The Effect of a Minimum Lot Size Reduction on Residential Property Values: The Case of Houston

Author: Joseph Shortell
Advisor: Dr. Enrique López-Bazo

Abstract

The reform of onerous land use regulations in the U.S. is finally having its moment in the spotlight as priority access to billions of dollars in federal grant money is being given to cities willing to make their land use regimes less exclusionary with the hope that this will ease the rising cost of housing (The United States Government, 2022). However, empirical studies on the effects of city-wide land use reform are few and far between due to the fact that examples are so rare. One of the few exceptions is Houston's 1998 and 2013 reduction of its mandated minimum-lot-size for single-family homes. Given that the this natural-experiment in housing reform remains astoundingly under studied, this paper takes the initiative to estimate the effect that Houston's minimum-lot-size reduction had on residential property values in the city using appraisal data and a difference-in-differences approach. The results show that that the market-value of single-family homes in Houston rose relative to those of the suburbs and that this was driven by an increase in the value of land. Although these results cannot say to what degree reducing minimum-lot-sizes would improve housing affordability, they do point to a generally more optimal use of land when size restrictions are relaxed.

Key Words: minimum-lot-size, land use policy, housing market, land value, difference-in-differences, propensity score matching

1. Introduction

In the U.S., land use regulations, particularly minimum-lot size-requirements, regularly force property developers to build larger houses than what the market demands, even in the suburbs of car-based cities where large houses are the norm. Critics of minimum-lot-size requirements argue that their reduction would increase housing affordability and decrease urban sprawl, especially in America's largest cities. However, the effect of these kinds of reforms on local property markets is far from clear given that that urban areas are composed of numerous municipalities with independence in their land use regimes.

This paper seeks to answer the following question: in the case of a large city surrounded by distinct suburban development, how does a city-wide reduction in the minimum-lot-size affect the price of single-family residential property in the city relative to the suburbs? The main hypotheses are that, in the city, the value of housing will decrease relative to the suburbs and the value of residential land will increase relative to the suburbs. The overall effect of the reform on relative market value depends on which component of property value the policy affects more.

These hypotheses are tested by examining Houston's 2013 extension of its minimum-lot-size reduction policy to all areas of the city. Using a difference-in-differences framework along with propensity-score matching based on property characteristics, the local effect of the policy on property values is estimated.

This analysis is able to estimate this effect at the individual property level due to an extremely rich dataset from the Harris County Appraisal District which provides detailed information about every single residential property in its jurisdiction. This means that minute, property-level attributes that may affect the outcome can be identified and controlled for.

The research question explored here is novel in that it analyzes this effects of a minimum-lot-size reduction within the context of a large city and its surrounding suburbs. Existing studies on minimum-lot-sizes and their effect on housing prices like Glaeser and Ward (2009) typically compare differences among suburbs and small towns. The city-suburb context is particularly interesting given that it is the primary arena for the today's most critical housing issues like sprawl and skyrocketing prices.

This empirical approach also differs from others that have been utilized in the literature by using an actual city-wide policy reform to determine the effect of a minimum-lot-size reduction on residential property values. Previous studies like Zabel & Dalton (2011) also used a differences-in-differences approach to estimate the effect of minimum-lot-size reductions on housing prices but lacked historical data on these reductions and had to make inferences based on changes in average lot sizes. The approach used here does not require inferences as the exact timing, magnitude and boundary of the policy change is clear.

The results show that the local effect of the policy is to increase single-family property values in the area where the minimum-lot-size is reduced and that this result remains robust when properties are matched based on their observable characteristics. They also show that this increase is driven primarily by higher land values. Building values also demonstrate a decrease following the treatment, but this result is questionable due to lack of parallel trends. Restricting the period under analysis to exclude years preceding the 2008 financial crises as well as years following the 2020 COVID-19 pandemic strengthens the justification for parallel trends in all of the models while leaving the results relatively unchanged.

Overall, these results indicate a strong local effect of Houston's minimum-size reduction on property values in the city. The primary channel by which this occurs is higher land values which could encourage denser development in the urban periphery going forward.

The paper is organized as follows: (1) a description of the Houston's 2013 minimum-lot-size reduction policy and the circumstances of its implementation, (2) a review of the relevant literature on land regulations and the mechanisms by which they affect housing prices, (3) a description of the methodological approach used to test the proposed hypotheses, (4) a description of the dataset and its relevant variables, (5) the results of the empirical analysis and consequent robustness checks, (5) a discussion of the results and concluding remarks, and (6) references and an appendix.

2. Policy Background

Houston is the 4th largest city in the U.S. by population with 2.3 million residents (U.S. Census Bureau, 2021). Its real-estate market is one of the largest in the country containing over 738,000 individual parcels of residential property within its limits. And it is the largest city in Harris county, a county that also includes many populous suburbs and has a total population of over 4.8 million people. Despite its (deserved) reputation for extreme urban sprawl, Houston has actually long been a laboratory for progressive land use regulations.

It is famously the only major city in the U.S. that has never implemented Euclidean zoning. Euclidean zoning is the city planning approach that divides land into zones by use. For example, in a single-family zone, no structures other than single-family homes may be built without special permits. Despite this, Houston employs numerous planning tools and development codes that function similar to zoning in shaping urban growth (Fulton, 2020). This is why, despite its lack of zoning, Houston does not look dramatically different to other large Texas cities.

However, Houston owns a more significant distinction with regards to land use policy that has received far less attention. This is its reform of minimum-lot-sizes in 1998 and 2013. As of today, to the best my knowledge, it remains the only major U.S. city to do this on a city-wide level. What follows is a description of: (1) how the policy was developed, (2) what the policy did, and (3) why the policy serves as a useful natural-experiment for this analysis.

Rules for land use in Houston are laid out in the city's code of ordinances along with all other laws enforced by the city. These rules are reviewed by the Council's Neighborhood Planning and Protection Committee which then presents its findings to the entire Council for a vote. In 1998, the Council voted to reform Chapter 42 of the city's code of ordinances which concerns Subdivisions, Development, and Platting. These are the rules that determine how tracts of land can be divided into smaller parcels which can then be sold and developed. Included in these rules are *minimum lot size requirements* (MLS), a lot being "a parcel [of land] intended as an undivided unit for the purpose of development" (Single-family residential lot size, 2013). MLS requirements specify how small lots can be and hence are one of the most powerful determinants of density in a city.

Prior to 1998, the MLS for single-family homes in Houston was 5,000 square feet. This is quite a large size for single-family home and led to a suburban pattern of development, characterized by sprawling, pedestrian-averse neighborhoods, even around Houston's Central Business District. The 1998 reform was the City Council's effort to address the degrading effect this had on the character of the inner city (Kapur, 2004).

Specifically, the Council's reform of Chapter 42 of the city's code of ordinances reduced the MLS of single family homes to 3,500 square feet for land within the 610 loop (a highway encircling the center of city and an area currently accounting for 21% of Houston's population and 15% of its land area). Furthermore, pending certain requirements MLS's could be as low as 1,400 square feet.

The reform remained as described until 2013 when it was extended beyond the boundaries of the 610 loop to apply to the entire city of Houston. In essence, this reform allowed developers to build up to three smaller homes on land that had previously been allotted for a single larger home. This is an extremely large jump in the potential housing stock of the city and, given that Houston is one of the largest real estate markets in the country, makes it a fruitful case to study for determining the effect of MLS's on residential property values.

Given the stated goals of this analysis, a natural counterfactual area is the suburban sprawl around Houston. These are places where no significant MLS reductions were implemented but which are in a similar housing market to Houston and so should follow similar trends in residential property values. Figure .1 shows Harris County divided into treatment and control groups.

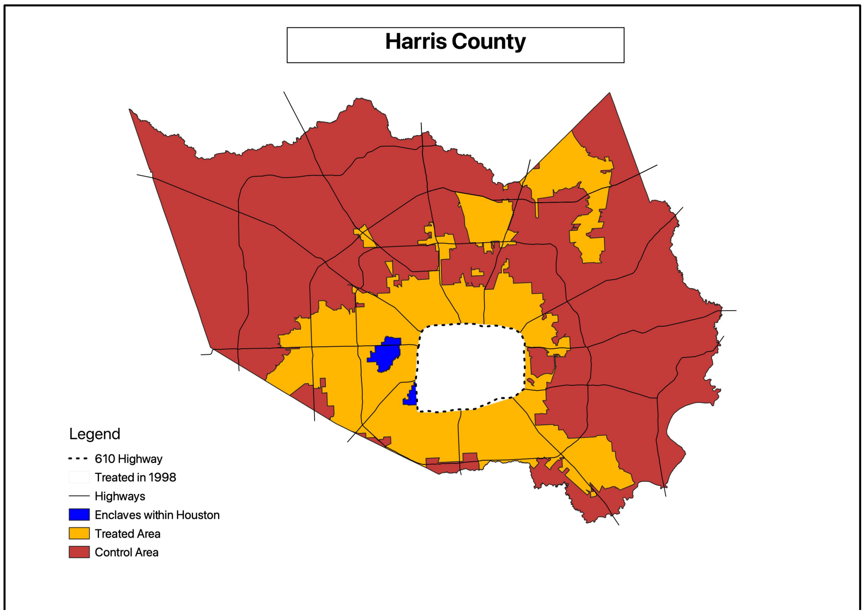

Figure 1. — Map of Treatment and Control Groups

The dashed line encircling the center of the map represents the 610 highway which was used as the border for the original implementation of the MLS reduction policy in 1998. Due to data limitations which will be discussed later, the analysis will be limited to the second round of the policy in 2013. For this reason, the treatment group includes only properties in Houston that are outside of the 610 loop (represented here in orange). The control group consists of all other properties within Harris county but outside the city of Houston (represented here in red). This includes many large suburbs with populations greater than 100,000. The blue sections within the treated area are enclave municipalities within Houston that enact their own land use regulations and are removed from the sample.

3. Literature Review

Land use regulations and their effects on housing and land prices have been the object of study for decades. Early theoretical work demonstrated that when MLS's are binding, an increase in the MLS will raise the size and value of newly constructed houses, but decrease the price of land (Bucovetsky, 1984). A MLS being binding means that lot sizes are generally larger than what they would be if the restriction were not in place. In this way, an MLS acts as a barrier to density because the construction of new homes requires more land than is necessary.

A study of four Texas suburbs (including Pearland, a suburb of Houston), where urban sprawl is widely accepted as the norm, found that in almost all cases, houses tend to be built very close to the minimum lot size (Gray, M. N., & Furth, S. 2019). This indicates that the restrictions are binding and that developers would prefer to build smaller houses. The results are also a promising indication for this study because if MLS's are binding in Houston's suburbs, they are almost certainly binding in the city itself.

Following theory, it can be expected that a reduction in the MLS would increase the unit price of land. The mechanism for this works as follows, if the MLS is binding, most individuals wishing to purchase a single-family home would prefer a lot-size somewhere below the minimum. The difference in area between the minimum lot size mandated by law and the preferred size of the home-buyer is land devoid of productive potential and essentially serves as a tax on housing consumption. In a scenario where the minimum-lot size is removed, property owners can divide their parcels optimally by only keeping what they require for themselves and selling the rest. So, following a reduction in the minimum-lot-size requirement, we would expect the unit value of land to increase because it can be put to more efficient use.

This has been confirmed in empirical studies like Glaeser and Ward (2009), which estimated the effect of land use restrictions, particularly MLS's, on land values and new construction in Boston suburbs. The authors found that housing density in Boston's suburbs is consistently below the level needed to maximize land value. This is a direct result of unduly large MLS's in those suburbs.

However, reducing minimum lot sizes has also been shown to work in the opposite direction, pushing house prices down in areas with fewer restrictions (Zabel & Dalton, 2011). Using a difference-in-differences approach, towns in the Boston area which lowered their MLS were shown to have lower home prices than comparable towns which did not augment their MLS. Even when taking into account spillovers to prices in adjacent towns, the estimated coefficient of the treatment remained negative and significant.

The mechanism by which this price effect works is related to the mechanism that increases the value of land. As was mentioned, an MLS reduction (assuming that it is binding) causes parcels of land to be divided more optimally than before which increases the amount of developable land in the city. This means that the supply of housing should increase in the treated area.

However, because the control group used in this analysis contains many single-family properties that are close substitutes with those in the treatment group, the potential increase in housing supply would affect estimated market values in both groups. However, the two groups being compared in this analysis are far from equivalent. There are certainly many homes in each group that would be considered near perfect substitutes by the majority of homebuyers, but there are also many others that would not, particularly at greater distances from the treatment boundary. This is because the character of the treatment group becomes distinctly less suburban at greater distances from the boundary such that it can be considered as a separate market. As a result, a difference-and-differences approach should detect the effect of the treatment on this separate market.

This approach is not unprecedented as housing price effects of land use regulations have been identified before via an intra-regional comparison of similar municipalities in the Boston area (Glaeser, Schuetz & Ward, 2006). The authors note that the estimation is less precise as a result of the shared market of these municipalities, but that municipality specific effects of differences in land use stringency are still significant and detectable.

It is clear from these previous studies that MLS's play an important role in determining the market price of housing. The two channels in which their effects operate are: (1) increasing the productive potential of land and hence its unit value, and (2) increasing the amount of developable land which should increase the local housing supply and push down prices.

This study expands on previous empirical work by analyzing the housing market effects of an MLS reduction within the context of a large city and its peripheral suburbs. The localized effect of an MLS reduction in this context is far more relevant than a comparison of small, interchangeable towns. This is the case for several reasons. Large cities have a far higher level of what Zabel & Dalton (2011) would call "community zoning power," that is, the degree to which a community cannot be easily substituted for another. As was mentioned before, while certain neighborhoods in the outer reaches of a city may be easily substitutable with suburban neighborhoods, there is a segment of the homebuyer market for which living in the city is non-negotiable no matter how comparable suburban properties might be. Hence, analyzing housing market effects of an MLS reduction by comparing a city to its suburbs should detect a stronger effect than comparing two suburbs or two small towns. The other reason is that major land use reforms are more likely to take place in large cities where pressure on housing price tends to be greater and public support for reform stronger.

This comparison of housing trends in a city to those in its suburbs is done via a difference-in-differences approach, the main challenge being the often substantial variation in housing characteristics between the two groups making an apples-to-apples comparison impossible if not addressed. McMillen & McDonald (2002) encountered a similar problem when using a difference-in-differences approach to analyze the effect of zoning classifications on land values in Chicago. They found significant selection bias in terms of neighborhood characteristics between different zoning classifications. To address this source of bias, they used a bi-weight kernel matching procedure to weight observations based on their propensity scores and then included these weights in the difference-in-differences regression.

This analysis employs a similar technique by estimating the propensity score for each parcel in the dataset of belonging to the treatment group. Fortunately, some previous studies offer insight into which of these characteristics are likely to affect price trends. Smith & Tesarek (1991) found that higher valued homes tend to increase more in value (relative to lower valued homes) during real-estate boom periods and decrease more in value during real-estate bust periods. Haurin & Zhou (2010) found that the age and quality of a house are significant determinants of volatility in the value of residential property.

The analysis presented in this paper uses these previous results to develop a matching procedure that should remove bias in observable characteristics between the treatment and control groups. This will allow for the difference-in-differences model to provide a relatively unbiased estimate of the MLS reduction policy on residential property values in the treated area.

4. Methodology

The goal of this analysis is to estimate the local, causal effect of Houston's 2013 MLS reduction on the market value of single-family residential properties in the city. To estimate this effect, a differences-in-differences approach will be used. The baseline model is as follows:

$$\pi_{it} = \beta_0 + \beta_1 Treatment_{it} + P_i + Y_t + \varepsilon_{it}$$

where π_{it} indicates the total estimated market value by square foot of parcel i in year t. $Treatment_{it}$ is a dummy variable that equals 1 if parcel i was subject to the policy and year t is post 2013 and 0 otherwise. P_i captures parcel fixed-effects while Y_t captures year fixed-effects. ε_{it} is the error term. The models estimating the treatment effect on the respective components of total market value (land and building value) will be identical except for the different outcome variables.

The parcels considered treated are all of those located within the city of Houston but outside of the 610 loop. This is because this analysis will be focusing on the effects of the second wave of the minimum-lot-size reduction policy which exclusively affected these this part of the city. The years of the treatment that will be analyzed range from 2005 to 2021.

The parcels in the control group (for which *Treatment* = 0) all come from the suburbs around Houston which were not affected by the minimum-lot-size reduction. Because the treated area of Houston is outside of the 610 ring-road containing the center-city, the character of neighborhoods is more similar to the control group in terms of suburban character. However, there are still significant differences in the pre-treatment averages of observable characteristics between the treatment and control groups. For this reason, a propensity-score matching procedure is implemented before the difference-in-differences analysis to ensure that the treatment and control groups are comparable.

Property characteristics used in the matching procedure include: total living area of the house, total base area of the house, the total land area of the parcel on which the house is built, the total value of extra features on the property (like garages or swimming pools), the age of the house, the construction quality of the house, a binary variable indicating if the house was remodeled, and the quintile of estimated market value in which the property is appraised.

Because some of these characteristics can change with time (like quality and the value of extra features), propensity scores for each parcel are estimated using the average of their pre-treatment values. The regression to estimate the propensity scores is a logit model and the matching algorithm is nearest-neighbor with replacement and uses calipers. The caliper indicates the minimum difference in propensity score a control property must have in order to be considered a "neighbor". Essentially, a smaller caliper imposes a stricter common support conditions and ensures better matches. This ensures that only treatment parcels that have statistical "twins" in the control group are included in the difference-in-differences regression.

An additional point that must be made clear is that this empirical approach is estimating the *local effect* of the MLS reduction on property value and its respective components. This means that the estimated effect of the MLS reduction on residential property values in Houston applies only within the local housing market. It's total effect on residential property values in Houston may be different. This distinction has to do with the difference-in-differences approach used. Because the properties constituting the control group are in the same general housing market as the properties in the treatment group, an effect of the policy on housing supply in the treatment group would affect home prices in both groups. Therefore, the differences-in-differences model will only pick up a supply-side effect of the treatment on properties in the treatment group that are not good substitutes for properties in the control group. The effect of the policy on the land component of property values does not suffer from the same problem as the supply of land in Houston and its suburbs is fixed both before and after the policy. The only difference following the policy involves how land can be divided in the treatment group. In this way, the direct effects of the policy are limited exclusively to the treatment group

5. Data

The dataset comes from the Harris County Appraisal District (HCAD) and contains parcel level data for all residential property in Harris County. This includes the city of Houston as well as 22 other (mainly) suburban municipalities. For each parcel, detailed information is provided about its financial and physical characteristics. The exact geographic coordinates of each parcel are contained in an associated shapefile compiled by HCAD.

An important note to make about this data is that the market value given for each property is an estimation made by the appraisal district, not an actual sales price. These values are calculated by HCAD using a computerized valuation program which estimates value using the cost approach. The basic formula used by the computer system is as follows:

(Market value of Improvements + Extra Features) + Market Land Value = Market Value of Property

The formula takes into account construction costs, economies of scale in construction, depreciation, remodeling, level of atypicality, and a host of other variables. However, the most important of these, at least for this analysis, is the *market adjustment factor*. While the other variables factored into the valuation have to do with the intrinsic value of the property, the market adjustment factor takes into account market data, particularly recent sales of comparable properties. This helps justify the use of appraised values of properties as a valid proxy for their market value. While there will certainly be differences between the appraised value and what the property would sell for on the market, the correlation between the two should be very high. Furthermore, there are examples in the literature of appraised property values being used as substitutes for market values (Smith, 1976).

The two terms on the left-hand side of the equation presented above decompose the total market value of the property into building and land components respectively. Given that each of these values are also included in the dataset, they can be used to determine to what degree each component is driving changes in total market value.

This information is available for every year between 2005 and 2021. Each parcel contains a unique account number that is constant across all years (in the case where an existing parcel is divided, the newly created portion receives its own number). Because of these unique identifiers, the data can be formatted as a panel in which every residential property in Harris County is observed during each of the 17 years included in the dataset.

The initial sample included 18,139,597 total observations with 1,149,820 unique parcels of residential land. From this, the sample was restricted to properties classified as single-family residential. This was done because the 2013 MLS reduction applied specifically to single-family properties and this analysis is interested in the effect of the policy on single-family property values. Because typical rental properties like duplexes and apartments are not included in the sample, the results say nothing about the effect of the policy on the rental housing market. Also, a very small number of single-family residential properties with more than one building was also excluded from the sample because the use of the extra buildings was not clear.

In order to create a balanced panel, only properties with observations in all years between 2005 and 2021 were used in the analysis. Doing so ensures a stable comparison group during the periods before and after the treatment. It also allows the statistical software to run parallel-trends tests and generate graphical diagnostics. There were also a relatively small number of properties that had inconsistent treatment status either due to the missed entry of data or changing municipal boundaries. Because inconsistent treatment status of observations prevents the difference-in-differences model from running, these properties were excluded from the sample.

Finally, observations within Houston’s 610 loop were removed from the sample due to the fact that the MLS reduction policy was implemented there in 1998. Because the difference-in-differences model used in this analysis requires observations in pre and post treatment time periods, the HCAD data, given that it begins in 2005, can only be used to evaluate the effect of policy on the part of Houston treated in 2013.

These changes yielded a total of 680,032 parcels which were observed for each of the 17 years between 2005 and 2021 giving the dataset 11,560,544 unique observations. Each parcel belongs to one of 2,125 neighborhoods defined by HCAD.

In Table 1., we can see summary statistics of the pre-treatment values of important variables separated by treatment and control group.[1]

Table 1.—Summary Statistics

Control Group	Mean	Median	SD
Total Value (ft2)	65.283	62.947	19.940
Building Value (ft2)	52.155	51.382	13.408
Land Value (ft2)	2.95	2.509	30.398
Base Area (ft2)	2621.494	2435	1038.489
Living Area (ft2)	2115.927	1934	863.589
Land Area (ft2)	20303.806	7839	3795647.212
Extra Features Value	1451.65	0	3925.217
Construction Quality	3.255	3.5	0.631
Building Age	25.827	25.5	16.745
Percent Remodeled	.55	1	0.497
Value Quintile	2.866	3	1.263
Distance to Treatment Boundary (miles)	16.656	18.997	7.749
Treatment Group			
Total Value (ft2)	70.123	62.296	33.987
Building Value (ft2)	49.283	48.309	16.314
Land Value (ft2)	4.786	2.649	53.322
Base Area (ft2)	2372.42	2215	1048.188
Living Area (ft2)	1927.95	1747	863.297
Land Area (ft2)	23008.585	7625	3862377.155
Extra Features Value	878.805	0	3314.425
Construction Quality	3.314	3.5	0.629
Building Age	34.835	34.5	16.883
Percent Remodeled	.58	1	0.494
Value Quintile	2.647	2	1.337
Distance to Treatment Boundary (miles)	11.774	11.224	4.351

This table reveals the significant differences between the two groups in terms of their property characteristics. For example, houses in the treatment group tend to be older, smaller, and of poorer construction quality. They also tend to be built on smaller properties which we can tell from the smaller median value of land area in the treated group, despite the fact that the mean value of land area is higher for those properties. This is likely due to the fact that there are extreme outliers (in terms of land area) in the treated group. We can also see that, although total property values tend to be higher in the control group, property values by square footage are higher in the treatment group. This makes sense given the smaller size of houses and the higher value of land within the city of Houston.

[1] Descriptions of these variables are included in Table A1. of the Appendix

6. Main Results

6.1 Matching

The results of the logistic regression used in the matching procedure are shown in Table 2. All of the variables are significant with the exception of land area which is likely due to its extremely high standard deviation. However, the odds ratio of base area, living area, and extra features value are all equal to 1. The most significant predictor of treatment status is whether or not a home has been remodeled with remodeled homes significantly more likely to be in the treatment group. We also observe that higher construction quality is a fairly significant predictor of not belonging to the treatment group.

Table 2.—Logit Model of Treatment Group

Treatment Group	Odds ratio.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
mean_act_ar	1	0	-52.42	0	1	1	***
mean_heat_ar	1	0	31.72	0	1	1	***
mean_land_ar	1	0	-0.05	.958	1	1	
mean_x_features_val	1	0	-59.17	0	1	1	***
mean_remodeled	1.56	.018	39.07	0	1.525	1.595	***
mean_quality	.76	.005	-43.60	0	.75	.769	***
mean_age	1.034	0	166.77	0	1.033	1.034	***
Mean_value_quintile : base 1	1	.	.	.	.	.	
2	1.346	.012	34.73	0	1.324	1.369	***
3	1.248	.013	22.03	0	1.223	1.272	***
4	1.196	.015	14.23	0	1.167	1.226	***
5	1.925	.033	38.21	0	1.861	1.99	***
Constant	1.745	.048	20.38	0	1.654	1.841	***

*** $p<.01$, ** $p<.05$, * $p<.1$

Nevertheless, matching properties based on propensity scores estimated by the logit model is successful in significantly reducing sampling bias between the two groups. The results of the matching procedure can be seen in figure 2. It depicts the results of nearest-neighbor matching with replacement and using a caliper of 0.0001. It is clear that the use of the caliper greatly reduces the amount of bias across covariates in the treatment and control groups.

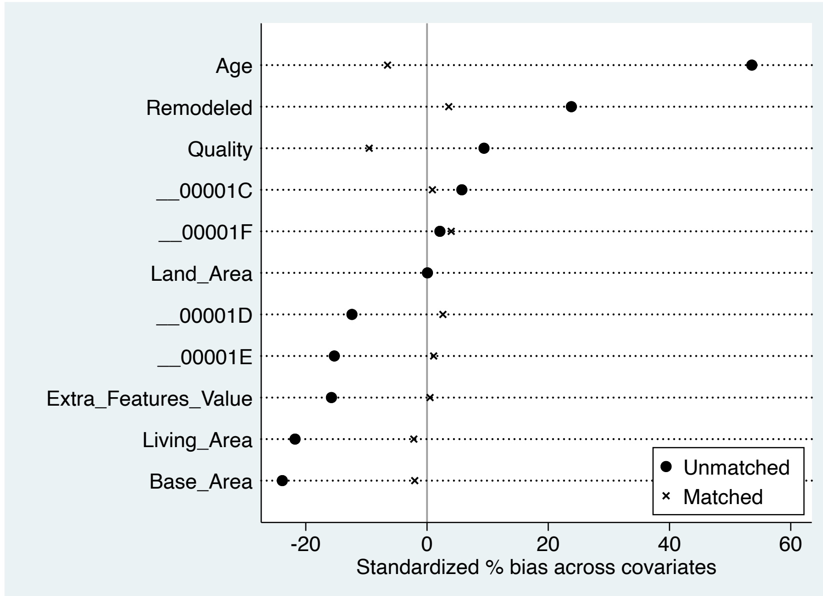

Figure 2.—Graphical Representation of Reduction in Bias Between Treatment and Control Groups after matching

6.2 Total Market Value

Table 3. presents the results of parcel level difference-in-differences regressions testing the effect of the treatment on the total value of properties per square-foot. This result will be interesting as it will give an early indication of which of its two components, building value and land value, is receiving a strongler local effect of the treatment,

Model 1 shows the estimated effect of the treatment when using the unmatched sample while Models 2-4 show the results when properties in the treatment and control groups are matched based on their propensity scores. The models including matched treatment and control groups use three different calipers of increasing restrictiveness and hence more accurate matches of treatment and control properties.

The estimated effect of the treatment is positive and highly statistically significant in all four models. This indicates that the treatment is increasing property values per square foot in the treated area. However, we can also see that increasing the restrictiveness of the caliper decreases the estimated effect of the treatment. This would suggest that part of the increase in property values is due to differential trends correlated with property characteristics which differ between the treatment and control group

Table 3.—Parcel Level DiD Regressions for Total-Market-Value (ft2)

	(1) Without Matching	(2) Matched with Caliper 0.0001	(3) Matched with Caliper 0.00001	(4) Matched with Caliper 0.000001
ATET				
r1vs0.TREAT	3.991***	3.922***	3.057***	1.261***
N	11560544	11549630	11349200	8419267

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

The validity of the difference-in-differences model depends on parallel trends of the outcome variable for the treatment and control group during pre-treatment periods. This is first tested by running a parallel-trends test which estimates a coefficient for the differences in linear trends prior to treatment. If this coefficient is insignificant then it means that the linear pretreatment trends are parallel. The model without matching passes this test with an insignificant coefficient, but all of the models that include matching fail with significant coefficients.

However, when we examine graphical representations of these trends in Figure 4 (which depicts graphical diagnostics of the model that includes matching using the most restrictive caliper), we can see that, while the pretreatment trends for the treatment and control group are not exactly parallel, their linear trends do not diverge by very much. Furthermore, the extremely large number of observations in these regressions (between 8 and 12 million for models 2-4) means that, although the test is rejected, the magnitude of the violation could be extremely small (Bilinski & Hatfield 2018). And, perhaps most convincingly, in the post treatment period, the linear trend of the treatment group actually surpasses the linear trend of the control group despite trending in the opposite direction during the pretreatment period.

So, while the coefficient on the treatment variable estimated by the difference-in-differences model might not be extremely precise due to the lack of parallel trends, the fact that it is positive and significant is hard to refute.

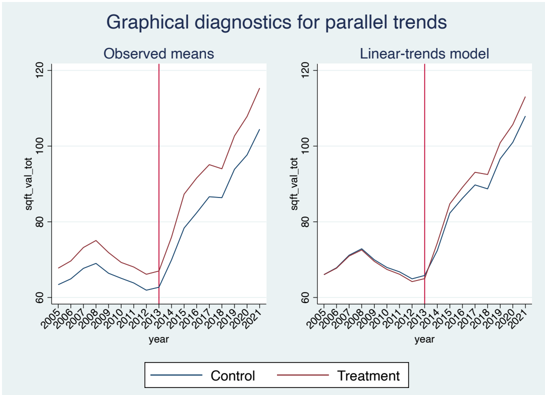

Figure 3.—Trends in Total Market Value for Model 1 (no matching)

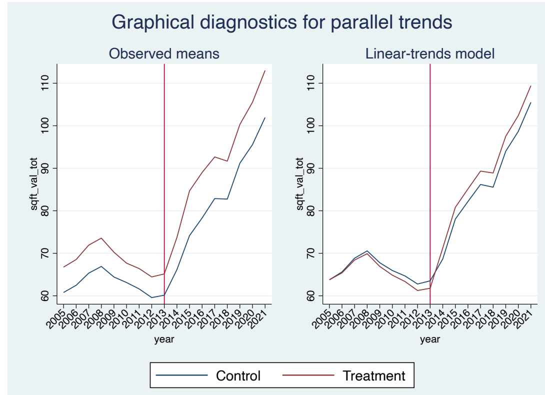

Figure 4.— Trends in Total Market Value for Model 4 (properties matched with caliper=0.000001)

6.3 Building Value

Now that the effect of the treatment on total property values has been estimated, the remaining analysis will try to determine the mechanism by which this effect works. This is done by estimating the effect of the treatment on the respective components of total market value: building value and land value. Table 4. presents the results of parcel level difference-in-differences regressions testing the effect of the treatment on building value per square-foot. Recall, the hypothesis is that the treatment will decrease the unit value of residential buildings for properties in the treated area.

Similar to the previous table, results are presented first for a model with all properties included (Model 5) and then for models using only matched observations with increasingly restrictive calipers (Models 6-8). The estimated treatment effects in all of the models are consistent with the hypothesis as they are negative and highly statistically significant. When the caliper is made more restrictive, the coefficient decreases in magnitude which indicates that at least some of the negative effect of the treatment on unit building values is due to differences between treatment and control groups.

Table 4.—Parcel Level DiD Regressions for Building Value (ft2)

	(5) Without Matching	(6) Matched with Caliper 0.0001	(7) Matched with Caliper 0.00001	(8) Matched with Caliper 0.000001
ATET				
r1vs0.TREAT	-3.142***	-3.152***	-3.110***	-2.344***
N	11560544	11549630	11349200	8419267

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

However, the validity of these estimates for the effect of the treatment on unit building values is questionable when testing the parallel trends assumption as the models all fail the parallel-trends test. This divergence is clear when looking at the trends of the observed means of the outcome variable depicted in Figures 5. and 6. The trends for the treatment and control groups are clearly diverging, particularly after 2008. Imposing even the most restrictive matching on the two groups does nothing to change this.

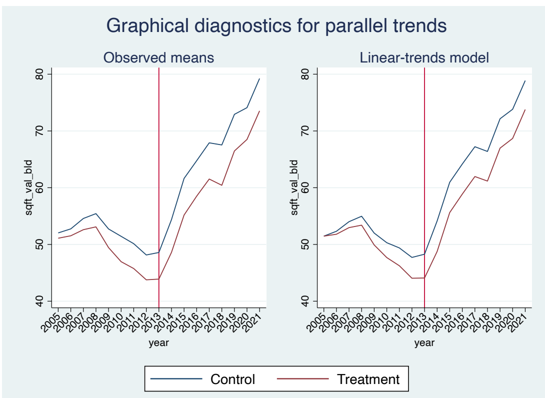

Figure 5.—Trends in Building Value for Model 5 (no matching)

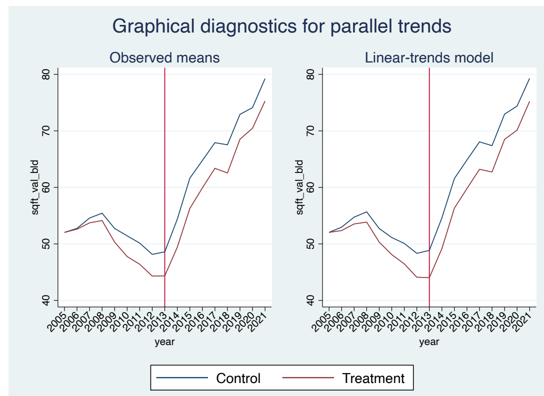

Figure 6.—Trends in Building Value for Model 8 (properties matched with caliper=0.000001)

6.4 Land Value

Given that the estimated effect of the treatment on total market values is positive while its estimated effect on building values is negative, it is reasonable to expect the treatment effect on land value to be positive and consistent with the hypothesis. Any different result would indicate some confounding factor accounting for the positive effects on total market value.

Table 5. presents the results of the difference-in-differences regressions testing the effect of the treatment on land value per square-foot. The estimated effect of the treatment is positive and highly significant for all of the models. It seems that, consistent with the hypothesis, the treatment has the effect of increasing unit land value in the treated area.

Identical to the results presented for the other outcome variables, the estimated effect of the treatment declines with a more restrictive caliper being used in the matching procedure. This points to at least some of this effect being due to differences in property characteristics between treatment and control groups.

Table 5.—Parcel Level DiD Regressions for Land Value (ft2)

	(9) Without Matching	(10) Matched with Caliper 0.0001	(11) Matched with Caliper 0.00001	(12) Matched with Caliper 0.000001
ATET				
r1vs0.TREAT	1.676 ***	1.661***	1.465***	0.970***
N	11548934	11538105	11342401	8426731

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

However, like in the case of the model estimating the treatment effect on building value, these models all fail parallel-trends tests which casts doubts on the validity of the estimation. Graphical diagnostics of these trends presented in Figures 7 And 8 show that linear trends in unit land values between the treatment and control groups are diverging in the pre-treatment period. However, looking only at the trends in observed means, it appears that, in the years after 2008, the difference in unit land value between the treatment and control group is fairly stable.

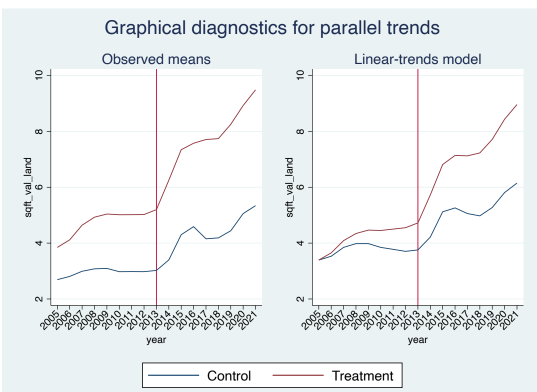

Figure 7.—Trends in Land Value for Model 9 (no matching)

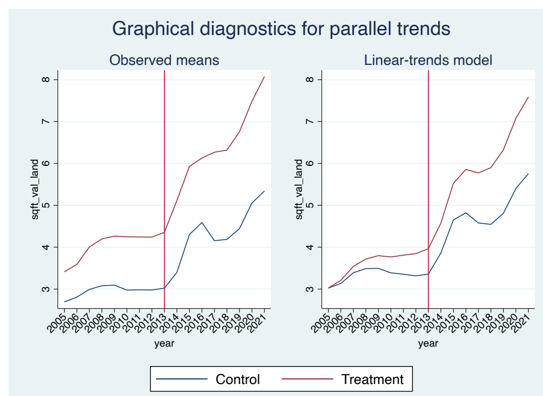

Figure 8.—Trends in Land Value for Model 12 (properties matched with caliper=0.000001)

7. Additional Regressions and Robustness Checks

7.1 Time Restricted Regressions

Most of the models in the main results section fail to demonstrate clear parallel-trends in the pre-treatment period. However, a common feature in all of these cases is that the difference between treatment and control groups changes significantly around 2008, but the trends before and after this year are fairly similar. It goes without saying that the financial crisis of 2008 was an extremely significant event for the U.S. housing market, and it is highly likely that it had differential effects on properties in the city of Houston compared to properties in the suburbs. Part of this is likely due to younger homebuyers, who made up a proportionally greater share of the market in Houston, being more negatively affected by the recession and hence more likely to enter the rental market. It is also likely that relative increases in land value in the city of Houston was due to the contraction of the construction sector following the financial crisis and a lower demand for newly built homes in the suburbs.

Whatever these reasons are, the differences in the housing market for treatment and control groups seem to have remained relatively stable during the pre-treatment period between 2009 and 20013. Because of this, it seems reasonable to re-estimate the models without the pre-financial-crisis years to see if the parallel-trends assumption is more justifiable and the estimated effect of the treatment remains similar. Following this same logic, the re-estimated models will also exclude the final two years of the panel (2020 & 2021) due to the COVID-19 pandemic and its significant effect on the U.S. economy which may have had differential effects on the treatment and control groups that would be difficult to parse out.

Table 6. presents the results of the re-estimated models for each of the three outcome variables. All models include only matched observations with a caliper of 0.00001. We can see that all of the coefficients have the same sign as the models including all years and remain highly statistically significant. The values are slightly less than in the other models but are still quite similar.

Table 6.—Time Restricted DiD Regressions

	(13) Total Value (ft2)	(14) Building Value (ft2)	(15) Land Value (ft2)
ATET			
r1vs0.TREAT	2.819***	-2.125***	0.971***
N	6676000	6676000	6669270

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

More interesting, however, are figures 9. 10. and 11. depicting the pre-treatment time trends of each of the three models. While none of them passes a parallel trends test, it has been noted that the extremely large sample size used in this analysis makes even small deviations between treatment and control groups enough for the test to reject the parallel-trends assumption. What is important is that, in the figures below, the pre-treatment time trends are extremely similar, much more so than in the models that included all years.

This is especially true in the case of unit land values (depicted in Figure 11). There is an enormous jump in the difference between treatment and control groups following the treatment, far in excess of the small difference in their trends before the treatment. The case of unit building value (depicted in Figure 10) is less convincing, as the divergence in pre-treatment trends between treatment and control groups is quite large relative to their post-treatment difference. However, it is still a significant improvement over the model with all years included.

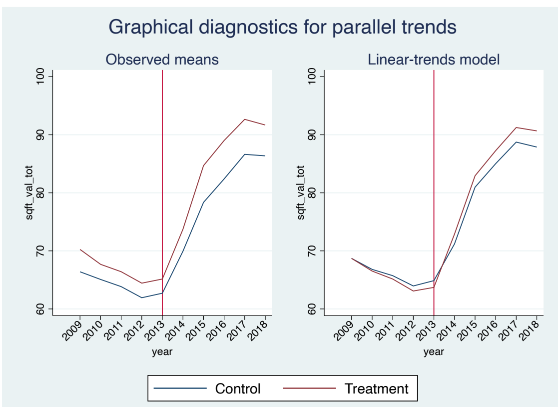

Figure 9.— Trends in Total Market Value for Model 13

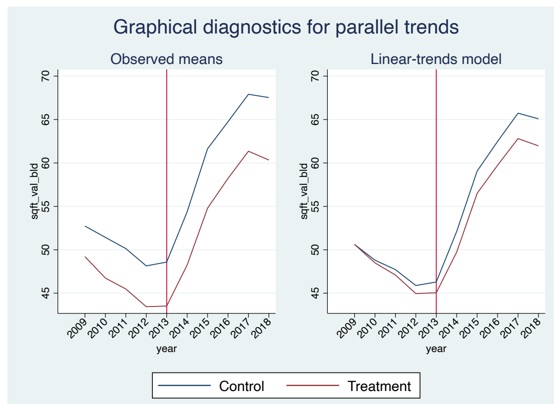

Figure 10.—Trends in Building Value for Model 14

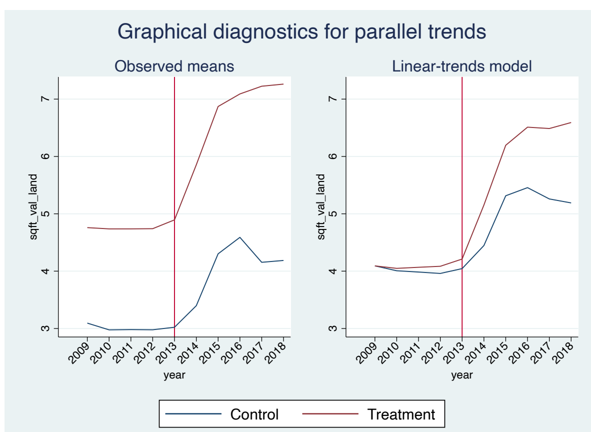

Figure 11.—Trends in Land Value for Model 15

This robustness check provides strong support for the validity of two out of the three results from the main section: (1) the treatment has a significant and positive effect on the total market value of properties in the control section, and (2) the channel by which the treatment is increasing total market values is the land component. Building values may indeed be negatively affected by the treatment, but it is hard to justify given their flagrant violation of the parallel trends assumption. Nevertheless, even if the negative effect of the treatment on building values is valid, it is clearly dwarfed by the positive effect of the treatment on land values given that total market values increase.

7.2 Regressions with Unbalanced Panel

Additional regressions are run that include the previously omitted properties which are missing from some of the years in the panel. These were removed for the main regressions in order to create a balanced panel and ensure consistent exposure to the treatment. This includes properties with houses constructed during the period under analysis as well as properties with houses that were demolished during the same period. However, the exclusion of these properties from the main regressions could bias the results if, for example, the value of newly constructed houses in the treatment group is increasing relative to the value of newly constructed houses in the control group.

However, when the regressions are run with all of these properties included in an unbalanced panel, the coefficients remain extremely similar to those in the main results.[2] The coefficients of the regressions on total market value and land value are slightly higher than before while the coefficients of the regression on building value is slightly lower than before. This indicates that, while new construction might receive a slightly different effect from the treatment than existing properties, it is not enough to seriously jeopardize the validity of the results.

7.3 Neighborhood Level Regressions with Distance Bands

Finally, additional difference-in-difference regressions are run in order to test differences in the treatment effect at varying distances from the treatment boundary. If the treatment is decreasing unit building value, the estimated treatment effect should decrease at greater distances from the boundary. This is because properties within Houston that are further from the boundary are, in theory, less substitutable with the more suburban control group properties. Hence, the supply side effect of the treatment on price

[2] These results are presented in Tables A2., A3. and A4. of the appendix

should be more detectable by the difference-in-differences model for these properties and help counteract increases in land value. This supplements the main analysis where the estimated effect of the treatment on building values is questionable due to unparallel pre-treatment trends.

Given the large amount of computing power required by parcel level regressions and the limited time-frame of this project, these regressions are run at the neighborhood level. This is done by aggregating land and housing characteristics by neighborhood, separating neighborhoods in the treatment group into quartiles by their distance from the treatment boundary, and then matching and estimating the difference-in-difference regression for each quartile with each neighborhood weighted by its number of parcels.

Results indicate that neighborhoods very close to the treatment boundary have their property values increased significantly by the treatment while neighborhoods far from the boundary either have their relative property values modestly decreased by the treatment, or experience no significant effect.[3] While the lack of parallel trends for several of these models makes their results questionable, the coefficients are consistent with the hypothesis that the treatment will have a negative local effect on building value, particularly in areas where properties are less substitutable for those in the control group.

8. Discussion

The main results of this analysis indicate a positive effect of Houston's 2013 MLS reduction on residential property values in the city. Given that reforms of land use regulations are usually intended to reduce the cost of housing, this may seem counterintuitive. However, as mentioned in the methodology section, the empirical approach used here is estimating the local effect of the MLS reduction policy, that is, the effect of the policy within the local housing market. It could very well be that the total effect of the policy was to decrease the cost of housing in Houston relative to the rest of the country, but to determine this, housing trends in Houston would have to be compared against those in another city.

However, the local effect of Houston's MLS reduction is still extremely important because the U.S. construction sector is quite localized compared to other industries and hence, a large share of property

[3] These results are presented in Table A5. Of the appendix

development decisions are made at the local level (Schuetz, 2022). This means that the local effect of Houston's MLS reduction has critical implications for patterns of residential development both within the city and in its surrounding area.

The local effect of the MLS reduction on single-family residential property values in Houston was, as this analysis found, driven by increases in land value. This is an effect that should encourage denser development in the city. Given that each unit of single-family residential land is more expensive, developers should gradually convert existing parcels to more efficient use in order to maintain profit margins. This could consist of more townhouses, multifamily housing like duplexes and triplexes, as well as apartment buildings. An increase in the supply of these kinds of properties would benefit low-income residents the most given that their total cost is less. Of course, this is purely speculative, and it would require further studies to determine the exact effect of the policy on Houston's construction market. Nevertheless, the connection between higher land values and higher density is clear (Ottensmann, 1977), especially in a city like Houston where the lack of traditional zoning means that new development is freer to adjust to the market.

Although the validity of the results obtained for building values is questionable given the lack of parallel trends, the estimated effect of the MLS reduction policy was still negative and significant. This is encouraging because, if the differences-in-differences model is picking up downward pressure on building values at the local level (where residential properties are fairly substitutable), there is a strong reason to believe that the a comparison of trends in building values between Houston and a similar city would yield a significantly larger reduction.

Finally, the general decrease in the estimated treatment effect when properties were matched with more restrictive calipers is worth discussing. This indicates that, after 2013, secular trends correlated with the property characteristics most typical in Houston are responsible for at least some of the increase in residential property values observed there. Some of this is likely due to the major rebound in Houston's economy occurring during this period which attracted younger and more educated workers with a higher willingness to pay for urban proximity. This would cause the smaller, older and poorer quality houses in

Houston to sell for higher prices. However, while this may explain some of the increase in Houston's residential property values post-treatment, it cannot explain all of it given that the estimated treatment effect remained positive and significant no matter how strict the matching procedure.

9. Conclusion

This analysis proposed two main hypothesis following from Houston's 2013 MLS reduction for single-family properties: (1) the unit value of housing in the city will decrease relative to the suburbs and (2) the unit value of residential land in the city will increase relative to the suburbs. These hypotheses were tested by estimating a difference-in-difference model incorporating propensity score matching. The results show that there is a fairly convincing increase in residential land value as a result of the treatment and a less convincing decrease in building value as a result of the treatment. Consequently, the total effect of the MLS reduction was to increase single-family property values in the city relative to the suburbs.

The fact that this effect worked primarily through increased land values bodes well for densification and a more efficient use of Houston's residential property. Higher land prices should incentivize developers to erect residential structures that take up less space and homeowners should benefit from the increased value of their property. There is great potential for future research to determine exactly how the MLS reduction affected trends in new construction and if these benefits were actually realized.

Also, given that this analysis cannot say how the MLS reduction policy affected Houston's residential property values relative to the rest of the country, it would be extremely interesting, in a future study, to compare housing trends in Houston to those of a similar city. Ideally, this would be done using real sales data as opposed to the estimated market values from the appraisal district that this analysis employed. Furthermore, if this kind of detailed home sales data was available, it could be used to verify if the estimated values from the appraisal district are indeed an unbiased proxy for the real values. This would further strengthen the validity of this paper's results.

References

Bilinski, A., & Hatfield, L. A. (2018). Nothing to see here? Non-inferiority approaches to parallel trends and other model assumptions. *arXiv preprint arXiv:1805.03273*.

Bucovetsky, S. (1984). On the effects of minimum-lot-size zoning. *Economics Letters*, *15*(1-2), 189-193.

Fulton, W. (2020, January). *The 'Z' Word*. American Planning Association. Retrieved from https://planning.org/planning/2020/jan/the-z-word/

Glaeser, E. L., Schuetz, J., & Ward, B. (2006). Regulation and the rise of housing prices in Greater Boston. *Cambridge: Rappaport Institute for Greater Boston, Harvard University and Boston: Pioneer Institute for Public Policy Research*.

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.

Gray, M. N., & Furth, S. (2019). Do minimum-lot-size regulations limit housing supply in Texas?. *Mercatus Research Paper*.

Kapur, T. M. (2004). Land use regulation in Houston contradicts the city's free market reputation. *Envtl. L. Rep. News & Analysis*, *34*, 10045.

McMillen, D. P., & McDonald, J. F. (2002). Land values in a newly zoned city. *Review of Economics and Statistics*, *84*(1), 62-72.

Ottensmann, J. R. (1977). Urban Sprawl, Land Values and the Density of Development. *Land Economics*, *53*(4), 389–400. https://doi.org/10.2307/3145984

Schuetz, J. (2022, March 9). *Who's to blame for high housing costs? it's more complicated than you think.* Brookings. Retrieved from https://www.brookings.edu/research/whos-to-blame-for-high-housing-costs-its-more-complicated-than-you-think/

Single-family residential lot size, 42 Houston Code of Ordinances § 181 (2013) https://library.municode.com/tx/houston/codes/code_of_ordinances?nodeId=COOR_CH42SUDEPL_ARTIIIPLST_DIV4LORE

Smith, B. A. (1976). The supply of urban housing. *The quarterly journal of economics*, *90*(3), 389-405.

Smith, B. A., & Tesarek, W. P. (1991). House prices and regional real estate cycles: Market adjustments in Houston. *Real Estate Economics*, *19*(3), 396-416.

The United States Government. (2022, May 16). *President Biden announces new actions to ease the burden of housing costs*. The White House. Retrieved June 14, 2022, from https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/16/president-biden-announces-new-actions-to-ease-the-burden-of-housing-costs/

U.S. Census Bureau (2021). Quick Facts Houston city, Texas. Retrieved from https://www.census.gov/quickfacts/houstoncitytexas

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.

Zhou, Y., & Haurin, D. (2010). On the determinants of house value volatility. *Journal of Real Estate Research*, *32*(4), 377-396.

Appendix

Table A 1.—Description of Matching Variables

Variable	Description
Total Value (ft2)	The estimated total market value of the parcel divided by the area of the house
Building Value (ft2)	The estimated market value of the house on the parcel divided by the area of the house
Land Value (ft2)	The estimated market value of the parcel's land divided by its total area
Base Area (ft2)	The total area of the parcel covered by the house
Living Area (ft2)	The total area of livable space in the house
Land Area (ft2)	The total area of the parcel
Extra Features Value	The estimated value of extra amenities on the parcel like garages and swimming pools
Construction Quality	The estimated construction quality of the house in its current state (expressed on a scale 1-7)
Building Age	The age of the house since its original construction
Percent Remodeled	A binary variable equal to 1 if the house was remodeled and 0 if it was not
Value Quintile	The quintile of total market value for the entire sample in which the parcel falls
Distance to Treatment Boundary (miles)	The distance in miles between the parcel and the border of the city of Houston

Table A2.—Unbalanced Parcel Level DiD Regressions for Total-Market-Value (ft2)

	(1) sqft_val_tot	(2) sqft_val_tot	(3) sqft_val_tot	(4) sqft_val_tot
ATET				
r1vs0.TREAT	3.967***	3.955***	3.445***	1.732***
N	13922316	13338208	13189235	10320298

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table A3.—Unbalanced Parcel Level DiD Regressions for Building Value (ft2)

	(1) sqft_val_bld	(2) sqft_val_bld	(3) sqft_val_bld	(4) sqft_val_bld
ATET				
r1vs0.TREAT	-2.978***	-2.970***	-2.973***	-2.205***
N	13922316	13338208	13189235	10320298

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table A4.—Unbalanced Parcel Level DiD Regressions for Land Value (ft2)

	(1) sqft_val_land	(2) sqft_val_land	(3) sqft_val_land	(4) sqft_val_land
ATET				
r1vs0.TREAT	1.966***	1.943***	1.824***	1.390***
N	13908408	13324434	13175552	10310819

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table A5.—Neighborhood Level DiD Regressions

	(13) All Neighborhoods No Matching	(14) All Neighborhoods With Matching	(15) Neighborhoods Within Q1	(16) Neighborhoods Within Q2	(17) Neighborhoods Within Q3	(18) Neighborhoods Within Q4
ATET						
r1vs0.TREAT	3.991***	3.177***	22.39***	-0.683	-1.841**	-1.468***
N	36125	35513	20893	21131	21318	21386

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01