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Zoning and the economic geography of cities☆

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A B S T R A C T

Comprehensive zoning is ubiquitous in U.S. cities, yet we know surprisingly little about its long-run impacts. We provide the first attempt to measure the causal effect of land use regulation over the long term, using as our setting Chicago's first comprehensive zoning ordinance adopted in 1923. Our results indicate that zoning played a central role in establishing residential neighborhoods free of industrial and commercial uses. The separation of uses established by the zoning ordinance persists to the present day and is reflected in housing prices, the location of polluting industrial sites, and population density.

1. Introduction

> *"This zoning law does not impose a very serious limit on the use of land, for if all the land in Chicago were built to the limit allowed by the zoning law, the entire population of the United States could be housed in the city …. Moreover, whenever there is any possibility of a higher use for any block or parcel of land than the one for which it is zoned, it is not very difficult to have it zoned for the higher use, as the five thousand amendments to the zoning law testify."*
>
> *-Homer Hoyt, One Hundred Years of Land Values in Chicago*

Among economists, conventional wisdom suggests market forces are the primary determinant of the spatial distribution of economic activity within cities. This emphasis on market forces can be seen theoretically and empirically. Both the monocentric city model and more recent models of agglomeration all tie market processes to the determination of land use patterns. In empirical work, the focus on markets and prices in determining the location of economic activity can be observed in the voluminous literatures on agglomeration economies, transportation costs, and residential sorting dynamics.[1]

The central role economists ascribe to market forces stands in stark contrast to the conventional understanding of zoning ordinances, which are typically thought of as endogenous, merely reflecting the locational choices of competing economic actors.[2] This view of zoning laws, however, is based on a surprisingly thin evidentiary base. Given the prevalence of urban planning and zoning laws in contemporary American society (except for Houston, every major city in the United States is subject to a comprehensive body of zoning laws), it is surprising that no work has been done evaluating the long-run impacts of land use regulation on the spatial organization of cities.

Accordingly, in this paper, we present a systematic empirical assessment of the long-term effects of zoning on the overall arrangement of economic activity in a city. Our analysis focuses on the city of Chicago, which adopted a comprehensive zoning ordinance for the first time in 1923. The distinguishing feature of our empirical approach is that we are able to observe land use patterns at the lot level for the entire city of Chicago *before* its first zoning law was implemented. Previous scholarship on the relationship between zoning and land use

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[1] For reviews of these literatures, see Duranton and Puga (2015), Combes and Gobillon (2015), Redding and Turner (2015) and Kuminoff et al. (2013).

[2] Two examples of papers that find zoning evolves to reflect the highest-value use for land include Wallace (1988) and Munneke (2005). On the other hand, both McDonald and McMillen (1998) and Zhou et al. (2008) provide evidence of a short-run price effects associated with different types of zoning. The notion that zoning is an ineffectual or fleeting constraint on land use patterns is itself controversial; to quote William Fischel (2001), this notion is "completely at odds with the attention paid to [zoning] by otherwise rational people" (The Homevoter Hypothesis, p. 57).

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has not utilized city-wide land use patterns in the years preceding the advent of zoning laws and therefore has had trouble cleanly identifying the impact of zoning on land use. Our findings suggest that the existing literature understates the importance of zoning in shaping urban form in contemporary American cities.

Specifically, we consider an array of city block-level outcomes, investigating the long-run influence of zoning on the location of manufacturing activity, commercial uses, residential areas, population density and polluting facilities. At a similar spatial scale, we also evaluate zoning's impact on present day housing prices. This analysis indicates that Chicago's 1923 zoning ordinance has had a sizable impact on present day land use. To understand the role of zoning vis-à-vis other key land use drivers, we use standardized multiple-partial regression to evaluate the relative importance of five different categories of variables: zoning, pre-existing land uses, pre-existing transportation networks, geography, and pre-existing demographics. We find that the impact of initial zoning classification is roughly similar in magnitude to that of pre-existing land use in determining present day use. Furthermore, while both are clearly important, our results indicate that transportation networks and geography, the stalwarts of urban land use theory, are less important than zoning for determining land use over the long run.

Finally, we examine the extent to which the organization of economic activity across the city as a whole shifted following zoning. We document a high degree of mixing of residential, commercial, and industrial activity in the city prior to zoning. Land use as imagined by the zoning board exhibited considerably more separation of uses, and this separation did in fact emerge by the end of the twentieth century. Following on this line of analysis, we consider the case of Houston, arguably the only major city in the U.S. which lacks a comprehensive zoning ordinance. We present evidence that polluting land uses (Toxics Release Inventory facilities) are less segregated in “un-zoned” Houston than they are in comparable zoned cities in Texas (Austin, Dallas and San Antonio). Finally, utilizing our empirical analysis of Chicago, we construct estimates of the distribution of these polluting land uses in Chicago both under zoning and in a counterfactual world without zoning. The resulting comparison suggests a zoning impact that is qualitatively very similar to what we find in our analysis of cities in Texas. These city-level results provide evidence that zoning can reshape the general spatial organization of a city over the long term.

Existing work on zoning has documented the fact that supply restrictions arising from higher overall levels of land use regulation are associated with higher land prices (Quigley and Raphael, 2005; Ihlanfeldt, 2007; Glaeser and Ward, 2009; Turner et al., 2014). These analyses largely focus on residential density restrictions, ignoring the extent to which different uses are separated by zoning; this is perhaps inevitable due to the ubiquity of separation of uses in U.S. cities.

A second literature seeks to disentangle the impact of various types of use restrictions on prices. Early results in this literature suggested that zoning did not respond to market forces once in place. Studies of parcel re-zoning suggest that zoning evolves over time in a manner that reflects the highest-valued land use for the affected parcels, indicating that the market influences zoning to some extent (Wallace 1988; Munneke 2005). The question of how zoning shaped urban spatial structure has received comparatively less attention in economics, and recent papers have largely focused on the existence of short-run price effects associated with different types of use zoning (McDonald and McMillen 1998; Zhou et al., 2008). Our contribution is to place local government institutions in context as a determinant of land use patterns over the long term.

2. Background on zoning

2.1. Brief history of zoning in the United States

New York City passed the first comprehensive zoning ordinance in the United States in 1916. Over the next twenty years, facilitated by the rapid enactment of state enabling ordinances modeled on a template developed by the U.S. Department of Commerce, over 700 additional cities adopted comprehensive zoning ordinances (Advisory Committee on Zoning, 1926). The demand for zoning was rooted in the prevailing condition of American cities, many of which saw rapid unplanned growth following large-scale European immigration and industrialization that began in the mid-nineteenth century.

Extremely high residential densities, combined with poor water and waste disposal infrastructure, led to high rates of infectious disease in major cities (Troesken, 2004). Noxious industrial uses were frequently located in densely populated areas and routinely encroached on higher-end retail and office districts. Many urban residents objected to the “canyon effect” created by unbroken rows of skyscrapers, citing the potential negative effects of reduced sunlight exposure and airflow on public health (Hall, 2002, pp. 36–47). Coinciding with this growth and squalor was the rise of the Progressive movement, whose proponents sought to apply scientific and technical expertise to the problem of managing overpopulated industrial cities. These reformers found common cause with powerful real estate interests, whose overarching concern was the protection of property values from threats posed by the unrestricted encroachment of undesirable land uses (Bassett, 1922).

2.2. Land use and zoning in Chicago

In many ways, Chicago was typical of the largest U.S. cities at this time. Overcrowding was prevalent, especially in black and first-generation immigrant communities (Shertzer et al., 2016). Dense skyscraper development in the central business district caused substantial controversy, and the unrestricted spread of commercial and industrial development threatened property values in higher income residential neighborhoods (Schwieterman and Caspall, 2006). Development in Chicago was also geographically constrained by both Lake Michigan and the Chicago River. While these conditions were shared by many major cities and spurred the adoption of land use regulation nationally, Chicago was exceptional in some ways beyond its rank as the second-largest city in the U.S. By the 1920s, the city had a highly developed fixed rail public transportation system and a significant number of buildings that are still standing today. This relatively large stock of durable capital may have blunted the impact of zoning in Chicago relative to cities that were less built up in the 1920s. Chicago is also known for having an especially corrupt local government, which may have made zoning variances easier to obtain. These caveats may limit the generalizability of our findings, which in part motivates our analysis of Texas cities in Section 6.

Chicago's city government had made previous attempts to control undesirable land uses, including an 1837 municipal code that prohibited landowners from maintaining nuisances such as dead animals, dung, putrid meat, or fish entrails on their property. However, such piecemeal approaches proved insufficient to meet the public demand for controlled development. In 1921, the newly created Chicago Zoning Commission began preparing a comprehensive zoning ordinance. The Commission, composed of eight aldermen and fourteen representatives from the Chicago community, spent eighteen months surveying existing land use in Chicago before issuing the initial statute. While the ordinance was designed by the Commission, the commission solicited feedback from numerous civic organizations and held public hearings in an attempt to create what they called a “people's ordinance” (Chicago Zoning Commission, 1922).

The ordinance that resulted from this process regulated land through separately defined and overlaying districts restricting allowed uses and building volumes. This dual-map system was typical of zoning ordinances in major cities at this time (see, e.g., New York City, 1917; Seattle, 1923; Boston, 1924; Baltimore, 1931). Four distinct use districts were included: residential (single-family housing), apartment, commercial, and manufacturing. These use districts were hierarchical, with apartment districts allowing residential uses, commercial districts allowing both apartments and single-family homes, and manufacturing districts allowing any use. Volume districts imposed restrictions on maximum lot coverage, aggregate volume, and height. The five volume districts in Chicago's ordinance were also hierarchical, with district 5 allowing the tallest buildings. Non-conforming uses existing at the time of the ordinance's passage were allowed to continue. However, these non-conforming uses could not be extended and, during any ten-year period, renovation expenditures were limited to an aggregate cost of no more than 50% of the value of the building.

The question of how closely the initial zoning ordinance followed existing land use has been explored in previous work, which found that zoning was sensitive to existing land uses, proximity to transportation networks, and distance to waterways (McMillen and McDonald, 1999). In other work, we show that the distribution of minority groups also impacted the initial zoning ordinance; in particular, southern black and first-generation immigrant neighborhoods were more likely to be zoned for industrial uses (Shertzer et al., 2016). In order to disentangle a causal effect of historical zoning on contemporary land use from persistence in land use over time, we require variation in how similar lots were zoned in 1923. We find that although zoning was influenced by extant uses, there remains significant variation in zoning outcomes across individual lots that were located at similar points along the commercial and/or manufacturing activity spectrum.

3. Data

There are eight components to the dataset used in our analysis. Five of these components are contemporary: the Chicago Metropolitan Agency for Planning's (CMAP's) 2005 land use inventory; the Environmental Protection Agency's Toxics Release Inventory (TRI); Chicago's 2012 zoning classification map; block-level demographic data from the 2000 U.S. census; and transaction prices for single-family homes in Chicago for the years 2000–2012 from DataQuick Information Systems. The other three data components are historical: the Chicago Zoning Board's 1922 land use survey, maps of Chicago's 1923 zoning ordinance, and enumeration district-level demographic data aggregated from the 1920 U.S. Census. Details on the construction of the variables used in the empirical analysis can be found in the Appendix. Table A.1 provides summary statistics of the various historical land use, historical zoning, and contemporary outcome variables. Except as otherwise noted, the unit of observations in our analysis is a single city block. A brief description of each of our data sources follows.

3.1. CMAP land use inventory

Our primary source of information on contemporary land use in Chicago is a 2005 comprehensive land use inventory compiled by the Chicago Metropolitan Agency for Planning. The survey measures actual land use at the acre to one-half acre level (a typical city block in Chicago is five acres) and distinguishes between a wide array of land uses: single-family and multifamily residential use are classified separately while commercial uses are separated into ten different classes and industrial uses are divided into four different classes.[3] The inventory also accounts separately for a variety of institutional, transportation, and open space uses.

3.2. The toxics release inventory

The Toxics Release Inventory (TRI) is an annually-updated inventory of industrial facilities in the United States. The TRI has been the basis for measuring exposure to industrial pollution and/or locally undesirable land uses (LULUs) in numerous empirical studies.[4] We include in our analysis all sites that reported to the TRI at any point between 1987 and 2010.

3.3. 2012 zoning

Zoning data come from the City of Chicago and delineates the city into residential, commercial, industrial, and other miscellaneous categories. We focus on the first three categories, as the others (e.g., planned unit developments featuring bespoke zoning arrangements) are not classifiable in terms of historical zoning.

3.4. 2000 census block data

Our contemporary land use data is supplemented with census block-level population and housing unit count data from the 2000 U.S. Census. GIS block maps were obtained from NHGIS. We attach the census block-level data to individual city blocks using areal interpolation.

3.5. Home sales

Our housing price data encompasses the universe of single-family home sales in Chicago over the years 2000–2012. In addition to sale prices, the data includes housing characteristics such as lot size, building square footage, number of stories, number of bedrooms and bathrooms, and the age of the building at sale. These data come from come from DataQuick Information Systems, under a license agreement with the vendor.

3.6. The 1922 Chicago land use survey

The historical land use survey we draw upon was conducted by the Chicago Zoning Commission in 1922 for the purposes of informing the drafting process for the 1923 zoning ordinance. We geocoded the entire pre-zoning survey for our study. From these survey maps we obtain the location of commercial and manufacturing land uses in the city; we also obtain the location and number of stories for every building with four or more stories. The data contains one commercial class and several manufacturing use classes. When delineating between areas with commercial and manufacturing uses, we include the lightest manufacturing class (Manufacturing A/Light Industry) with the commercial uses.

3.7. Comprehensive zoning ordinance of 1923

We digitized the initial zoning ordinance for Chicago, recording both use zoning and volume zoning. Use zoning delineated all areas of the city into one of four distinct districts: residential (single-family homes), apartment, commercial, and manufacturing. These use districts were hierarchical, with apartment districts allowing residential uses, commercial districts allowing both apartments and single-family homes, and manufacturing districts allowing any use.[5] The residential category was rarely used in the initial zoning ordinance; only three percent of the enumeration districts in our sample have any zoning of this type. The volume districts in the zoning ordinance are essentially rough concentric rings radiating out from the central business district.

[3] In the analysis, we aggregate the distinct commercial and industrial land use categories.

[4] For instance, see Bui and Mayer (2003), Banzhaf and Walsh (2008), and Perlin et al. (1995).

[5] There were additional gradations within the commercial and manufacturing districts, with certain objectionable commercial uses barred if they were within 125 ft of a residential or apartment district, while certain manufacturing uses were barred if they were within 100–200 ft of a residential, apartment, or commercial district. Some commercial uses within 125 ft of residential or apartment districts also saw restrictions on the hours during which trucking activities could occur.

Under volume district 1, buildings were essentially capped at 3 stories in height. For district 2, the maximum height was on the order of 8 stories; district 3, eleven stories; and district 4, sixteen stories. District 5, which was restricted to the central business district, allowed a maximum building height about 22 stories. If a building satisfied requirements on additional setbacks from the street, the allowed height was increased. There were no density "minimums," only restrictions on the maximum volume, height, and lot coverage. Further details on the use and density zoning ordinances, including sample images, can be found in the Appendix.

3.8. Census enumeration district data for 1920

There is evidence that neighborhood demographics impacted the initial zoning ordinance (Shertzer et al., 2016). Therefore, in our empirical work we include a number of controls for 1920 demographic composition. Specifically, we obtained overall population counts, counts of the number of southern and northern blacks, and counts of first- and second-generation European immigrants from the 1920 census, aggregated to the enumeration district level and then aerially interpolated to city blocks.

4. Zoning and land use: descriptive evidence

We begin with visual evidence on the relationship between pre-zoning land use patterns, Chicago's 1923 zoning ordinance, and contemporary land use patterns. The three panels in Fig. 1 focus on industrial land uses. The location of pre-zoning (1922) industrial uses are presented in Panel A.[6] While industry was concentrated along the Chicago River, there were isolated industrial uses scattered across all of the developed portions of the city, particularly west of downtown. In contrast, the initial zoning ordinance (Panel B) restricted industrial uses to locations along the Chicago River, Lake Michigan shoreline, railroads, or near existing concentrations of heavy industry. Furthermore, large tracts for industry were set aside in the outlying areas of the city. New industrial uses were disallowed from entire areas of the city south and west of the central business district. Panel C shows the location of industrial uses in 2005. Despite the grandfather clause, which permitted the continuation of pre-existing non-conforming uses, the vast majority of isolated uses disappeared over the ensuing eighty years, with most industrial uses now locating in areas that were zoned for industry in 1923. We note however that, in spite of the presence of manufacturing zoning, industrial uses also disappeared from the lakefront region of the city.

Similarly, commercial land uses evolved over this eighty-year period to a pattern that was reflective of the 1923 ordinance. Fig. 2 replicates Fig. 1 for commercial uses. Panel A shows that commercial uses essentially carpeted the developed portion of the city in 1922. In contrast, the new zoning ordinance restricted commercial activity to main streets and large tracts around the CBD and bordering the lake (Panel B). Present day land use (Panel C) suggests remarkable success in removing commercial uses from minor streets; the distribution of commerce in 2005 is very similar to the pattern established by the 1923 zoning ordinance, following a grid pattern along with major streets.

To give a further sense of the raw correlations and to highlight the identifying variation in our data, Table 1 summarizes the relationship between historical land uses, the 1923 zoning ordinance, and present day land uses. Panel A reports the correspondence between historical uses and the 1923 ordinance.[7] Not surprisingly, pre-existing uses were reflected in the new zoning rules: 77% of blocks with pre-existing commercial uses included some zoning for commerce and 63% of blocks with industrial uses included some zoning for industry. Conversely, 9% of blocks without pre-existing industry included industrial use zoning and 39% of blocks without pre-existing commerce included zoning for commercial uses. In total, over 40% of all city blocks experienced zoning that did not reflect pre-existing land uses. This divergence likely arose from the zoning board's top-down approach and the planning ideology of the era, which emphasized the value of the separation of "incompatible" uses. Aspirational zoning for future commercial areas and the concentration of industry away from the downtown no doubt played a role as well, as is clear from Figs. 1 and 2. Importantly, Table 1 indicates the existence of useful variation in our data for studying how zoning affected the later evolution of land use.

Having established the presence of considerable variation in historical zoning outcomes given pre-existing uses, we turn our attention to the extent of change in land use over the 1923–2005 period in Chicago. Previous scholarship provides almost no evidence on the micro-level persistence of land use over this level of time scale. Thus, one contribution of our paper is documenting the persistence of land use for a complete city over an eighty-year span. We are interested in the extent of persistence because if the distribution of land use had already been locked in place by 1922, there would be little scope for zoning to have shaped contemporary uses. However, this is not the case: The patterns of land use in the city have shifted dramatically. Panel B of Table 1 summarizes these shifts. There is much divergence. Only 52% of blocks with historical commercial uses hosted any commercial activity in 2005 and only 47% of blocks which historically hosted manufacturing activity still have such uses today. Conversely, 21% of blocks without historical commercial uses have commerce today; the analogous figure for manufacturing is 8%. Thus, while there is clearly persistence in land use, there are also substantial changes in land use composition over time. Below, we argue that zoning can explain a significant portion of this dynamism.

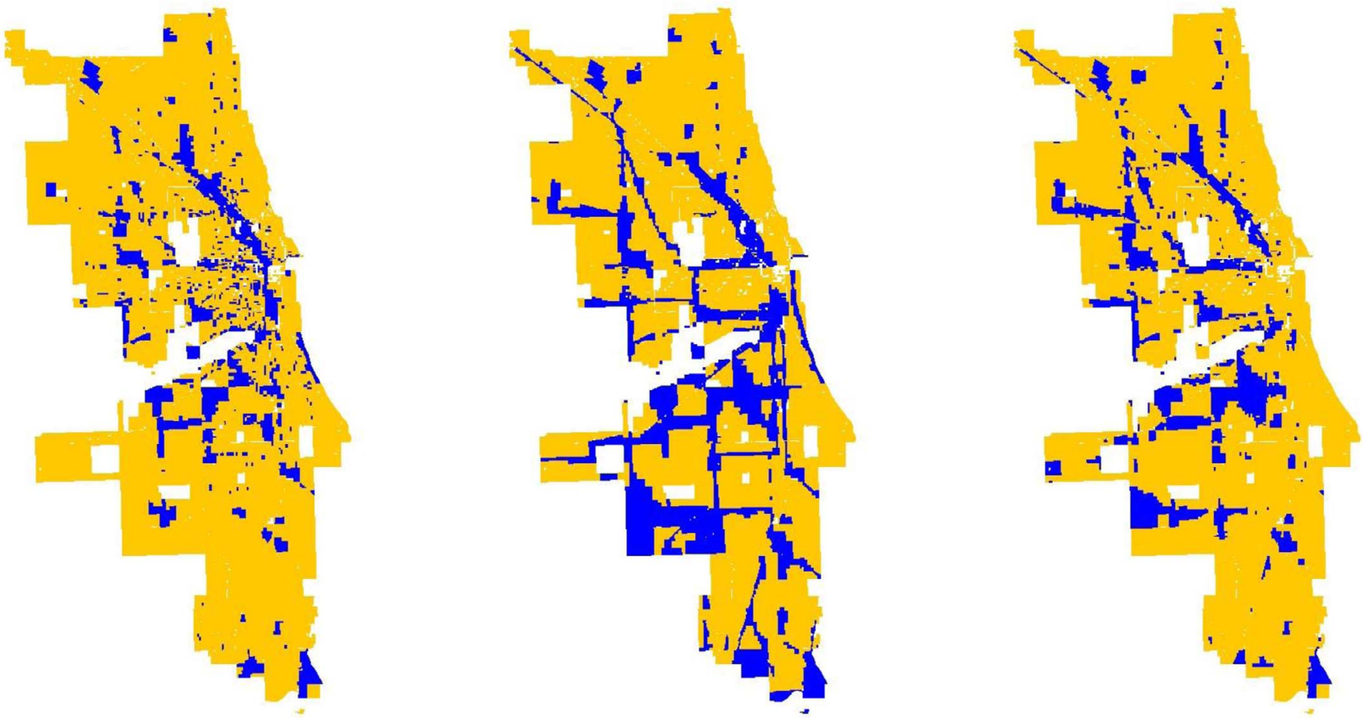
5. Empirical results at the city block level

We now turn to assessing the causal effect of Chicago's first zoning ordinance in determining present day land use at the city-block level. We begin with linear models and attempt to control for all relevant confounding factors that may have influenced both the zoning board's decisions and future land use. The digitized comprehensive pre-zoning land use survey of 1922 allows us to form an extensive suite of control variables for pre-existing commercial uses, manufacturing sites, and tall buildings. We also use digitized 1920 enumeration district-level census data to control for the demographic composition of each block. We account for geographic factors such as proximity to the central business district, Lake Michigan, or a major river (in most cases, the Chicago River) as well. Additional controls are included for proximity to railroads and major streets. Finally, to capture the latent development potential of each block, we include a measure of land values transcribed by Gabriel Ahlfeldt and Daniel McMillen from the 1913 edition of Olcott's Blue Books (see McMillen, 2012).

Because we observe and employ the same geographic, land use, transportation and demographic data that was available to the Zoning Commission when it drew the initial ordinance, it may be reasonable to assume that we can control for all relevant confounds and identify a causal relationship using this strategy. Of course, there is always a concern that there may be unobserved factors that influenced both the zoning law and contemporary land use. For instance, the members of the Zoning Commission may have been aware of features of a neighborhood (unobserved to us) suggesting that it would transition away from industrial uses in the future. In a second set of analyses we exploit the fact that, while zoning borders are sharp, any unobserved confounds will likely vary continuously over space. In particular, we verify our main results with both nonparametric and parametric regression discontinuity models that should be robust to any confounding

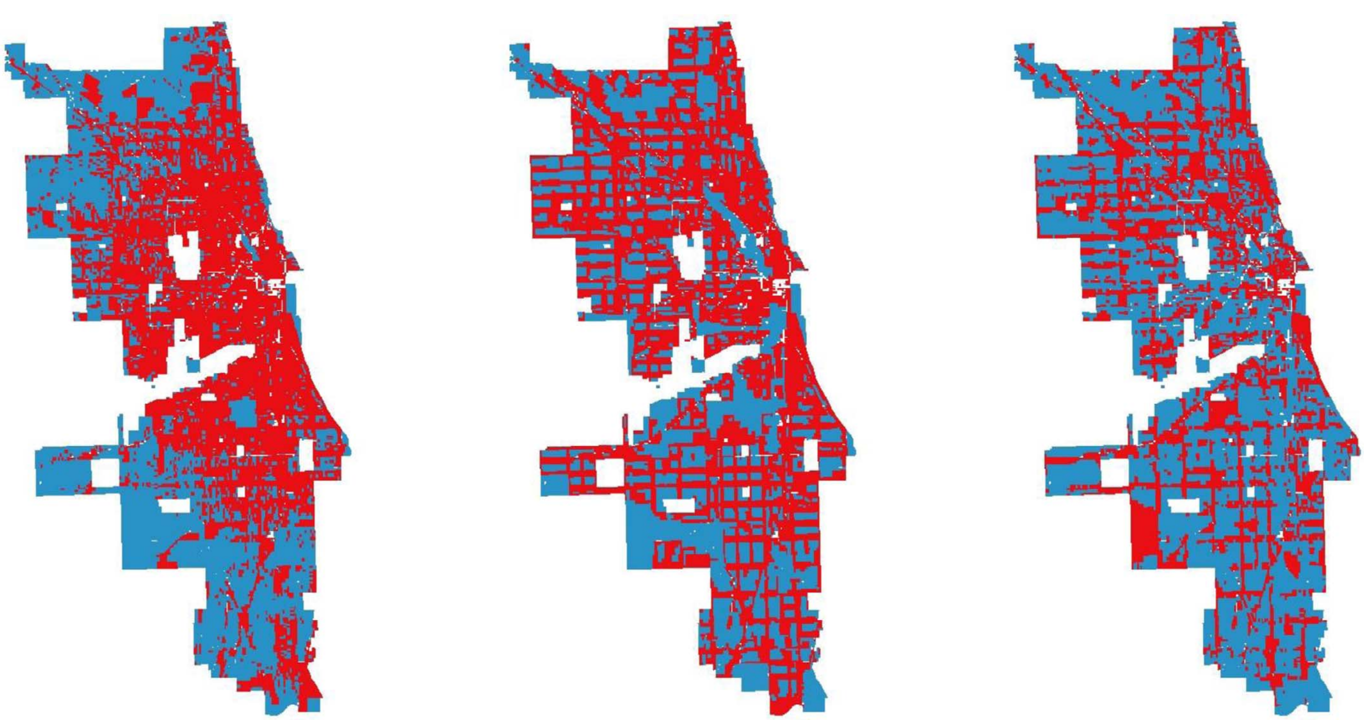
[6] White spaces in the maps are mainly large parks and Midway airport; some of the smaller white spaces are due to missing or damaged land use maps.

[7] Because the commercial use zone allowed for the types of light industry that were classified as Manufacturing A in the 1922 land use survey, we treat Manufacturing A as a commercial use for the comparisons in Table 1.



A. 1922 Land Use *B. 1923 Zoning* *C. 2005 Land Use*

Fig. 1. Distribution of industrial land use in 1922 and 2005 and zoning for industry in 1923. *Notes:* This image contrasts 1922 land use with 1923 zoning and 2005 land use. Blue areas in panel A contained industrial uses prior to zoning. Blue areas in panel B were zoned for industry. Blue areas in panel C contained industry in 2005. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)



A. 1922 Land Use *B. 1923 Zoning* *C. 2005 Land Use*

Fig. 2. Distribution of Commercial land use in 1922 and 2005 and zoning for commerce in 1923. *Notes:* This image contrasts 1922 land use with 1923 zoning and 2005 land use. Red areas in panel A contained commercial uses prior to zoning. Red areas in panel B were zoned for commercial use. Red areas in panel C contained commercial uses in 2005. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1
Historical land use, 1923 zoning ordinance, and modern day land use.

Panel A. Historical land use and the 1923 zoning ordinance

	Any historical commercial zoning?	
	No	Yes
No historical commercial/mfg A uses	61%	39%
Historical commercial/mfg A uses	23%	77%
	Any historical industrial zoning?	
	No	Yes
No historical mfg. B, C or S	91%	9%
Some historical mfg B, C or S	38%	62%

Panel B. Historical land use and modern day land use

	Any modern commercial uses?	
	No	Yes
No historical commercial/mfg A uses	79%	21%
Historical commercial/mfg A uses	48%	52%
	Any modern industrial uses?	
	No	Yes
No historical mfg. B, C or S	92%	8%
Some historical mfg B, C or S	53%	47%

Notes: The unit of observation is a city block. Because the commercial use zone allowed for the types of light industry that was classified as Manufacturing A in the 1922 land use survey, we treat Manufacturing A as a commercial use for these comparisons. Panel A describe the correspondence between land uses in 1922 and zoning in 1923. Panel B describes the correspondence between land uses in 1922 and those in 2005.

variables for which we fail to control.

We consider a number of different outcome variables in our analysis. To examine the impact of zoning on commercial and industrial activity, we regress indicators for the presence of such activities today on the full suite of historical covariates discussed above. To examine residential use, we regress the share of each city block devoted to single and multifamily residences on our covariates. Our baseline specification is of the form:

$$Outcome_i = 1923\ zoning_i'\beta\ + 1922\ controls_i'\ \gamma + \varepsilon_i, \tag{1}$$

where 1922 controls include all variables describing geography, land use, transportation, demographics, and land prices at the block level prior to the introduction of zoning as well as densities of historical uses in 500 and 1000 foot rings around each block. The historical use zoning variables we include are the percentage of the block zoned for commercial use, manufacturing use, or single-family homes; the omitted category is zoning for apartment buildings. We also include volume zoning variables measuring the percentage of the block zoned for each of volume districts 1, 2, and 3; volume districts 4 and 5 together form the omitted category.[8] We use robust standard errors throughout the analysis (White, 1980).[9]

In addition to the analysis of present day land use, we examine the impact of zoning on single-family home prices. In these regressions, we include housing characteristics, census tract fixed effects, and year-month of sale fixed effects as well as the historical covariates discussed above. Finally, one might expect heterogeneous effects of zoning across different levels of pre-existing development. To capture this possibility, we replicate much of our analyses on subsamples of the data split at the median level of population density (17 persons per acre). The above-median density areas reflect the developed portion of the city radiating out from the central business district. The below-median density areas are largely in the undeveloped outlying portions of the city.[10] Where appropriate, as a further robustness check, we also split the sample based on pre-existing levels of commercial and industrial development.

5.1. Land use regressions

We begin by analyzing the impact that zoning had on the location of specific land uses today. Tables 2 through 4 present results for industrial, commercial and residential land uses, respectively. All variables are scaled so that the reported coefficients reflect the influence of a one standard deviation change in their respective variables. Column 1 of Table 2 reports the estimated impact of historical zoning variables on the likelihood that a block hosted manufacturing activity in 2005, conditional on our controls. All else equal, blocks that received more manufacturing and/or commercial zoning in 1923 were significantly more likely to host manufacturing activity in 2005 than were blocks that received residential or apartment (omitted category) zoning.[11] A one standard deviation increase in the percent of manufacturing zoning is associated with a 1.7 percentage point increase in the likelihood of a block having manufacturing activity – a fairly large effect given that only 7.7% of city blocks experienced manufacturing activity in 2005.

Commercial use zoning had a comparably large positive effect on future manufacturing activity. While, relative to apartment zoning, zoning for single-family homes had no impact on the likelihood of manufacturing activity. Relative to the densest volume categories (classes 4 and 5 which together comprise the omitted category for density zoning), larger shares of all three lower density zoning classes were negatively associated with the likelihood of manufacturing activity on a block in 2005, suggesting that conditional on use zoning, manufacturing uses developed in places where the densest construction was permitted.

The remaining columns of Table 2 explore heterogeneity in the impact of zoning across locations with differing initial conditions. Columns 2 and 3 split the sample between blocks that had pre-existing industrial uses and those that did not. Fully 95% of our sample lies in the latter category, so it is unsurprising that our full-sample results are essentially unchanged for this subsample (Column 2). In those locations that had pre-existing manufacturing activity (Column 3) we are generally measuring the impact of zoning on the survival of these uses. Focusing on volume zoning and commercial use zoning, we find results that are similar in magnitude as those predicting the presence of industrial uses in areas which previously had none. In contrast, manufacturing zoning itself appears not to matter for this subsample. One potential explanation for this result is the combination of small sample size and collinearity between the use and volume zoning overlays. To this point, when the volume district zoning variables are omitted from the analysis (Column 4), the coefficient on manufacturing zoning becomes large in magnitude and highly significant. The Table's final two columns subdivide the sample by pre-existing population densities. Although one may have expected zoning to matter more in places that were not already built up, manufacturing zoning seems to have had a larger impact on the portion of Chicago that was developed in 1922. This result may reflect the successful efforts of the zoning commission to concentrate the widely scattered industrial uses that existed in the developed areas of Chicago in 1922.

Use zoning also appears to have exerted a strong influence on the distribution of commercial activity (Table 3). Across the entire city

[8] Volume district 5 was concentrated around the central business district, and volume district 4 included provisions very similar to that of district 5 and formed a tight boundary around district 5. We aggregate the two in the analysis.

[9] Using the method of Conley (1999) to construct standard errors robust to spatial autocorrelation consistently resulted in smaller standard errors. To be conservative, we report robust standard errors and not the Conley standard errors.

[10] An alternative measure of development based on a linear index of population density, density of different pre-existing uses, and geographic factors like proximity to the CBD and Lake Michigan yielded a very similar sample and led to very similar results.

[11] Here we consider a block to host manufacturing if at least 5 percent of its area is devoted to one of the four industrial land uses classified by CMAP.

Table 2
Impact of 1923 zoning on the contemporary land use: manufacturing.

	Dependent variable = 1 if manufacturing activity in block in 2005					
	(1)	(2)	(3)	(4)	(5)	(6)
Percent manufacturing zoning	0.017***	0.018***	−0.009	0.069***	0.016***	0.027***
	(0.003)	(0.003)	(0.025)	(0.025)	(0.0039)	(0.004)
Percent commercial zoning	0.061***	0.056***	0.052*	0.006	0.047***	0.097***
	(0.004)	(0.004)	(0.027)	(0.024)	(0.0049)	(0.008)
Percent single family res. zoning	−0.002	−0.002*	−0.146	−0.143	−0.006***	−0.011***
	(0.001)	(0.001)	(0.163)	(0.158)	(0.0017)	(0.003)
Percent volume district 1 zoning	−0.050***	−0.039***	−0.151*		−0.118***	−0.039***
	(0.012)	(0.013)	(0.085)		(0.0455)	(0.013)
Percent volume district 2 zoning	−0.051***	−0.042***	−0.114**		−0.112***	−0.029**
	(0.012)	(0.013)	(0.049)		(0.0432)	(0.013)
Percent volume district 3 zoning	−0.027***	−0.023***	−0.032		−0.033*	−0.024***
	(0.008)	(0.008)	(0.025)		(0.0193)	(0.008)
Mean of dependent variable	0.077	0.056	0.473	0.473	0.074	0.081
Std. dev. of dependent variable	0.267	0.230	0.500	0.500	0.261	0.273
Sample restriction	None	# Mfg = 0	# Mfg > 0	# Mfg > 0	Undeveloped	Developed
R-squared	0.344	0.242	0.460	0.455	0.446	0.309
Observations	14,582	13,830	752	752	7221	7361

Notes: Outcome variable is an indicator that equals 1 if the city block contained any manufacturing activity in 2005. Models include full set of spatial, demographic, and land use controls described in Section IV. Estimation uses OLS. Zoning variables are standardized on the full sample (columns (1)–(4)), undeveloped sample (column (5)), or developed sample (column (6)). Columns (5) and (6) restrict to the section of the city below and above median 1920 population density, respectively.

Table 3
Impact of 1923 zoning on the contemporary land use: commercial uses.

	Dependent variable = 1 if commercial activity in block in 2005					
	(1)	(2)	(3)	(4)	(5)	(6)
Percent commercial zoning	0.108***	0.191***	0.105***	0.034***	0.133***	0.078***
	(0.005)	(0.008)	(0.012)	(0.009)	(0.0068)	(0.0078)
Percent manufacturing zoning	0.015***	0.007	0.01	0.016	−0.001	0.032***
	(0.005)	(0.006)	(0.014)	(0.014)	(0.0067)	(0.0075)
Percent single family res. zoning	−0.020***	−0.011***	−0.013	−0.011	−0.016***	0.000
	(0.003)	(0.003)	(0.014)	(0.036)	(0.0042)	(0.0036)
Percent volume district 1 zoning	0.056***	−0.02	−0.006	0.042	−0.002	0.046***
	(0.019)	(0.037)	(0.051)	(0.028)	(0.0611)	(0.0150)
Percent volume district 2 zoning	0.088***	−0.005	0.042	0.068***	0.031	0.094***
	(0.018)	(0.037)	(0.051)	(0.024)	(0.0576)	(0.0201)
Percent volume district 3 zoning	0.025**	−0.024	0.028	0.016	0.007	0.034**
	(0.011)	(0.022)	(0.031)	(0.013)	(0.0254)	(0.0140)
Mean of dependent variable	0.373	0.219	0.427	0.614	0.321	0.424
Std. dev. of dependent variable	0.484	0.414	0.495	0.487	0.467	0.494
Sample restriction	None	# Com = 0	0 < # Com ≤ 2	# Com > 2	Undeveloped	Developed
R-squared	0.337	0.304	0.322	0.250	0.376	0.327
Observations	14,582	7483	2963	4136	7221	7361

Notes: Outcome variable is an indicator that equals 1 if the city block contained any commercial activity in 2005. Models include full set of spatial, demographic, and land use controls described in Section IV. Estimation uses OLS. Zoning variables are standardized on the full sample (columns (1)–(4)), undeveloped sample (column (5)), or developed sample (column (6)). Columns (5) and (6) restrict to the section of the city below and above median 1920 population density, respectively.

(Column 1), a one standard deviation increase in the percentage of commercial zoning is associated with an 11 percentage point increase in the likelihood of commercial use today, an increase of 28% with respect to the mean. In contrast to manufacturing, inclusion in one of the lower volume districts is associated with increased shares of commercial uses. Single-family residential zoning is associated with less commercial activity.

Looking across locations that differ in terms of pre-existing level of commercial activity (Columns 2–4) and population density (Columns 5 and 6), we find a meaningful and statistically significant impact of commercial zoning across all subsamples, with the largest impacts occurring in locations that had lower population densities or no pre-existing commercial uses. We attribute this result to the zoning commission's successful effort to create new commercial areas in outlying areas. The impact of volume districting is concentrated in the developed portions of the city. These are the regions of the city where the highest volume districts occur (omitted category). Overall, the pattern of results suggest that the volume district coefficients reported in Column 1 (full sample) are generally driven by differences between being in one of the two high volume districts as opposed to one of the three low volume districts.

Finally, in Table 4 we investigate the impact of zoning on the location of multifamily and single-family housing. Again we see zoning's persistent impact. Single-family residential zoning is associated with a larger share of single-family housing and a lower share of multi-family housing. The single-family home effect is particularly large for the areas of Chicago that were undeveloped in 1922. A one standard deviation increase in single-family residential zoning (relative to apartment zoning) was associated with a 4 percentage point increase in the share of a block used for single-family homes, an increase of 10% relative to the mean. We speculate that zoning may have been crucial for establishing residential neighborhoods comprised entirely of single-family

Table 4
Impact of 1923 zoning on the contemporary land use: residential areas.

	Percent single-family residential			Percent multifamily residential		
	(1)	(2)	(3)	(4)	(5)	(6)
Percent single family residential zoning	0.040***	0.052***	0.037***	−0.029***	−0.032***	−0.030***
	(0.003)	(0.0039)	(0.0038)	(0.003)	(0.0023)	(0.0029)
Percent commercial zoning	−0.034***	−0.051***	−0.027***	−0.047***	−0.033***	−0.065***
	(0.003)	(0.0046)	(0.0039)	(0.003)	(0.0035)	(0.0053)
Percent manufacturing zoning	−0.013***	−0.010	−0.035***	−0.057***	−0.040***	−0.068***
	(0.003)	(0.0059)	(0.0040)	(0.003)	(0.0035)	(0.0050)
Percent volume district 1 zoning	0.118***	0.043	0.076***	−0.048***	0.023	−0.040***
	(0.011)	(0.0366)	(0.0070)	(0.011)	(0.0326)	(0.0107)
Percent volume district 2 zoning	0.034***	−0.027	0.014*	0.007	0.059*	0.001
	(0.011)	(0.0340)	(0.0077)	(0.010)	(0.0303)	(0.0140)
Percent volume district 3 zoning	0.013**	−0.020	0.016***	−0.009	0.004	−0.008
	(0.006)	(0.0142)	(0.0046)	(0.006)	(0.0122)	(0.0095)
Mean of dependent variable	0.388	0.593	0.187	0.291	0.143	0.436
Std. dev. of dependent variable	0.396	0.383	0.291	0.339	0.247	0.354
Sample restriction	None	Undeveloped	Developed	None	Undeveloped	Developed
R-squared	0.546	0.456	0.354	0.433	0.318	0.334
Observations	14,582	7221	7361	14,582	7221	7361

Notes: Outcome variable in columns (1)–(3) is the percentage of the city block devoted to single-family residential use in 2005. Outcome variable in columns (4)–(6) is the percentage of the city block devoted to multifamily residential use in 2005. Models include full set of spatial, demographic, and land use controls described in Section IV. Estimation uses OLS. Zoning variables are standardized on the full sample (columns (1) and (4)), undeveloped sample (columns (2) and (5)), or developed sample (columns (3) and (6)). Columns (2) and (5) restrict to the section of the city below median 1920 population density. Columns (3) and (6) restrict to the section of the city above median 1920 population density.

homes in the portion of the city that was undeveloped when the ordinance was introduced, explaining the relatively large effect in this part of the sample. Meanwhile, relative to apartment zoning, every other type of use zoning is negatively associated with the share of the block dedicated to single-family and/or multi-family dwellings in 2005. These results hold across both developed and undeveloped sections of the city.

5.2. Spatial discontinuities

A potential concern with the above findings is that, despite our large set of control variables, they may be driven by some unobserved path dependence in land use that is correlated with the initial zoning outcome. In this case our estimates would not reflect the causal effect of zoning. To address this concern, we present the results from a border identification exercise in the spirit of Black (1999). We isolate subsamples of blocks that are within 500 ft of the border between two different use zoning types. We then estimate local linear regressions on the residuals from OLS regressions run on each border subsample.[12] Figs. 3–6 display the results from these nonparametric regressions on the residuals. Included on these figures as plotted points are the binned averages from the underlying residuals. Appendix Table A.2 reports analogous linear regression results.

We begin with the boundary between residential zones (single family and apartment) and non-residential zones (commercial and manufacturing). Panel A of Fig. 3 shows how the unexplained component of 2005 commercial use varies relative to this boundary. We find a distinct discontinuity at the border, with the likelihood of commercial use being approximately 0.4 standard deviations (20 percentage points) higher on the commercial/manufacturing side of the border. This difference declines as we move farther away from the border to the left (and further into districts were commercial activity is permitted). This result is consistent with the findings of our linear model. Further, it suggests that commercial uses prefer to locate near residential areas, perhaps due to customer proximity.

Because zoning was impacted by pre-existing uses, one might be concerned that the number of pre-existing commercial uses varied discretely across these zoning boundaries in a manner that is not adequately addressed by our residual modeling. As a further robustness check, we present the same nonlinear regressions limiting the analysis to subsamples with the following characteristics: no pre-existing commercial uses on either side of the border (Panel B); exactly one or two commercial uses on each side of the border (Panel C); and three or more commercial uses on each side of the border (Panel D). The clear discontinuity in the likelihood of having commercial uses today is evident in all three subsamples.

Next, we consider the impact of commercial-industrial borders on the location of industrial activity. In Fig. 4, the left-hand sides of the border consist of commercially zoned blocks (where manufacturing activity was prohibited) while the right-hand sides consist of blocks with manufacturing zoning. We see a sharp discontinuity in the likelihood of modern industrial uses on different sides of the border; manufacturing uses are much more likely to locate in manufacturing zones. Again, this finding is consistent with the nature of the zoning law, which restricted the location of manufacturing uses relative to commercial uses. As was the case with our baseline regression results, the impact of industrial zoning is less clear in locations with pre-existing manufacturing uses (Panel C). While the border analysis shows no discrete jump in this subsample, the upward slope of the relationship is suggestive of a zoning-driven agglomeration effect under which manufacturing activity is increasing in proximity to the center of manufacturing zones.

In Fig. 5, we remain focused on the commercial/industrial borders. However, we now assess their impact on commercial activity. In contrast to the industrial uses analyzed in Fig. 4, commercial activities were permitted on both sides of these borders. While overall levels of commercial activity are generally higher on the commercial side of the border, we find no evidence of a discrete change. Thus, summarize these three sets of results, for uses where zoning binds we find a discrete jump at the boundary. When zoning does not bind, we find no such discrete jump.

Finally, Fig. 6 considers the difference in the percentage of a block devoted to single-family residential use, comparing blocks which received the lowest density zoning with blocks that received the next lowest density zoning (which accommodated mid-rise apartment

[12] This approach allows us to control for confounds that vary continuously across the discrete zoning boundaries. We estimate the border regressions on residuals from a model including all of our control variables in order to control for any observed confounds that vary discretely at the zoning boundaries. There is very little qualitative difference between the residual analyses presented here and border regressions that do not include these controls.

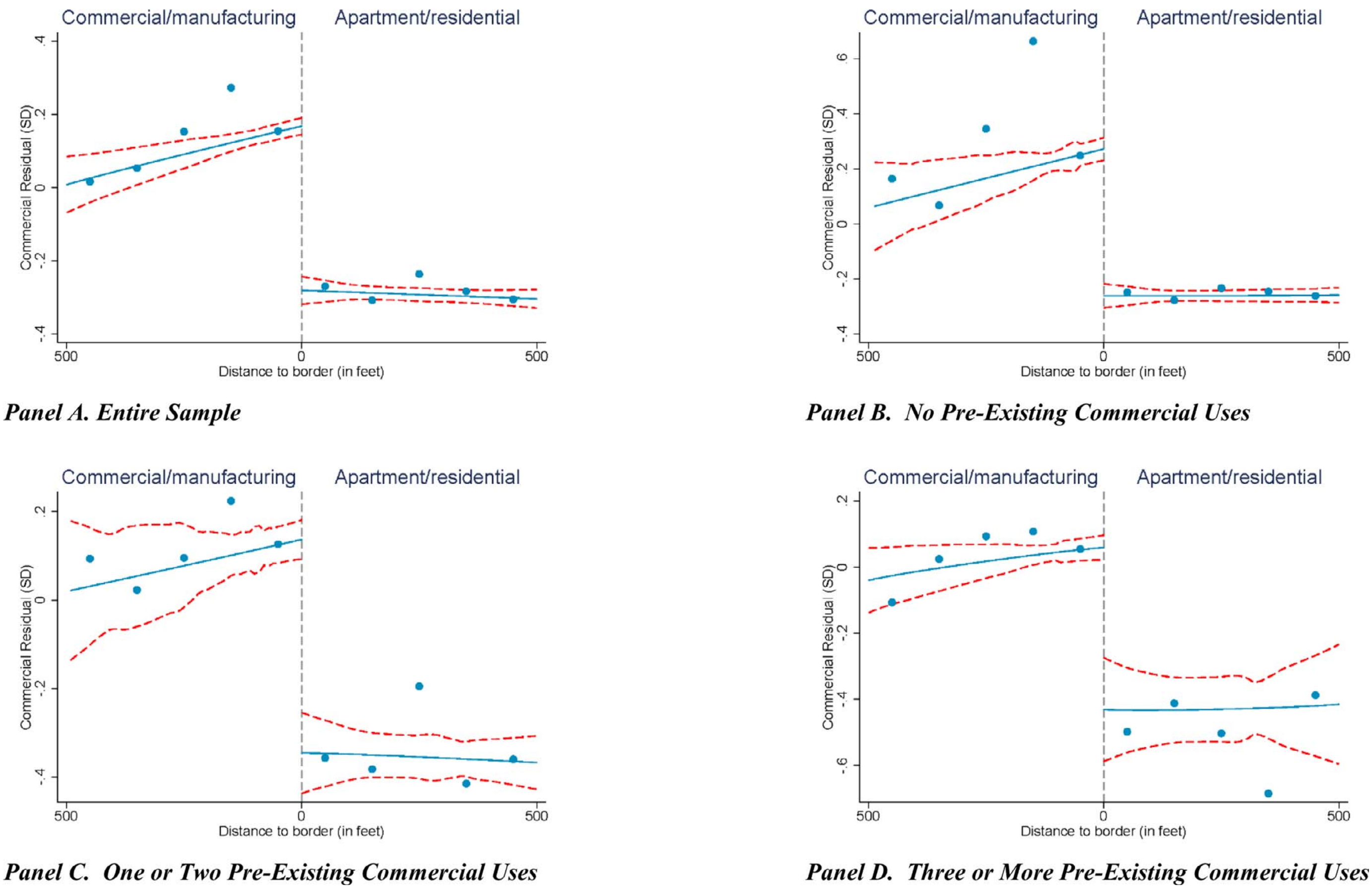


Fig. 3. Local linear regression residual plots: probability of commercial use in 2005 across 1923 commercial/apartment zoning border. *Notes:* Subsample includes blocks with 1923 commercial/manufacturing zoning that are within 500 ft of a block containing only apartment/residential zoning as well as apartment/residential only blocks within 500 ft of a block containing commercial/manufacturing zoning. Left hand side of border includes commercial/manufacturing blocks. Right hand side includes apartment/residential blocks. Outcome variable is the residual from a linear regression of an indicator for 2005 commercial use on all pre-1923 zoning covariates. Scatterplot of outcome means binned at 100-foot intervals.

complexes). There is a sharp discontinuity, with lower density blocks hosting 0.3 standard deviations (12 percentage points) more single-family housing than neighboring higher density blocks. The effect of density zoning is evident across both high and low population density subsamples.

Taken as whole the non-parametric border analysis confirm the results from our simple linear models. Parametric border regressions which correspond to these non-linear models are included in Appendix Table A.2 and corroborate the nonparametric results.

5.3. The effect of zoning on LULUs, density and prices

We next broaden our analysis to consider the impact of zoning on several additional margins that drove the adoption of these ordinances: exposure to undesirable land uses, population density, and home prices. A major motivation for the establishment of manufacturing use zones in these early land use plans was the desire to constrain the location of locally undesirable land uses so that they would not "destroy real estate for residential and retail business purposes."[13] To evaluate the long-run impact of zoning on the location of these LULUs, we assess the impact of the 1923 zoning ordinance on the distribution of polluting (TRI) facilities later in the twentieth century. The results presented in Table 5 demonstrate that 1923 manufacturing zoning had a quantitatively significant impact on where such polluting facilities are located today. A one standard deviation increase in the share of a neighborhood zoned for manufacturing is associated with a 1.4 percentage point increase in the likelihood of a city block hosting a TRI facility; this is a quantitatively large effect given that only 1.8% of blocks in our sample hosted a TRI facility during the analysis period. Commercial zoning had a similar, but smaller in magnitude, effect. This relationship is stable across the no pre-existing manufacturing, undeveloped, and developed subsamples. As with our above analysis of manufacturing outcomes, the small sample of blocks that already had manufacturing in 1922 responds differently. In these blocks, we see that zoning apparently had no impact on the location of TRI facilities today.

Population density is another concern that both explicitly and implicitly underpinned the Zoning Commission's work.[14] Table 6 shows that, relative to zoning for apartments, zoning for single family homes, commercial and manufacturing uses all lead to lower population densities in 2010. Volume zoning also impacted future density. Here, the primary distinction being between the lowest volume districts (1 and 2) and the highest volume districts (3–5). To give a sense of magnitude, the model predicts that a one standard deviation increase in the percentage of a block receiving both single-family zoning *and* volume district 1 zoning is associated with a 7 person per acre decline in population density; given that the city-wide average population density is 28 persons per acre, this is a sizable impact.

Property values were also a key driver of Chicago's initial zoning ordinance, particularly for real estate interests. Prior to passage of the ordinance, Ivan O. Ackley, former president of the Chicago Real Estate

[13] New York Times, July 26, 1916.

[14] See Chicago Zoning Commission (1922) and Shertzer et al. (2016).

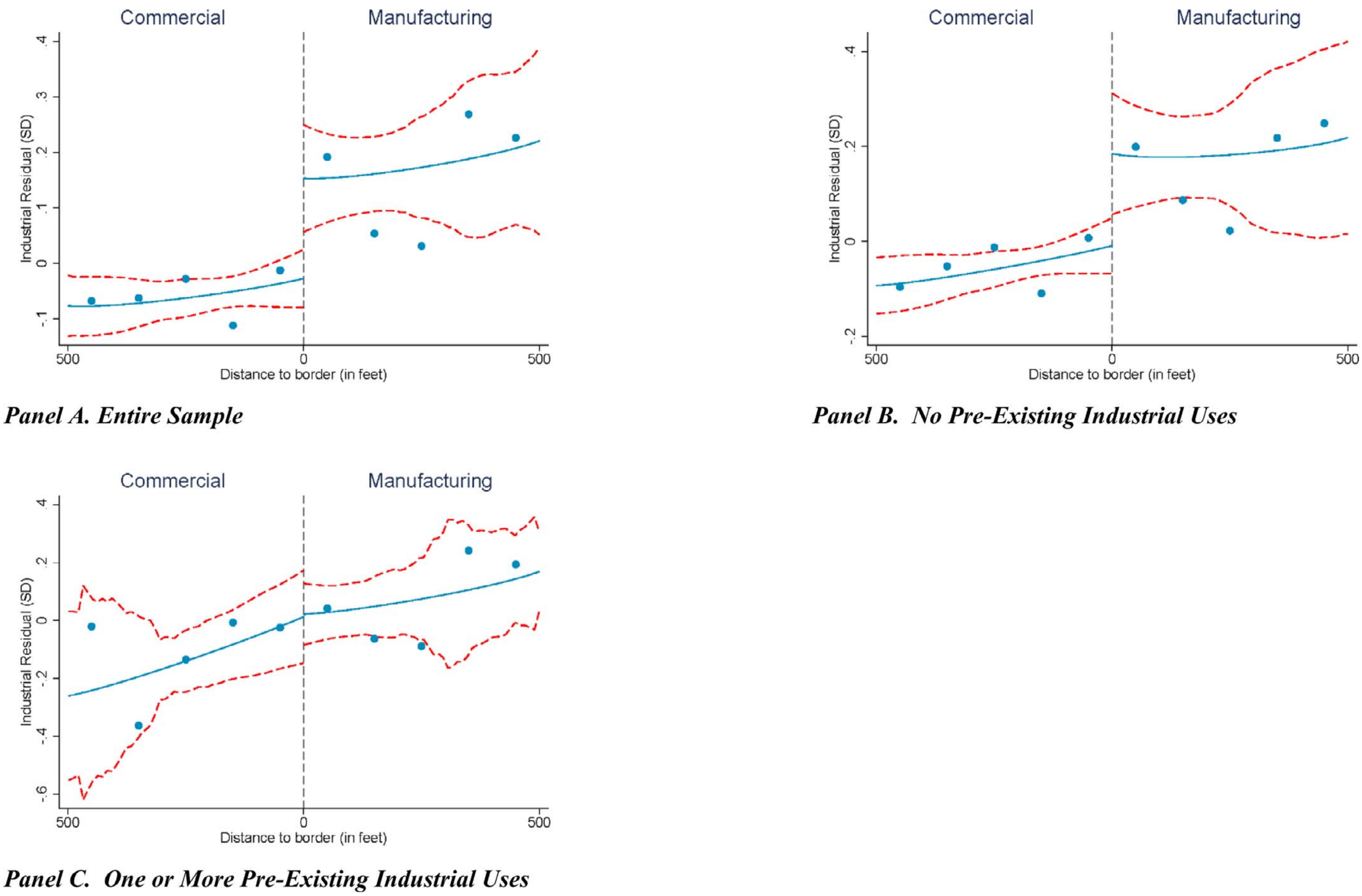


Fig. 4. Local linear regression residual plots: probability of industrial use in 2005 across 1923 commercial/industrial zoning border. *Notes:* Subsample includes blocks with 1923 commercial zoning (and no manufacturing zoning) that are within 500 ft of a block containing manufacturing zoning (and no commercial/residential zoning) as well as blocks containing manufacturing zoning (and no commercial/residential zoning) that are within 500 ft of a block containing commercial zoning (and no manufacturing zoning). Left hand side of border includes commercially zoned blocks. Right hand side includes manufacturing zoned blocks. Outcome variable is the residual from a linear regression of an indicator for 2005 industrial use on all pre-1923 zoning covariates. Scatterplot of outcome means binned at 100-foot intervals.

Board, predicted that comprehensive zoning would increase property values in Chicago by one billion dollars (more than 25%).[15] While we are not in a position to assess Ackley's prediction regarding zoning's impact on the overall price level, we can explore how spatial differences in the 1923 zoning patterns are reflected in housing prices today. Table 7 reports the effects of the 1923 zoning ordinance on single-family home sale prices over the period 2000–2012, controlling for housing characteristics, all pre-zoning control variables, and census tract fixed effects. Our results suggest that the patterns of land use established by the 1923 ordinance are still relevant in today's housing market.

To characterize historical zoning around a given home's location, for each zoning designation, we compute its share within a quarter mile of the home, between a quarter and half mile away, and between a half and a full mile away. Full sample results are presented in Column 1. Our strongest finding is that single-family residential zoning is associated with higher home values in both the immediate vicinity of the home and further away. Moving from the proximate region to further away, a one standard deviation increase in the share of single-family home zoning is associated with a 1.2%, 1.4%, or 1.6% increase in home values, respectively. Commercial zoning in the immediate vicinity is associated with lower home values, while commercial zoning in the most distant region (between half and a full mile) increases home values, suggesting that homebuyers value access to commercial activity, so long as it is not right next door.

Manufacturing uses are also associated with higher home sale values when they are between one half and a full mile away. This effect is strongest in the developed portion of the sample (see Column 2).[16] Focusing on the developed sample, historical manufacturing appears to be associated with *higher* home values for the high-density portion of the sample whether it was in the immediate vicinity or more distant. Supplemental analysis shows that this effect is driven by the subset of homes located in relatively high-poverty census block-groups today, which may reflect a preference by low-income central city residents for accessible manufacturing jobs.[17]

Taken together, these results demonstrate that contemporary home prices have been impacted by the 1923 ordinance's lasting effect on Chicago's spatial structure. They further suggest that, to the extent that the ordinance lead to the concentration of residential uses, zoning in Chicago has likely increased residential property values.

5.4. Zoning vs. transportation and geography

Economists have typically focused on the role of transportation costs and geography in determining urban spatial structure. Our analysis suggests zoning also can have a lasting impact on land use patterns. Do

[15] Chicago Tribune, January 15, 1922.

[16] P-value in the undeveloped sample is 0.17.

[17] Appendix Table A.3 shows analogous estimation results on the developed portion of the sample by poverty quartiles. Large positive impacts of manufacturing zoning both within a quarter mile and a full mile on home values are apparent for the subsample of city blocks in the top quartile of poverty rates only.

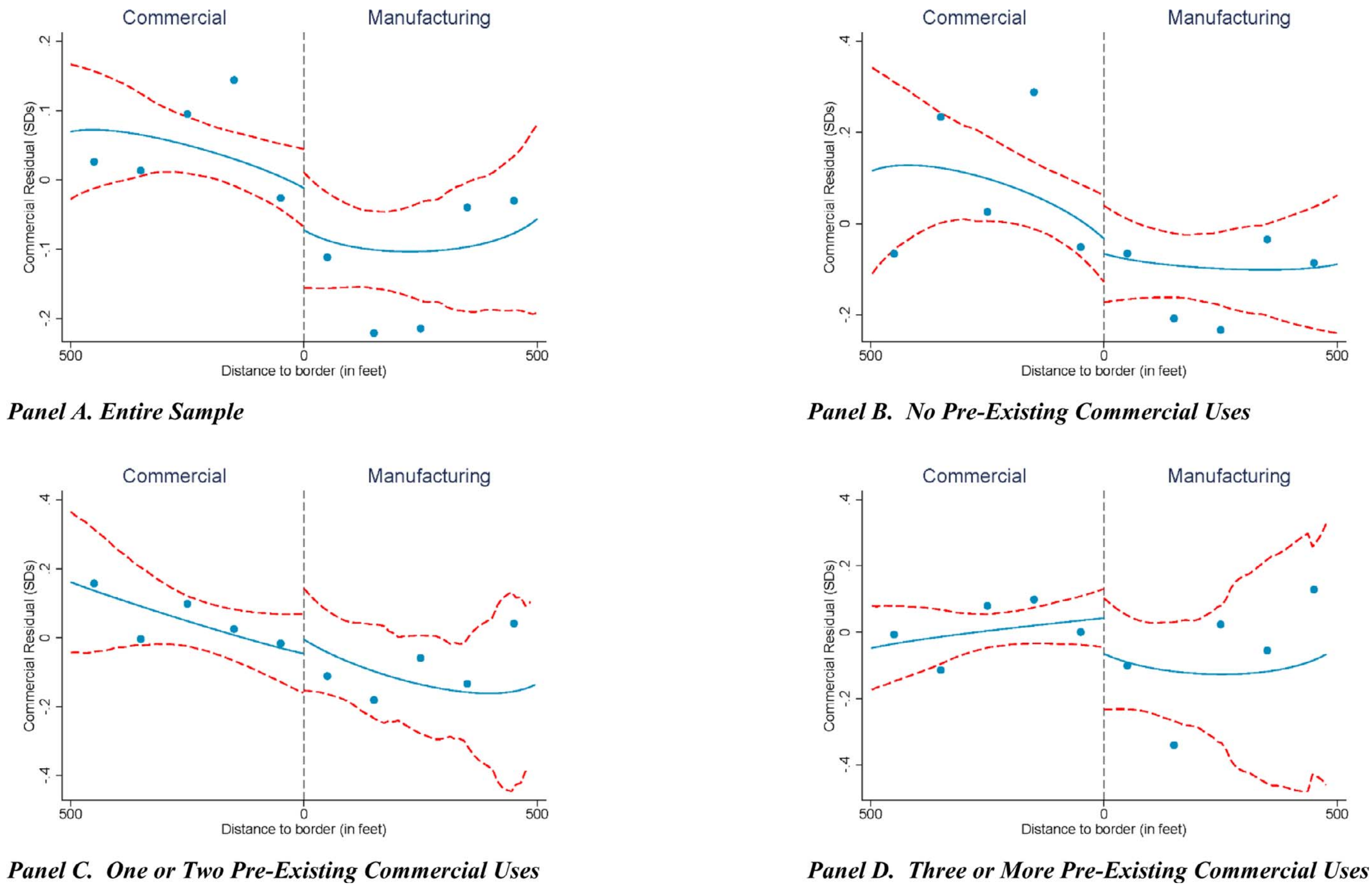


Fig. 5. Local linear regression residual plots: probability of commercial use in 2005 across 1923 commercial/industrial zoning border. *Notes:* Subsample includes blocks with 1923 commercial zoning (and no manufacturing zoning) that are within 500 ft of a block containing manufacturing zoning (and no commercial/residential zoning) as well as blocks containing manufacturing zoning (and no commercial/residential zoning) that are within 500 ft of a block containing commercial zoning (and no manufacturing zoning). Left hand side of border includes commercially zoned blocks. Right hand side includes manufacturing zoned blocks. Outcome variable is the residual from a linear regression of an indicator for 2005 commercial use on all pre-1923 zoning covariates. Scatterplot of outcome means binned at 100-foot intervals.

these results warrant placing increased weight on planning relative to transportation and geography? To assess the importance of zoning relative to other determinants of future land use, we re-estimate the baseline models from Tables 2 and 3 and extract standardized multiple-partial regression coefficients for five blocks of variables capturing: zoning, geography, transportation networks, demographics, and pre-existing land use. We use the method of sheaf coefficients to treat each block of variables as if its impact on future commercial and industrial land use were channeled through a single latent variable (Heise, 1972; Whitt, 1986). Estimating the coefficients on these standardized latent variables gives us comparable measures of the relative importance of each block of variables.

Table 8 presents these results.[18] The 1923 zoning and pre-existing land uses are found to be of comparable importance in determining present day land use, and both have a considerably larger impact than transportation infrastructure, geography, or demographics on the contemporary arrangement of land use. This result is somewhat surprising given the emphasis in the urban economics literature on the importance of transportation networks and proximity to the central business district (geography). One possibility is that the impacts of transportation and geography were already realized through the sorting of land uses and residents prior to zoning. To test for this possibility, and to provide for a cleaner comparison between zoning, geography and transportation, we replicate the analysis including only three blocks of variables: zoning, transportation, and geography. These results are presented in the final two columns of Table 8. Here we find that the combined impact of geography and transportation is slightly less than that of zoning, suggesting a more prominent role for land use regulation in the shaping of cities than many ascribe.[19]

6. The citywide organization of land use

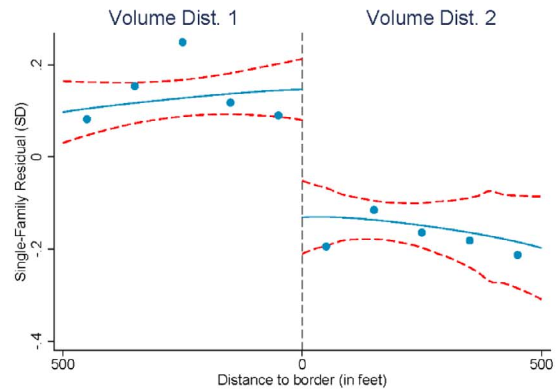
We have demonstrated that, from the perspective of an individual city block, Chicago's initial zoning ordinance had a marked impact on land use. In doing so, did the ordinance impact the overall pattern of development in the city, or did the basic pattern remain the same as uses were simply shifted from one location to another? We conclude our analysis by addressing this broader question and considering the impact of zoning on the overall city-wide organization of land use. Ideally this analysis would involve replicating our Chicago data set for a large panel of cities. Such an undertaking greatly exceeds the scope of this study and, given limitations on historical land use data, is likely infeasible even in a world without resource constraints. We can, however, make headway relative to this larger question on several fronts.

6.1. Dispersion of commercial and industrial uses

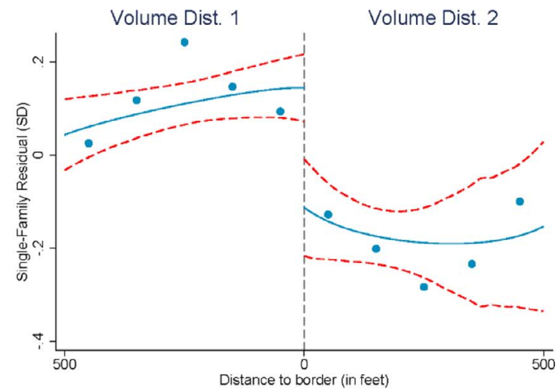
We begin with an analysis of how the distribution of commercial

[18] Because there is essentially no different in the sheaf coefficient estimates for the developed and undeveloped subsamples, for parsimony, we only report results for the full sample in Table 8.

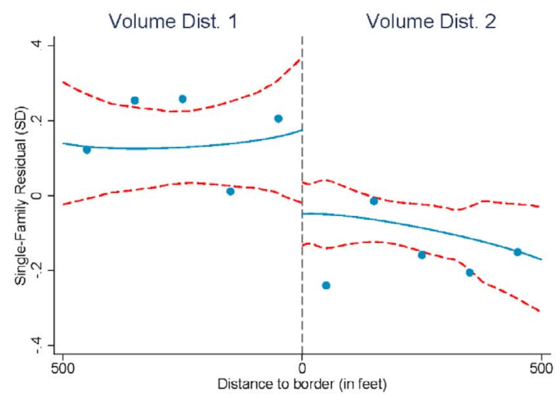
[19] A related issue is the persistence of the zoning itself. In Appendix Table A.4, we show that zoning in 1923 quite predictive of zoning today.



Panel A. Entire Sample



Panel B. Low Population Density



Panel C. High Population Density

Fig. 6. Local linear regression residual plots: percent of block devoted to single-family residential use across 1923 volume zoning borders. *Notes:* Left hand side of border includes blocks with the lowest level of 1923 density zoning. Right hand side includes blocks with the next lowest level of 1923 density zoning (accommodating mid-rise apartment complexes). Panel B restricts the sample to blocks with below median population density in 1920; Panel C restricts to blocks with above median population density in 1920. Outcome variable is the residual from a linear regression of the share of the block devoted to single-family residential use in 2005 on all pre-1923 zoning covariates. Scatterplot of outcome means binned at 100-foot intervals.

Table 5
Impact of 1923 zoning on LULUs (TRI facilities).

	Dependent variable = 1 if TRI facility in block				
	(1)	(2)	(3)	(4)	(5)
Percent manufacturing zoning	0.014***	0.013***	−0.001	0.015***	0.011***
	(0.002)	(0.002)	(0.018)	(0.0035)	(0.0037)
Percent commercial zoning	0.005***	0.004***	−0.006	0.007***	0.006**
	(0.002)	(0.002)	(0.016)	(0.0022)	(0.0022)
Percent single family residential zoning	0.000	0.000	−0.070	−0.000	−0.001*
	(0.001)	(0.001)	(0.095)	(0.0010)	(0.0005)
Percent volume district 1 zoning	−0.001	0.003	−0.007	−0.006	−0.003
	(0.006)	(0.005)	(0.059)	(0.0227)	(0.0047)
Percent volume district 2 zoning	−0.001	0.003	−0.01	−0.008	−0.001
	(0.006)	(0.005)	(0.040)	(0.0216)	(0.0066)
Percent volume district 3 zoning	−0.001	0.001	−0.005	0.001	−0.002
	(0.004)	(0.003)	(0.020)	(0.0092)	(0.0049)
Mean of dependent variable	0.018	0.011	0.145	0.019	0.016
Std. dev. of dependent variable	0.132	0.104	0.352	0.137	0.127
Sample restriction	None	# Mfg = 0	# Mfg > 0	Undeveloped	Developed
R-squared	0.180	0.094	0.310	0.256	0.132
Observations	14,582	13,830	752	7221	7361

Notes: Outcome variable is an indicator that equals 1 if the city block contained any TRI facilities over the period 1987–2010. Models include full set of spatial, demographic, and land use controls described in Section IV. Estimation uses OLS. Zoning variables are standardized on the full sample (columns (1)–(3)), undeveloped sample (column (4)), or developed sample (column (5)). Columns (4) and (5) restrict to the section of the city below and above median 1920 population density, respectively.

and manufacturing land uses today reflects the goals of the 1923 ordinance. Recall Figs. 1 and 2, which show that considerable mixing of uses took place before zoning. Indeed, 82% of blocks in the developed portion of the city contained commercial activity prior to zoning, and 10% contained heavy industry. Focusing on the developed subsample of the city so that we can evaluate the ability of zoning to reshape existing

Table 6
Impact of 1923 zoning on present day population density.

	(1)	(2)	(3)
Percent commercial zoning	−2.487***	−2.956***	−2.601***
	(0.281)	(0.297)	(0.447)
Percent manufacturing zoning	−1.655***	−1.371***	−1.179***
	(0.120)	(0.162)	(0.203)
Percent single family res. zoning	−3.556***	−2.753***	−4.383***
	(0.222)	(0.254)	(0.378)
Percent volume district 1 zoning	−3.694***	4.717	−3.651***
	(1.271)	(4.114)	(1.008)
Percent volume district 2 zoning	−2.233*	5.410	−3.251**
	(1.279)	(3.893)	(1.399)
Percent volume district 3 zoning	−0.103	1.521	−0.689
	(0.768)	(1.744)	(1.000)
Mean of dependent variable	27.74	23.84	31.56
Std. dev. of dependent variable	23.73	19.27	26.86
Sample restriction	None	Undeveloped	Developed
R-squared	0.333	0.397	0.349
Observations	14,582	7221	7361

Notes: Outcome variable is persons per acre in the city block in 2000. Models include full set of spatial, demographic, and land use controls described in Section IV. Estimation uses OLS. Zoning variables are standardized on the full sample (column (1)), undeveloped sample (column (2)), or developed sample (column (3)). Columns (2) and (3) restrict to the section of the city below and above median 1920 population density, respectively.

Table 7
Impact of 1923 zoning on contemporary single family house prices.

	(1)	(2)	(3)
Percent commercial zoning within ¼ mile	−0.00862**	−0.0116	−0.00637*
	(0.00379)	(0.00843)	(0.00357)
Percent mfg. zoning within ¼ mile	−0.00389	0.0224***	−0.00770
	(0.00391)	(0.00808)	(0.00497)
Percent residential zoning within ¼ mile	0.0118***	0.00379	0.0157***
	(0.00368)	(0.00678)	(0.00471)
Percent commercial zoning between ¼ and ½ mile	−0.00424	−0.00766	0.00173
	(0.00527)	(0.0110)	(0.00464)
Percent mfg. zoning between ¼ and ½ mile	0.00848	0.0224**	0.00118
	(0.00523)	(0.0114)	(0.00648)
Percent residential zoning between ¼ and ½ mile	0.0144***	−0.000661	0.0200***
	(0.00394)	(0.00727)	(0.00512)
Percent commercial zoning between ½ and 1 mile	0.0165*	0.0200	0.0129
	(0.00911)	(0.0176)	(0.00784)
Percent mfg. zoning between ½ and 1 mile	0.0443***	0.0588**	0.0134
	(0.00815)	(0.0245)	(0.00967)
Percent residential zoning between ½ and 1 mile	0.0162***	−0.00306	0.0223***
	(0.00492)	(0.0135)	(0.00620)
Constant	12.74***	11.59***	12.65***
	(0.217)	(0.325)	(0.419)
Sample restriction	None	Developed	Undeveloped
R-squared	0.794	0.822	0.704
Observations	50,556	18,378	32,178

Notes: Observations are individual home sales between 2000 and 2012. Models include full set of spatial, demographic, and land use controls described in Section IV as well as housing characteristics, census tract fixed effects, and year-month sale fixed effects. Estimation uses OLS. Zoning variables are standardized on the full sample (column (1)), undeveloped sample (column (2)), or developed sample (column (3)). Columns (2) and (3) restrict to the section of the city above and below median 1920 population density, respectively. The dependent variable is the log of the sales price.

urban areas, we begin by calculating the spatial distribution of parcel exposure to industrial and commercial uses. Specifically, we overlay the developed portion of the city with a mesh of evenly-spaced points (250 ft apart). For each point, we measure the distance to the nearest industrial (commercial) land use in 1922 and plot the distribution of these distances. We compare this distribution to that of distances to 1923 industrial (commercial) zoning and 2005 industrial (commercial) land use. The results of this analysis are presented in Panels A and B of Fig. 7. When land uses are thoroughly mixed throughout the city, the density of distances will be concentrated near zero. If uses are segregated into zones, there will be more mass in the right tail of the density.

Table 8
Sheaf statistics: developed Chicago (1923).

	Commercial	Industrial	Commercial	Industrial
Zoning	0.152***	0.075***	0.191***	0.111***
	0.004	0.004	0.004	0.004
Geography	0.072***	0.058***	0.071***	0.060***
	0.007	0.004	0.006	0.003
Transportation	0.100***	0.019***	0.115***	0.026***
	0.004	0.003	0.004	0.003
Demographics	0.031***	0.007***		
	0.007	0.003		
Land Use	0.152***	0.092***		
	0.008	0.004		

Notes: Table presents the sheaf coefficients and standard errors for the estimated latent variables capturing the impact of zoning, pre-existing land use, transportation, demographics, and geography; the estimated latent variables are standardized to have standard deviation of one for comparability of coefficients (Heise 1972; Whitt 1986). Outcome variables are indicators for commercial and industrial land use in 2005.

The solid lines in these graphs plot the density of distances from points in the city to their nearest 1922 commercial and industrial use neighbors. It is clear that the mass is concentrated near zero; almost all locations were within a half mile of an industrial use in 1922 and within a tenth of a mile of a commercial use. The dashed lines plot the density of distances envisioned by the zoning ordinance. The zoning board's preoccupation with separating uses is evident here as the zoning densities have substantially more mass farther from zero, indicating that many locations in the city were placed in residential zones isolated from commercial and manufacturing activity. The intermittently dashed and dotted lines demonstrate the extent to which the zoning board's goals were achieved; these lines plot the density of distances to industrial and commercial uses in 2005. A comparison across the two sets of densities shows that the spatial distribution of land use today is much closer to that envisioned by Chicago's planners in 1923 than it is to the actual landscape to which these planners were reacting; thus, providing suggestive evidence that zoning has played a role in shaping the city's overall land use patterns as well.

6.2. Houston, zoning and land use patterns

More direct evidence on the ability of zoning to affect patterns of development at the city-wide level could be found by comparing outcomes in zoned and un-zoned cities. However, zoning is ubiquitous in the United States, with virtually every sizable municipality subject to a zoning ordinance. Only one major city in the U.S. has so far resisted the implementation of zoning: Houston, Texas. Many scholars argue that Houston provides a free-market counterfactual to the zoned city (Siegan, 1970, 1973). However, in lieu of zoning, Houston actually employs a wide array of strategies to legally control land use and there is some debate about how to view Houston vis-à-vis zoning.[20] Nonetheless, it is the case that Houston lacks an overall planning framework

[20] The most prominent of these strategies is restrictive covenants or deed restrictions. These are agreements between neighboring property owners which legally bind them to observe certain limitations on the use of their property. Restrictive covenants are frequently employed to limit uses to single-family homes, preventing the encroachment of commercial or industrial activity. The implementation of restrictive covenants in Houston differs markedly from its pre-zoning implementation in U.S. cities. Due to the issue of legality and the high coordination and enforcement costs associated with covenants, the state of Texas granted the Houston city government the power to enforce covenants directly, without recourse to the court system (Susman, 1966; Kapur, 2004). Thus, the enforcement of covenants in Houston is similar to the enforcement of zoning in other cities. In Houston, covenants are employed to impose a wide range of restrictions beyond use, regulating setbacks, minimum lot sizes, structural density, landscaping, noise levels, and architectural features. To lower coordination costs and permit covenants to more closely mimic zoning, covenants in Houston can be created or renewed by a simple majority of lot owners in an area. The unanimous agreement of property owners is no longer required, moving this policy far from the realm of consensual contract.

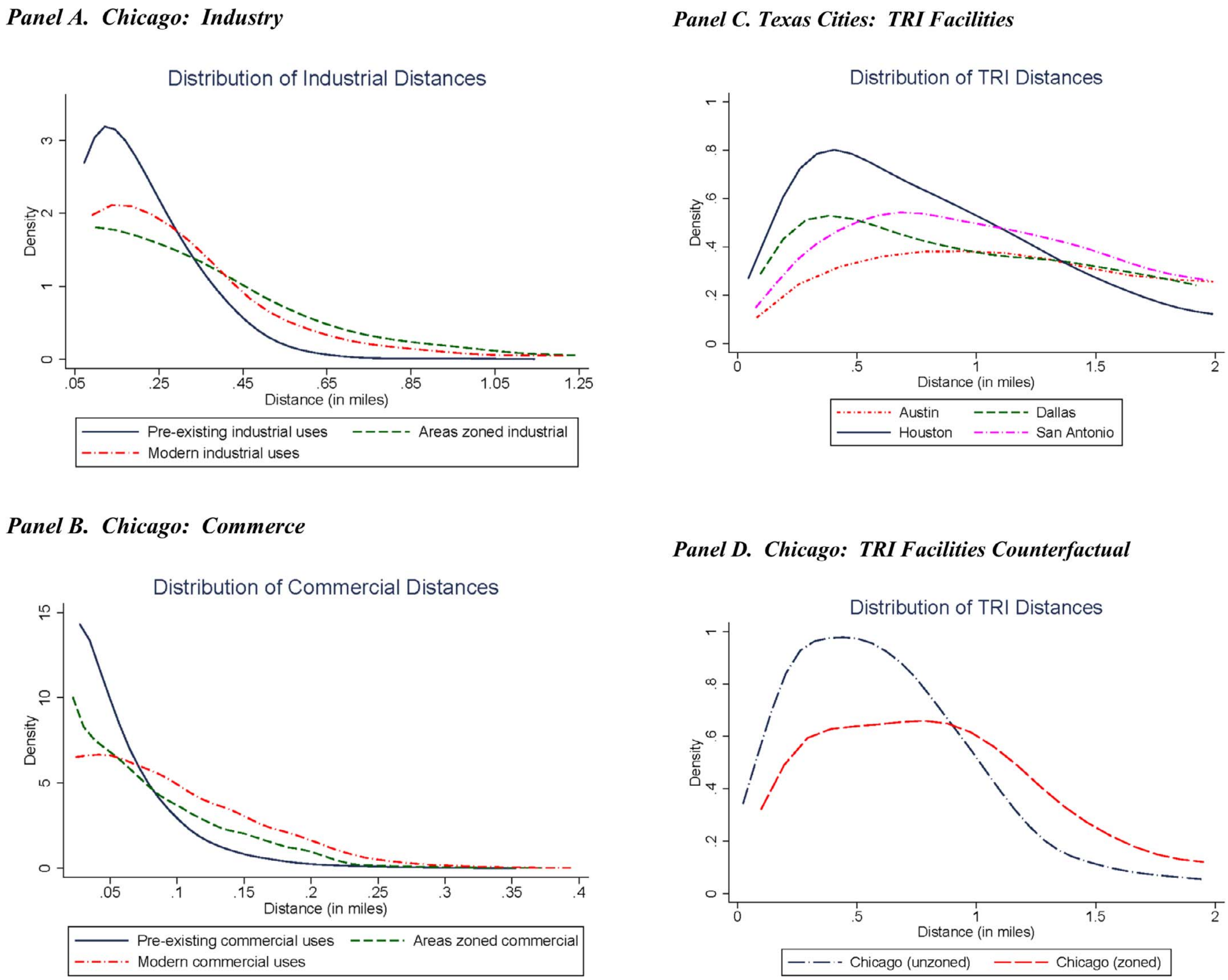


Fig. 7. Distribution of distances to nearest industrial or commercial use. *Notes:* Panel A shows the distribution of distances from each point of a mesh of equidistant (250 foot spaced) points to the nearest 1922 industrial use (blue line), nearest 1923 industrial zoning (green line), and nearest 2005 industrial use (red line). Analysis is restricted to the portion of the city with above median population density in 1920. Panel B repeats the analysis for commercial uses and zoning. Panel C reports a distribution of distances to TRI facilities over 1987–2010 in four Texas cities, restricting to the area within 10 miles of the central business district. Panel D reports a similar analysis for the distribution of distances to predicted TRI facilities in Chicago under zoning (red line) and under a counterfactual of unrestricted zoning (blue line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

designed to guide growth and create distinct zones for incompatible uses. As a result, the city has seen multiple referenda on the issue, most recently in 1993 when zoning was defeated by a narrow margin (Kapur, 2004). Specific objections to the lack of zoning in Houston have focused on the poor treatment of low-income communities and a feeling that the current system allows excessive mixing of uses, leading to "ugly chaos" (Verhovek, 1993). Thus, there may be scope to use Houston as a counterfactual.

To assess the extent to which land use patterns actually differ in Houston relative to a hypothetical zoned version of the city, we analyze the diffusion of TRI facilities in Houston relative to that in three neighboring cities that employ comprehensive zoning: Austin, Dallas, and San Antonio.[21] We focus on polluting facilities because separation from undesirable land uses is central to municipal zoning and because the TRI provides a readily available source of directly comparable data for cross-city comparisons.[22] We measure diffusion of TRI facilities using the same approach that is discussed above for manufacturing and commercial uses in Chicago.

Panel C of Fig. 7 shows that the distribution of distances from points throughout the city of Houston to the nearest TRI facility has a greater mass near zero than that of Dallas; a result that is even more striking for Austin and San Antonio. A convenient summary is provided by the percentage of points that lie within one mile of a TRI facility. In Austin, Dallas, and San Antonio this is 30%, 44%, and 43%, respectively; in Houston, it is 65%. The extent to which Houston represents an "un-zoned" counterfactual remains an open question. It is, however, clearly distinct from the un-zoned state of early twentieth century Chicago. Our cursory analysis of TRI facilities suggests that land use patterns in relatively un-regulated Houston differ measurably from comparable cities that experienced formal zoning.

[21] To account for the different spatial extents of these cities, we take only the portions of each city within 10 miles of its central business district. Results are similar if the entire extent of each city is used.

[22] The criteria for classifying TRI facilities is established by the EPA and will not reflect idiosyncratic differences in the classification of land use across different cities.

6.3. Chicago counterfactual

Would a lack of zoning in Chicago have given rise to a landscape more akin to Houston's? To answer this question, we conclude our work with a statistical counterfactual analysis based on the TRI regression results. Using the results in Column 1 of Table 5, we predict the location of TRI facilities under the actual 1923 zoning ordinance and under a counterfactual in which we set the zoning everywhere at its most permissive level on both volume and use dimensions (high-density/industrial). We then compute the distribution of distances as in the comparisons above. The results, presented in Panel D of Fig. 7, are consistent with our analysis of cities in Texas. They suggest that zoning shifted the distribution of TRI distances away from the origin significantly and provide further evidence that zoning has had a significant impact on the overall city-wide pattern of land use.

7. Conclusion

Comprehensive zoning is central to the lives of urban residents in the United States, yet we know surprisingly little about how these policies have shaped contemporary cities. In this paper we provide the first attempt to measure the causal effect of land use regulation over the long term, using as our setting the first comprehensive zoning ordinance adopted by the city of Chicago in 1923. Our analysis relies on both the digitized ordinance and a lot-level land use survey undertaken in 1922, enabling us to control for a rich set of pre-zoning characteristics as well as identify the boundaries between areas zoned for different uses.

The results of this study indicate that zoning has had a broader and more significant impact on the spatial distribution of economic activity than was previously believed. In particular, zoning may be more important than either geography or transportation networks – the workhorses of urban economic geography models – in explaining where commercial and industrial activity are located. Furthermore, rather than simply "following the market," zoning appears to be a powerful tool for achieving separation of uses. Our results strongly suggest that over the long-run urban planning has been effective in creating residential neighborhoods that are distant from undesirable manufacturing uses, and that houses in these neighborhoods are more valuable as a result.

We close with implications of our findings. First, more work is needed to understand the institutions that drive aggregate land use patterns. Previous research has focused on the causes of macro-level persistence such as agglomeration economics, locational fundamentals, durable capital, and natural advantages (Krugman, 1991; Davis and Weinstein, 2002; Glaeser and Gyourko, 2005; Redfearn, 2009; Bleakley and Lin, 2012). At the same time, block-level persistence has received far less attention, and institutional factors such as zoning have been left largely unexplored. While we establish that zoning played a prominent role in Chicago's development, the mechanisms through which it influenced future land use are less clear. Did zoning establish early patterns of development that then persisted to the present? Or was zoning itself persistent, perpetuating itself through later revisions of the ordinance? Recent work by Twinam (2017) in Seattle suggests that both channels may play a prominent role; however, more research is necessary to document this phenomenon thoroughly. Regardless, our results suggest that policymakers have great power to shape the overall form of cities, and the spatial arrangement of economic activity in urban areas a century from now may be largely the consequence of land use regulation choices made today.

Appendix

A.I. Data Appendix

This section describes the eight components of the dataset compiled for this paper in more detail.

(1) CMAP land use inventory
Our primary source of information on contemporary land use in Chicago is drawn from a 2005 comprehensive land use inventory compiled by the Chicago Metropolitan Agency for Planning, the official regional planning organization for Cook County and the six neighboring counties. The CMAP land use inventory was created to inform the development of a comprehensive regional plan. The survey is based on 2005 aerial photography as well as data from other government and private organizations. The survey measures land use at the acre to one-half acre level (a typical city block in Chicago is five acres) and distinguishes between a wide array of land uses: single-family and multifamily residential use are classified separately while commercial uses are separated into ten different classes and industrial uses are divided into four different classes. The inventory also accounts separately for a variety of institutional, transportation, and open space uses.

(2) The Toxics Release Inventory
The Toxics Release Inventory (TRI) is an annually-updated inventory of industrial facilities in the United States. It was created in 1986 following several high-profile toxic waste management disasters with the aim of informing the public about potential environmental hazards in their communities. Facilities which manage or release into the environment certain hazardous chemicals in quantities greater than certain thresholds must report these quantities to the EPA, and these are compiled into the TRI. The TRI has been the basis for measuring exposure to industrial hazards and/or locally undesirable land uses (LULUs) in numerous empirical studies.[23] We include in our analysis any sites that reported to the TRI at any point between 1987 and 2010.

(3) 2012 Zoning
Zoning data come from the City of Chicago and delineates the city into residential, commercial, industrial, and other miscellaneous categories. We focus on the first three categories, as the others (e.g., planned unit developments featuring bespoke zoning arrangements) are not classifiable in terms historical zoning.

(4) 2000 Census block data
Our contemporary land use data is supplemented with counts of housing units, African Americans, and Hispanics at the census block level for the year 2000. Census data and GIS block maps were obtained from NHGIS. We attached the census block data to our Chicago city block data using areal interpolation.

(5) Home sales
Our housing price data encompasses the universe of single-family home sales in Chicago over the years 2000–2012. In addition to sale prices, the data includes housing characteristics such as lot size, building square footage, number of stories, number of bedrooms and bathrooms, and the

[23] See for instance, Banzhaf and Walsh (2008)

Table A.1
Summary statistics.

	Full sample		Developed sample		Undeveloped sample	
	Mean	SD	Mean	SD	Mean	SD
Population density	28.70	31.95	52.41	29.85	4.89	4.37
Fraction southern black	0.02	0.08	0.03	0.10	0.01	0.05
Fraction northern black	0.01	0.04	0.01	0.05	0.00	0.02
Fraction first-gen. immigrant	0.47	0.19	0.45	0.20	0.49	0.17
Fraction second-gen. immigrant	0.21	0.07	0.22	0.08	0.19	0.06
Indicator for commercial use	0.49	0.50	0.75	0.43	0.23	0.42
Indicator for mfg. A use	0.18	0.38	0.28	0.45	0.08	0.27
Indicator for mfg. B use	0.04	0.18	0.04	0.20	0.03	0.16
Indicator for mfg. C use	0.02	0.14	0.02	0.16	0.01	0.12
Indicator for mfg. S use	0.01	0.08	0.00	0.07	0.01	0.09
Indicator for warehouse use	0.05	0.22	0.07	0.26	0.02	0.16
Density of commercial uses	0.43	0.72	0.74	0.86	0.11	0.33
Density of mfg. A uses	0.07	0.23	0.11	0.27	0.03	0.17
Density of mfg. B uses	0.01	0.05	0.01	0.05	0.01	0.05
Density of mfg. C uses	0.00	0.04	0.01	0.04	0.00	0.04
Density of mfg. S uses	0.00	0.01	0.00	0.01	0.00	0.02
Density of warehouses	0.01	0.09	0.02	0.10	0.01	0.07
Density of 4 story buildings	0.05	0.18	0.08	0.23	0.01	0.09
Density of 5 story buildings	0.01	0.07	0.01	0.08	0.00	0.06
Density of 6–25 story buildings	0.02	0.12	0.02	0.14	0.01	0.10
Average 1913 land value	0.61	3.58	0.75	2.79	0.47	4.22
Railroad indicator	0.00	0.02	0.00	0.02	0.00	0.02
Major street indicator	0.63	0.48	0.62	0.49	0.64	0.48
River indicator	0.00	0.07	0.00	0.06	0.01	0.08
Coast indicator	0.01	0.09	0.01	0.10	0.01	0.08
CBD indicator	0.03	0.17	0.04	0.19	0.02	0.14
Commercial zoning indicator	0.59	0.49	0.68	0.47	0.50	0.50
Manufacturing zoning indicator	0.13	0.34	0.10	0.30	0.16	0.37
Residential zoning indicator	0.07	0.25	0.02	0.14	0.12	0.32
Percent commercial zoning	0.17	0.20	0.21	0.21	0.12	0.16
Percent manufacturing zoning	0.08	0.21	0.05	0.17	0.10	0.24
Percent residential zoning	0.04	0.14	0.01	0.06	0.06	0.19
Percent volume 1 zoning	0.35	0.44	0.14	0.31	0.57	0.45
Percent volume 2 zoning	0.49	0.46	0.62	0.45	0.35	0.43
Percent volume 3 zoning	0.11	0.30	0.17	0.35	0.05	0.21
Percent residential land use, 2005	0.68	0.35	0.62	0.36	0.73	0.34
Percent commercial land use, 2005	0.13	0.21	0.15	0.23	0.11	0.20
Percent industrial land use, 2005	0.04	0.17	0.04	0.16	0.04	0.18
Indicator for commercial land use, 2005	0.37	0.48	0.42	0.49	0.32	0.47
Indicator for industrial land use, 2005	0.08	0.27	0.08	0.27	0.08	0.27
Indictor for TRI facility	0.02	0.13	0.02	0.13	0.02	0.14
Population density, 2010	27.68	23.71	31.56	26.86	23.78	19.28
Housing unit density, 2010	12.16	15.23	15.05	17.91	9.25	11.24
Percent manufacturing zoning, 2012	0.04	0.16	0.05	0.17	0.04	0.15
Percent residential zoning, 2012	0.70	0.35	0.63	0.37	0.76	0.33
Percent commercial zoning, 2012	0.14	0.21	0.16	0.23	0.11	0.19
N	14,690	14,690	7361	7361	7329	7329

Notes: Densities are with respect to acres. The developed sample includes blocks with above median population density (17 persons per acre) in 1920; the undeveloped sample captures those blocks with below median population density in 1920.

age of the building at sale. These data come from come from DataQuick Information Systems, under a license agreement with the vendor.

(6) 1922 Chicago land use survey
The historical comprehensive land use survey we draw upon was conducted by the Chicago Zoning Commission in 1922 to inform the drafting process for the zoning ordinance. Four teams, each equipped with an automobile, recorded the use of every building and lot in the city (Zoning Chicago 1922 Pamphlet). From these survey maps we obtain the location of every commercial and manufacturing use in the city; we also obtain the location and number of stories of every building with four or more stories. We geocoded the entire pre-zoning survey for our study.
Fig. A.1. A provides a map image of several blocks from the survey. The Tilden Public School in the center of the image is surrounded by noxious facilities, indicated by "+ +N" on the map. The building heights of all structures over four stories can also be seen (surveyors occasionally indicated three-story buildings although not consistently). The letters on buildings correspond to specific uses, which we classified as residential, commercial, or manufacturing using the same system as the Chicago Zoning Commission in 1922. Of particular use for our identification strategy are the manufacturing classes: classes A and B include general manufacturing that does not cause a nuisance but may require yard storage, class S includes large-scale industrial facilities such as rail yards and granaries, class D covers storage of explosives and high pressure gases (only one instance in our sample), and class C includes manufacturing facilities that emit noise, smoke, odors, or pose a fire risk. Commercial use is indicated using only one category and covers retail establishments, offices, and entertainment venues such as theaters. Class A manufacturing included such uses as printers and laundries, so we group these with commercial uses when splitting samples along these lines.

(7) Comprehensive zoning ordinance of 1923
We digitized the initial zoning ordinance for Chicago, recording both use zoning and volume zoning. Use zoning delineated the city into four distinct districts: residential (single family homes), apartment, commercial, and manufacturing. These use districts were hierarchical, with

Table A.2
Zoning border regressions.

A. Blocks within 500 ft of both a residential or apartment block and some commercial or industrial zoning: probability of commercial use

	(1)	(2)	(3)	(4)
Commercial side of border	0.719***	0.688***	0.751***	0.731***
	(0.0305)	(0.0488)	(0.0675)	(0.0989)
Distance to nearest comm. or mfg. zoning	−0.211***	−0.195***	−0.347**	−0.024
	(0.0510)	(0.0587)	(0.1355)	(0.2971)
Distance to nearest res. or apt. zoned block	−0.028	0.052	−0.072	−0.131
	(0.0923)	(0.2027)	(0.2016)	(0.1329)
Sample restriction	None	# Com = 0	0 < # Com ≤ 2	# Com > 2
Observations	10,805	5662	2297	2846
R-squared	0.398	0.358	0.399	0.296

B. Blocks within 500 ft of both commercial and industrial zoning: probability of industrial use

	(1)	(2)	(3)
Manufacturing side of border	0.326***	0.292***	0.148
	(0.0642)	(0.0772)	(0.1782)
Distance to nearest comm. zoning	0.178	0.159	0.463
	(0.2550)	(0.3214)	(0.5618)
Distance to nearest mfg. zoning	−0.310***	−0.365***	−1.077*
	(0.1059)	(0.1188)	(0.6278)
Sample restriction	None	# Mfg = 0	# Mfg > 0
Observations	3118	2758	360
R-squared	0.338	0.250	0.547

C. Blocks within 500 ft of both commercial and industrial zoning: probability of commercial use

	(1)	(2)	(3)	(4)
Commercial side of border	0.177***	0.197**	0.044	0.189
	(0.0593)	(0.0946)	(0.1383)	(0.1249)
distance to nearest comm. zoning	−0.086	−0.103	−0.878	−0.143
	(0.2043)	(0.2741)	(0.5683)	(0.6571)
Distance to nearest mfg. zoning	0.350**	0.560*	0.596*	−0.118
	(0.1476)	(0.3039)	(0.3303)	(0.2351)
Sample restriction	None	# Com = 0	0 < # Com ≤ 2	# Com > 2
Observations	2945	1136	699	1110
R-squared	0.245	0.245	0.304	0.292

D. Blocks within 500 ft of residential (single family) zoning: percent of block dedicated to single family residential

	(1)	(2)	(3)
Low density (volume 1) side of border	0.523***	0.562***	0.450***
	(0.0605)	(0.0797)	(0.1380)
Distance to nearest volume 1 zoning	−0.102	−0.102	−0.244
	(0.1795)	(0.2972)	(0.2544)
Distance to nearest volume 2 zoning	0.047	-0.042	0.108
	(0.1197)	(0.1430)	(0.3439)
Sample restriction	None	Undeveloped	Developed
Observations	2518	1634	884
R-squared	0.502	0.480	0.459

Notes: Panel A replicates the analysis from Fig. 3 using OLS. Similarly, Panels B, C and D replicate Figs. 4, 5, and 6, respectively. Sample restrictions are with respect to 1922 land use. The developed sample includes blocks with above median population density (17 persons per acre) in 1920; the undeveloped sample captures those blocks with below median population density in 1920. All models include the full set of historical covariates.

apartment districts allowing residential uses, commercial districts allowing both apartments and single-family homes, and manufacturing districts allowing any use.[24] The residential category was rarely used in the initial zoning ordinance; only three percent of the enumeration districts in our sample have any zoning of this type. Fig. A.1.B shows a section of a use zoning map from an area west of the downtown along the Chicago River. Zones for apartments, commercial activity, and manufacturing can all be seen.

The volume districts in the zoning ordinance are essentially rough concentric rings radiating out from the central business district. Fig. A.1.C

[24] There were additional gradations within the commercial and manufacturing districts, with certain objectionable commercial uses barred if they were within 125 ft of a residential or apartment district, while certain manufacturing uses were barred if they were within 100–2000 ft of a residential, apartment, or commercial district. Some commercial uses within 125 ft of residential or apartment districts also saw restrictions on the hours during which trucking activities could occur.

Table A.3
Impact of 1923 zoning on single family house prices by poverty rate.

	Dependent variable is single-family home sale values		
	(1)	(2)	(3)
Percent commercial zoning within a quarter mile	−0.00441 (0.0178)	0.00774 (0.0141)	−0.0105 (0.0279)
Percent manufacturing zoning within a quarter mile	0.0424*** (0.0160)	0.00995 (0.0132)	−0.00557 (0.0314)
Percent residential zoning within a quarter mile	0.0193 (0.0147)	−0.00127 (0.0115)	0.0144 (0.0235)
Percent commercial zoning within a half mile	−0.0413* (0.0222)	−0.0101 (0.0173)	0.0360 (0.0416)
Percent manufacturing zoning within a half mile	0.00908 (0.0214)	0.0167 (0.0219)	−0.0506 (0.0497)
Percent residential zoning within a half mile	0.00933 (0.0168)	−0.0183 (0.0120)	0.00337 (0.0225)
Percent commercial zoning within a mile	−0.0353 (0.0398)	0.0444 (0.0309)	0.00709 (0.0586)
Percent manufacturing zoning within a mile	0.130*** (0.0447)	0.0852 (0.0523)	−0.283** (0.119)
Percent residential zoning within a mile	0.0429 (0.0376)	−0.0175 (0.0200)	0.0372 (0.0465)
Constant	11.88*** (0.808)	12.22*** (0.791)	13.78*** (2.267)
Sample restriction	Developed, top quartile of poverty rates (high poverty)	Developed, middle two quartiles of poverty rates	Developed, bottom quartile of poverty rates (low poverty)
Observations	5813	8323	4242
R-squared	0.735	0.807	0.772

Notes: Observations are individual home sales between 2000 and 2012. Models include full set of spatial, demographic, and land use controls described in Section IV as well as housing characteristics, census tract fixed effects, and year-month sale fixed effects. Estimation uses OLS. Zoning variables are standardized the developed sample. Poverty rate is drawn from 2010 Census block-group data. The dependent variable is the log of the sales price.

Table A.4
Determinants of contemporary zoning.

	Percent mfg. zoning 2012 (1)	Percent comm. zoning 2012 (2)	Percent mfg. zoning 2012 (3)	Percent comm. zoning 2012 (4)	Percent mfg. zoning 2012 (5)	Percent comm. zoning 2012 (6)
Percent manufacturing zoning	0.053*** (0.0032)	0.007*** (0.0020)	0.084*** (0.0056)	0.017*** (0.0036)	0.035*** (0.0037)	0.001 (0.0026)
Percent commercial zoning	0.015*** (0.0022)	0.079*** (0.0029)	0.029*** (0.0036)	0.078*** (0.0043)	0.012*** (0.0026)	0.082*** (0.0036)
Percent single family residential zoning	0.000 (0.0008)	−0.007*** (0.0011)	−0.002** (0.0007)	0.001 (0.0013)	−0.003** (0.0011)	−0.006*** (0.0016)
Percent volume district 1 zoning	−0.007 (0.0152)	0.047*** (0.0165)	0.020* (0.0105)	0.032*** (0.0124)	−0.170 (0.1561)	−0.014 (0.1091)
Percent volume district 2 zoning	−0.011 (0.0151)	0.064*** (0.0164)	0.028** (0.0130)	0.049*** (0.0152)	−0.167 (0.1528)	0.004 (0.1065)
Percent volume district 3 zoning	−0.004 (0.0083)	0.031*** (0.0087)	0.011 (0.0098)	0.031*** (0.0110)	−0.058 (0.0495)	0.001 (0.0348)
Sample restriction	Full	Full	Undeveloped	Undeveloped	Developed	Developed
R-squared	0.377	0.504	0.464	0.522	0.438	0.507
Observations	12,035	12,035	5695	5695	6340	6340

Notes: Outcome variables are shares of blocks devoted to each zoning type in 2012; the omitted zoning type is residential (single and multifamily). Columns (3) and (4) are restricted to developed blocks in 1920, while (5) and (6) are restricted to undeveloped blocks. Only blocks covered by residential, commercial, and/or industrial zoning are included; many blocks are covered by bespoke zoning arrangements through Planned Unit Developments, and we are unable to classify the zoning in these blocks. All models include the full set of historical covariates.

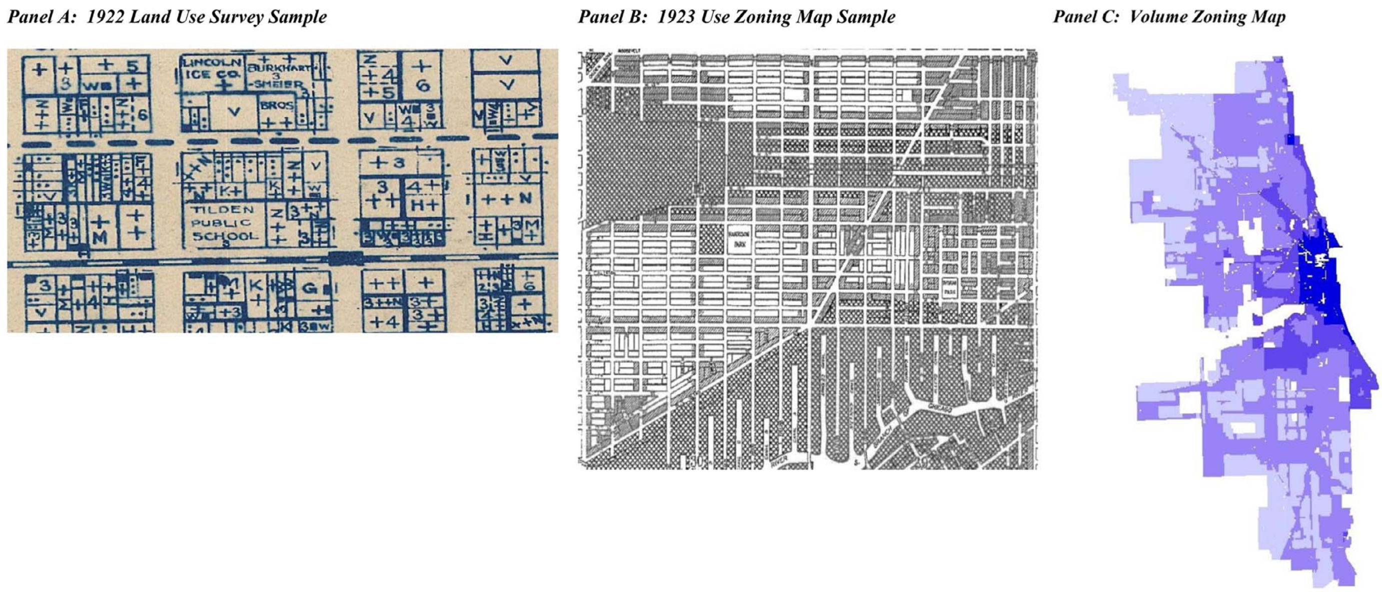


Fig. A.1. Land use survey and use zoning map samples. *Notes:* A portion of the 1922 land use survey map created by the Chicago Zoning Commission. These blocks are located just across the Chicago River to the west of the downtown. Numbers indicate building heights in stories. Black squares within parcels indicate commercial uses; letters sometime accompany these to indicate a specific commercial activity. V indicates a vacant lot/building. Letters followed or preceded by a single + indicate light industrial uses. Letters preceded by + + indicate heavier industrial uses; in particular, + + N indicates uses which "by reason of excessive noise, odor, fumes, gases, etc., affect the adjacent territory." *Notes:* This image shows the area of Chicago west of the downtown along the Chicago River. Unhatched areas are zoned for apartments, hatched areas are zoned for commercial uses, and cross-hatched areas are zoned for manufacturing. *Notes:* This map shows volume districts in the Chicago zoning ordinance with enumeration districts assigned to the volume district in which the majority of its area fell. District 5 (darkest hue) permitted the tallest buildings, up to 22 stories. District 1 (lightest hue) was the most restrictive, allowing only buildings with three or fewer stories.

shows the digitization of these districts with each enumeration district assigned to the volume district most common within its borders. The volume district 1 maximum building height was 33 ft, corresponding to roughly three stories. For district 2, the maximum height was about six stories; district 3, eleven stories; and district 4, sixteen stories. District 5, which was restricted to the central business district, allowed a maximum building height about 22 stories. If a building satisfied requirements on additional setbacks from the street, the allowed height was greater. There were no density "minimums," only restrictions only the maximum volume, height, and lot coverage.

(8) Census Enumeration District Data for 1920
In the empirical work we control for four categories of racial and ethnic minorities in 1920 since there is evidence that the spatial distribution of these groups impacted the initial zoning ordinance (Shertzer et al., 2016). We obtained counts of the number of blacks and white ethnic groups from the 1920 census at the enumeration district level using the genealogy website Ancestry.com. Enumeration districts were small administrative units used internally by the Census Bureau to divide cities up into small areas that could be surveyed by one person.[25] In order to place individuals in 1920 urban space, we digitized the 1920 enumeration district map of Chicago. We first used written descriptions of the enumeration districts available on microfilm from the National Archives. The information from these microfilms has been digitized and made available on the web due to the work of Stephen P. Morse.[26] Second, we took digital photographs of the physical map of the 1920 census enumeration districts of Chicago from the National Archives. Working primarily with a geocoded (GIS) historic base street map developed by the Center for Population Economics at the University of Chicago, we generated a GIS representation of the Chicago enumeration district map that is consistent with the historic street grid.[27]

We define southern blacks to be individuals who report their race as black or mulatto and their place of birth as in the South.[28] We define "second-generation" blacks, that is, individuals born in the North but with southern-born fathers, in the southern black category. Northern blacks are defined as black or mulatto individuals who were both born outside the South with fathers born outside the South. First-generation immigrants include all foreign-born individuals plus second-generation individuals under the age of 18, the latter of whom are presumably children residing in the same household as their foreign-born parents. Second-generation immigrants are defined as individuals who were born in the U.S. and who are at least 18 years old with foreign-born fathers.[29]

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[25] The Census Bureau did not switch to a mail-based survey system until 1960.

[26] Website: http://stevemorse.org/ed/ed.php.

[27] These data are available on line at http://uadata.org/.

[28] We use an eleven state definition of the South, defining the region to include Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia.

[29] Using these definitions, we avoid the standard problem in the segregation literature of immigrant populations being diluted by the presence of their native-born children (see Cutler et al., 2008).

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