e-07)	(7.79e-08)	(8.42e-08)	(6.87e-08)	(3.25e-08)
Gini Coefficient	-0.03963	-0.07184	-0.21410	0.34602**	0.29830***
	(0.09203)	(0.11587)	(0.18458)	(0.15341)	(0.09861)
Average Commute Time	-0.00649	-0.00088	-0.00181	0.00269	-0.00203
	(0.00406)	(0.00209)	(0.00152)	(0.00274)	(0.00132)
Unemployment Rate	0.12114	-0.07150	0.44312***	0.55272***	0.58910***
	(0.17221)	(0.13817)	(0.15925)	(0.16283)	(0.18148)
% of Residents with Bachelor +	-0.11010	0.00731	-0.07004	0.11803*	-0.14869
	(0.10530)	(0.10484)	(0.12058)	(0.07083)	(0.11450)
% of White Residents	-0.04126	0.04316	0.12635*	0.09890	-0.04737
	(0.06329)	(0.02930)	(0.07621)	(0.09860)	(0.04647)
Constant	0.40387**	0.25596**	0.19116	-0.24074	-0.02925
	(0.16817)	(0.10005)	(0.12445)	(0.16888)	(0.06290)
Jurisdictions	178	201	209	205	181
Within R^2	0.2546	0.2921	0.2913	0.522	0.5442

Standard errors clustered by jurisdiction in parentheses

Significance Codes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.2 Incorporating All Policies

Table 6 contains the output of model (2), which examines the impact of the three regulations of interest on quantity of housing units per household in each jurisdiction. By solely including one policy measure in the model, one could argue that the coefficient on the regulatory index may contain the impact of other policies I did not include in the model. By incorporating all three policies in one model, I can see whether the effects of each regulation are still statistically significant and impact housing quantity in the same direction.

For the Density Restriction Index, the result from model (1) holds. The coefficient on the DRI is only significant at a 10% level within the 4th quintile of population density with a value of -0.01384. Thus, for jurisdictions in this quintile, a 1 standard deviation increase in the DRI leads a 1.4% decrease in the quantity of housing units per household. For the Approval Delay Index, the results from model (1) also hold. In the 4th quintile of population density, a 1 standard deviation increase in the ADI is associated with a 0.76% decrease in the quantity of housing units per household. On the other hand, in the 5th quintile, a 1 standard deviation increase in the ADI is associated with a 0.7% increase in the quantity of housing units per household. Again, these results are consistent with model (1)'s findings. For the Exactions Index, we again find similar results. In the 3rd quintile, the presence of impact fees leads to a 1.7% decrease in the number of housing units per household. This estimate is significant at the 10% level. In the 4th quintile, the imposition of impact fees leads to a 1.1% decrease in the number of housing units per household. This estimate is significant at the 5% level. We again see a positive point estimate (0.00851) of the coefficient on EI in the 5th quintile; however, this estimate is not statistically different from 0.

The consistency of the estimates of coefficients between model (1) and model (2) indicates that the effects of each policy are likely independent of one another, and they may affect the quantity of housing units per household through different mechanisms.

Table 6: Impact of Regulatory Policies on Units per HH; Simultaneous Incorporation

VARIABLES	Quintile of Population Density				
	(1)	(2)	(3)	(4)	(5)
Density Restriction Index	-0.00509	0.00089	0.00498	-0.01384*	-0.00203
	(0.00569)	(0.00485)	(0.00455)	(0.00715)	(0.00285)
Approval Delay Index	-0.00098	0.00130	0.00185	-0.00760*	0.00700**
	(0.00384)	(0.00385)	(0.00280)	(0.00423)	(0.00319)
Exactions Index	0.00074	-0.01199	-0.01744**	-0.01131**	0.00851
	(0.00792)	(0.00807)	(0.00856)	(0.00551)	(0.00794)
Population Density	-0.00002	-0.00014***	-0.00007***	-0.00001	-0.00001**
	(0.00008)	(0.00004)	(0.00002)	(0.00002)	(0.00001)
Median HH Income	6.52e-07*	6.47e-07	8.78e-07*	8.56e-07***	9.00e-07***
	(3.36e-07)	(6.64e-07)	(4.83e-07)	(2.71e-07)	(3.03e-07)
Median Home Value	-3.12e-07**	4.49e-08	1.24e-07	-1.55e-07**	4.40e-08
	(1.42e-07)	(7.99e-08)	(8.36e-08)	(6.60e-08)	(3.35e-08)
Gini Coefficient	-0.05622	-0.11282	-0.18827	0.28516**	0.32197***
	(0.08686)	(0.12274)	(0.19694)	(0.12308)	(0.10686)
Average Commute Time	-0.00716*	-0.00078	-0.00178	0.00212	-0.00180
	(0.00384)	(0.00212)	(0.00147)	(0.00233)	(0.00135)
Unemployment	0.15608	-0.08084	0.43199***	0.62429***	0.62431***
	(0.15228)	(0.13929)	(0.16116)	(0.15981)	(0.18203)
% of Population with Bachelor +	-0.05010	0.01663	-0.08387	0.14590*	-0.17371
	(0.11312)	(0.11528)	(0.13259)	(0.07911)	(0.11420)
% of White Residents	-0.04996	0.03942	0.12487	0.03685	-0.08275
	(0.06365)	(0.03045)	(0.07580)	(0.06548)	(0.06193)
Constant	0.41914***	0.27409***	0.17165	-0.18752	0.03117
	(0.15359)	(0.10472)	(0.12352)	(0.12229)	(0.08519)
Jurisdictions	177	199	207	202	179
Within R^2	0.3262	0.3025	0.3155	0.638	0.5848

Standard errors clustered by jurisdiction in parentheses
Significance Codes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.3 Interaction Model

Model (3) allows for the possibility of interaction between density restrictions with impact fees and interaction between approval delays with impact fees. Results of model (3) are presented in Table 7. The 3rd quintile of population density is the only quintile in which the interaction of the Exaction Index with either the DRI or ADI is statistically significant from zero. The coefficient of the interaction term $(DRI * EI)$ is -0.01343, significant at the 10% level. The coefficient on density restrictions alone is 0.01193, which is also significant at the 10% level. Thus, in the absence of impact fees, a one standard deviation increase in the DRI is associated with a 1.2% increase in housing units per household. On the other hand, if exaction fees are present, a one standard deviation increase in the DRI is associated with a 0.01193 – 0.01343 = 0.15% decrease in housing units per household. In terms of the Approval Delay Index, the individual coefficient is not statistically different from zero; however, the interaction term $(\mathrm{ADI} * EI)$ is statistically significant at the 10%, indicating that there may be differential impacts of ADI conditional on the presence of impact fees. Overall, jurisdictions within the 3rd quintile of population density face a nuanced policy question: the presence of impact fees may alter the effects of density controls and approval delays. This complex relationship warrants further study.

Table 7: Impact of Regulatory Restrictions on Households, Accounting for Possible Interactions with Impact Fees

VARIABLES	Quintile of Population Density				
	(1)	(2)	(3)	(4)	(5)
Density Restriction Index	0.00055	-0.00226	0.01193*	-0.00909	-0.00322
	(0.00535)	(0.00602)	(0.00707)	(0.00565)	(0.00509)
Approval Delay Index	-0.00543	-0.00700	-0.00452	-0.01021**	0.00743
	(0.00479)	(0.00749)	(0.00367)	(0.00398)	(0.00837)
Exactions Index	0.00520	-0.01083	-0.01340	-0.01090*	0.00853
	(0.00718)	(0.00746)	(0.00890)	(0.00600)	(0.00773)
EI * DRI	-0.00867	0.00551	-0.01343*	-0.00497	0.00146
	(0.00703)	(0.00551)	(0.00731)	(0.00761)	(0.00448)
EI * ADI	0.00671	0.01191	0.00903*	0.00410	-0.00071
	(0.00714)	(0.00812)	(0.00542)	(0.00658)	(0.00697)
Population Density	-2.20e-06	-0.00014***	-0.00006***	-0.00001	-0.00001**
	(0.00009)	(0.00004)	(0.00002)	(0.00002)	(0.00001)
Median HH Income	6.59e-07**	6.70e-07	7.56e-07	8.51e-07***	8.78e-07***
	(3.30e-07)	(6.18e-07)	(5.14e-07)	(3.00e-07)	(2.90e-07)
Median Home Value	-2.87e-07**	1.97e-08	1.35e-07	-1.64e-07**	4.69e-08
	(1.39e-07)	(8.63e-08)	(9.64e-08)	(6.71e-08)	(3.45e-08)
Gini Coefficient	-0.08112	-0.11149	-0.08466	0.29084**	0.32352***
	(0.09173)	(0.11729)	(0.17186)	(0.12358)	(0.10802)
Average Commute Time	-0.00761**	-0.00024	-0.00283*	0.00202	-0.00183
	(0.00363)	(0.00218)	(0.00148)	(0.00243)	(0.00133)
Unemployment Rate	0.21715	-0.05912	0.41419***	0.64463***	0.63126***
	(0.14460)	(0.12969)	(0.15095)	(0.16385)	(0.18767)
% of Residents with Bachelor +	-0.06121	0.03977	-0.11648	0.15254*	-0.16914
	(0.11551)	(0.11263)	(0.13002)	(0.07942)	(0.10470)
% of White Residents	-0.07173	0.04472	0.10488	0.03199	-0.08026
	(0.06720)	(0.02931)	(0.06797)	(0.06677)	(0.06218)
Constant	0.43421***	0.25983**	0.17026	-0.19228	0.02796
	(0.15740)	(0.10507)	(0.12392)	(0.12722)	(0.08209)
Jurisdictions	177	199	207	202	303
Within R^2	0.353	0.3382	0.3574	0.6413	0.5853

Standard errors clustered by jurisdiction in parentheses

Significance Codes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

7 Conclusion and Limitations

My analysis provides evidence that three measures of land use regulation – density controls, approval delays, and impact fees – have differential impacts on the quantity of housing units per household across jurisdictions of differing population densities. Density controls seem to have binding negative impacts on the quantity of housing for jurisdictions with population densities from ~2200 to ~3300 residents per square mile. Approval delays appear to have binding negative impacts in jurisdictions above ~2200 residents per square mile. Surprisingly, in the highest quintile, increased approval delays are associated with higher quantities of housing, a phenomenon that may warrant further study. Lastly, the presence impact fees appears to reduce housing quantity in jurisdictions with population densities ranging from ~1500 to ~3300. In the 3rd quintile of population density, there appears to be potential interactions between the imposition of impact fees and the other two regulatory measures. This is another result that may warrant further research. In general, there appears to be an optimal range within the distribution of population density where decreasing regulation likely acts to increase the housing supply.

A limitation throughout the analysis is the potential for endogeneity due to reverse causality. To correct for this, instrumental variables for regulation variables could be exploited in future analysis. While other studies in the literature utilize, it is challenging to find an instrumental variable that predicts changes in regulation from 2006-2018 without violating the exclusionary assumption required of a valid IV. Another limitation of the dataset is the lack of variability in regulation changes. The three selected regulatory measures were the most variable of the total set of measures provided in the Wharton dataset. Future variability in regulation will provide more variation in regulations that can provide further insights into the impacts of more stringent regulations. Lastly, an interesting area of future research would be the relationship between regulatory restrictiveness and demographics, a relationship significantly understudied in the current literature.

References

Baum-Snow, N. (2023). Constraints on City and Neighborhood Growth: The Central Role of Housing Supply. *Journal of Economic Perspectives*, *37*(2), 53–74.

Bertaud, A., & Brueckner, J. K. (2005). Analyzing Building-height Restrictions: Predicted Impacts and Welfare costs. *Regional Science and Urban Economics*, *35*(2), 109–125. https://doi.org/10.1016/j.regsciurbeco.2004.02.004

Ding, C. (2013). Building Height Restrictions, Land Development, and Economic Costs. *Land Use Policy*, *30*(1), 485–495. https://doi.org/10.1016/j.landusepol.2012.04.016

Einstein, K. L., Glick, D. M., & Palmer, M. (2020). Neighborhood Defenders: Participatory Politics and America's Housing Crisis. *Political Science Quarterly*, *135*(2), 281–312.

Davidoff, T., Pavlov, A., & Somerville, T. (2022). Not in my Neighbour's Back Yard? Laneway Homes and Neighbours' Property Values. *Journal of Urban Economics*, *128*, 103405.

Glaeser, E. L., & Ward, B. A. (2009). The Causes and Consequences of Land Use Regulation: Evidence from Greater Boston. *Journal of Urban Economics*, *65*(3), 265–278.

Glaeser, E., & Gyourko, J. (2018). The Economic Implications of Housing Supply. Journal of Economic Perspectives, 32(1), 3–30.

Green, R. K., Malpezzi, S., & Mayo, S. K. (2005). Metropolitan-Specific Estimates of the Price Elasticity of Supply of Housing, and Their Sources. *American Economic Review*, *95*(2), 334–339.

Grout, C. A., Jaeger, W. K., & Plantinga, A. J. (2011). Land-use Regulations and Property Values in Portland, Oregon: A Regression Discontinuity Design Approach. *Regional Science and Urban Economics*, *41*(2), 98–107.

Gyourko, J., & Glaeser, E. (2025). *America's Housing Affordability Crisis and the Decline of Housing Supply*. BPEA Conference Draft, Spring.

Gyourko, J., Hartley, J. S., & Krimmel, J. (2021). The Local Residential Land Use Regulatory Environment across U.S. Housing Markets: Evidence from a New Wharton Index. *Journal of Urban Economics*, *124*, 103337.

Gyourko, J., & McCulloch, S. (2023). Minimum Lot Size Restrictions: Impacts on Urban Form and House Price at the Border. *NBER Working Paper Series*. National Bureau of Economic Research.

Harter-Dreiman, M. (2004). Drawing Inferences about Housing Supply Elasticity from House Price Responses to Income Shocks. *Journal of Urban Economics*, *55*(2), 316–337.

Hilber, C. A. L., & Vermeulen, W. (2016). The Impact of Supply Constraints on House Prices in England. *The Economic Journal*, *126*(591), 358–405.

Hsieh, C.-T., & Moretti, E. (2019). Housing Constraints and Spatial Misallocation. *American Economic Journal: Macroeconomics*, *11*(2), 1–39.

Ihlanfeldt, K. R. (2007). The effect of land use regulation on housing and land prices. *Journal of Urban Economics*, *61*(3), 420–435.

Jackson, K. (2016). Do Land Use Regulations Stifle Residential Development? Evidence from California cities. *Journal of Urban Economics*, *91*, 45–56.

Kono, T., & Joshi, K. (2019). Chapter One - Introduction. In *Traffic Congestion and Land Use Regulations* (pp. 1–19). essay, Elsevier.

Kulka, A., Sood, A., and Chiumenti, N. (2023). How to Increase Housing Affordability: Understanding Local Deterrents to Building Multifamily Housing. *Federal Reserve Bank of Boston Research Department Working Paper*. No. 22-10.

Mayer, C. J., & Somerville, C. T. (2000). Land Use Regulation and New Construction. *Regional Science and Urban Economics*, *30*(6), 639–662.

Mills, E. S. (2005). Why Do We Have Urban Density Controls? *Real Estate Economics*, *33*(3), 571–585.

Pendall, R. (2000). Local Land Use Regulation and the Chain of Exclusion. *Journal of the American Planning Association*, *66*(2), 125–142.

Quigley, J. M., & Raphael, S. (2005). Regulation and the High Cost of Housing in California. *American Economic Review*, *95*(2), 323–328.

Saiz, A. (2010). The Geographic Determinants of Housing Supply*. *Quarterly Journal of Economics*, *125*(3), 1253–1296.

Santosh Anagol, Ferreira, F., & Rexer, J. (2021). Estimating the Economic Value of Zoning Reform. *NBER Working Paper Series*. National Bureau of Economic Research.

Skidmore, M., & Peddle, M. (2006). Do Development Impact Fees Reduce the Rate of Residential Development? *Growth and Change*, *29*(4), 383–400.

Steven Manson, Jonathan Schroeder, David Van Riper, Katherine Knowles, Tracy Kugler, Finn Roberts, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 19.0 [dataset]. Minneapolis, MN: IPUMS. 2024.

Turner, M.A., Haughwout, A. and van der Klaauw, W. (2014), Land Use Regulation and Welfare. Econometrica, 82: 1341-1403.

Wheaton, W. C., Chervachidze, S., & Nechayev, G. (2014). Error Correction Models of MSA Housing Supply Elasticities: Implications for Price Recovery. *MIT Department of Economics Working Paper No. 14-05*.

Zabel, J., & Dalton, M. (2011). The Impact of Minimum Lot Size Regulations on House Prices in Eastern Massachusetts. *Regional Science and Urban Economics*, *41*(6), 571–583.

Appendix

Table A1: Summary Statistics for Subindices and Overall Index

Index	Mean	Standard Deviation	Minimum	Maximum
Density Restriction Index, 2006	0.1898	0.3924	0	1
Density Restriction Index, 2018	1.9936	1.272	0	4
Approval Delay Index, 2006	5.834	3.7823	0.6074	22.77778
Approval Delay Index, 2018	5.6011	4.3495	0.8833	40
Exactions Index, 2006	0.773	0.4191	0	1
Exactions Index, 2018	0.5468	0.4981	0	1
WRLURI, 2006	0.0218	0.9341	-2.024483	4.056232
WRLURI, 2018	-0.00394	0.9129	-2.295228	3.203058

Notes: subindices not standardized in calculations of summary statistics

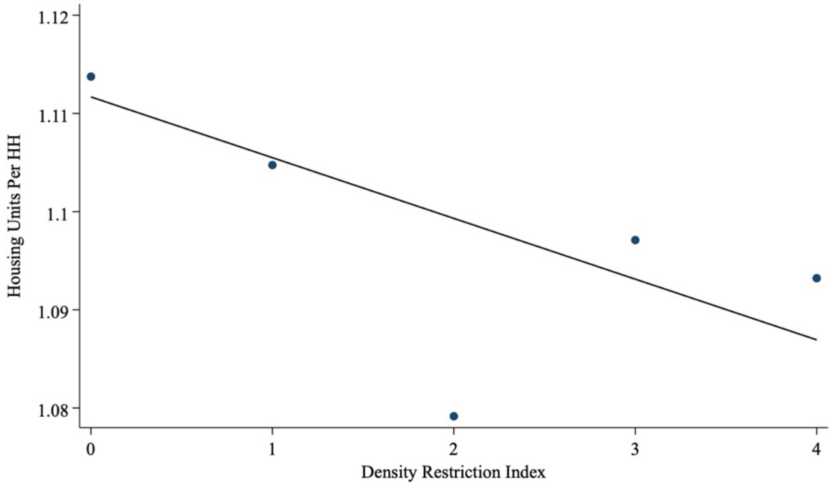
Table A2: Summary Statistics for Dependent Variable

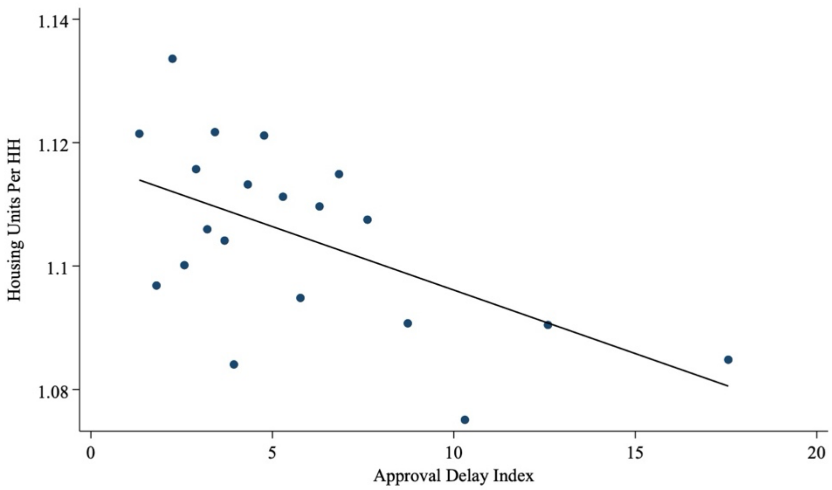
Index	Mean	Standard Deviation	Minimum	Maximum
Housing Units per Household, 2006	1.110489	0.1179692	1	2.479726
Housing Units per Household 2018	1.098753	0.1202517	1	2.474061

Table A3: Summary Statistics for Control Variables

Variable	Mean	Standard Deviation	Minimum	Maximum
Total Population, 2006	37,572.4	83,476.02	2,516	1,450,206
Total Population, 2018	42,306.62	94,041.69	2,137	1,609,456
Median Household Income, 2006	$82,088.39	$35,809.54	$24,855.1	$250,001
Median Household Income, 2018	$87,552.19	$39,525.07	$30,317	$250,001
Median Home Value, 2006	$327,438.9	$225,222.9	$51,272.67	$1,000,001
Median Home Value, 2018	$343,061.9	$224,050.1	$49,100	$1,000,001
Gini Coefficient, 2006	0.4227035	0.0554516	0.274	0.599
Gini Coefficient, 2018	0.4352246	0.0507416	0.2985	0.6074
Average Commute Time to Work, 2006 (minutes)	25.09716	5.870139	11.55785	43.70514
Average Commute Time to Work, 2018 (minutes)	26.39663	6.115806	10.65846	49.71399
Proportion of Residents with Bachelor's Degree, 2006	0.3230887	0.1725219	0	0.861465
Proportion of Residents with Bachelor's Degree, 2018	0.3807737	0.1867057	0.0293255	0.8577697

Figures A1-A3: Mean Housing Units per HH at Each Level of Subindices





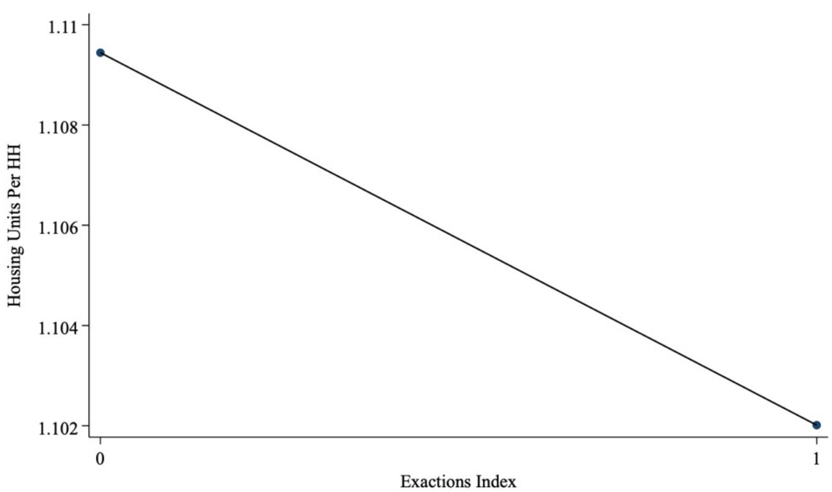


Table A4 displays the output of the following model:

$$\Delta\text{REG}_j = \beta_0 + \beta_2 \Delta\,\text{HH}_j + \beta_2 \boldsymbol{X}_j + \phi_j \tag{4}$$

where ΔREG_j denotes the change in the given regulatory index in jurisdiction j from 2006 to 2018, $\Delta\,\text{HH}_j$ denotes the change in units of housing per household for jurisdiction j from 2000 to 2006, and $\boldsymbol{X}_j$ denotes a vector of control variables (the same ones used in all models throughout this paper). The lack of statistically significant coefficients helps alleviate concerns that previous availability in regulation predicts changes in regulation.

Table A4: Regression Output for Model (4)

VARIABLES	(1) ΔDRI, 2006-18	(2) ΔADI, 2006-18	(3) ΔEI, 2006-18
ΔUnits per HH, 2000-06	-0.97409	-3.85193	0.01935
	(0.89488)	(3.57148)	(0.42412)
Population Density, 2006	-0.00020***	0.00029***	0.00000
	(0.00003)	(0.00011)	(0.00001)
Median HH Income, 2006	0.00000	0.00001	-0.00000
	(0.00000)	(0.00001)	(0.00000)
Median Home Value, 2006	0.00000**	0.00000	0.00000***
	(0.00000)	(0.00000)	(0.00000)
Gini Coefficient, 2006	0.34067	-1.94720	-0.54221
	(1.03792)	(4.18125)	(0.48967)
Avg Commute Time, 2006	0.02203**	-0.06418*	0.01795***
	(0.00946)	(0.03820)	(0.00444)
Unemployment Rate, 2006	-0.95596	-9.49670	0.33499
	(1.71111)	(6.90422)	(0.81261)
% of Residents with Bachelor +	0.02571	-4.24772**	-0.33178
	(0.48991)	(1.95038)	(0.22830)
% of White Residents	-0.47794	-2.62017**	0.00523
	(0.30635)	(1.23297)	(0.14434)
Constant	1.63124**	4.39807*	-0.53679*
	(0.64292)	(2.58656)	(0.30227)
Observations	780	762	788
R^2	0.011	0.032	0.097

Standard errors in parentheses
Significance Codes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$