Three Essays in Economic History

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This dissertation contains three essays that contribute to the field of economic history with a focus on the determinants of local policy and urban inequality in the United States during the early twentieth century. Chapter 1 explores the initial spread of comprehensive zoning ordinances among American cities. Using land available for urban expansion as an instrument for low-density, fringe development, I show that the growth of such development contributed to the adoption of zoning. Among non-Southern municipalities, I also show that the arrival of Southern black migrants increased the likelihood of zoning using a shift-share instrumental variables strategy. Finally, I present correlational evidence on the importance of proposed determinants of zoning adoption. Chapter 2 investigates the role of air pollution in the establishment and maintenance of racial inequities in US cities prior to World War II using newly digitized data on air pollution in Pittsburgh. Race and nativity were stronger predictors of pollution exposure than income, and that racial inequity in exposure increased significantly between 1910 and 1940, with black Pittsburghers exposed to more than half a standard deviation more pollution than their white counterparts by 1940. Air pollution was salient in Pittsburgh's housing market, with a 5% drop in housing price associated with a standard deviation increase in air pollution. The findings suggest that air pollution contributed to the establishment and maintenance of racial disparities in US cities prior to World War II. Chapter 3 examines how women's suffrage impacted the election of women to local office, the characteristics of female officials, and whether the presence of female officials was associated with policy changes. I digitize rosters of municipal and county officials in Ohio from 1910 to 1940 and find the presence of women in local office increased following suffrage. Female officials were more highly educated than male officials, and, congruent with norms against married women working outside the home, less likely to be married. Using a difference-in-differences strategy, I find measures of women's political power did not consistently increase female office holding. Similarly, the presence of women in government

is largely uncorrelated with changes in local government finances.

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1.0 Protecting Empty Land: The Rise of Zoning in America

1.1 Introduction

The policy of zoning spread from a single city to over 1,200 municipalities in the United States between 1916 and 1936.[1] Zoning ordinances impose broad restrictions on real estate development and are ubiquitous among municipalities in the United States. These laws originate from democratically elected local governments and create clear winners and losers among local residents and property owners. Existing scholarship attributes the rapid spread of zoning to the growth of negative externalities arising from industrial nuisances and urban density (Bassett, 1936; Fischler, 2019). However, the enthusiasm for zoning in this period is not matched by any proportionate deterioration in urban conditions, which were in many ways improving compared to prior decades (Fischel, 2004). Thus, changes to negative externalities cannot adequately explain the timing of zoning's appearance or why it superseded earlier, less restrictive land use regimes with such exceptional speed

This paper provides causal estimates for two alternative determinants of zoning adoption; Southern Black migration to non-Southern cities and low density, fringe development. Zoning adoption followed from a surge in automobile-oriented, fringe development that enlarged the share of urban property owners who could, on net, benefit from broad zoning restrictions on land use and density. Moreover, new fringe owners did not disproportionately benefit from zoning because they faced greater exposure to negative externalities, but rather because they lacked opportunities for profitable intensive development as a result of their peripheral location. Although not mutually exclusive, my emphasis on the growth of low-density, fringe development stands in contrast to existing scholarship's focus on growing negative externalities as the proximate cause of zoning adoption. A separate strand of literature attributes the popularization of zoning to the segregationist goals of white homeowners, asserting that the policy emerged in the wake of the First Great Migration and primarily

[1] In this interval zoning was adopted by 31% of municipalities with at least 2,500 inhabitants (the census cut-off for classification as an urban area) and by 84% of municipalities with at least 25,000 inhabitants. New York City passed the first zoning ordinance in 1916 (Toll, 1969).

sought to exclude black residents from desirable neighborhoods (Silver, 1991; Rothstein, 2017)

To assess the factors responsible for the spread of zoning laws, I use instrumental variables, a new dataset of zoning laws enacted prior to 1937 compiled from multiple federal surveys, and newly constructed estimates of developable land surrounding cities. The Department of Commerce began surveying cities on zoning in the mid-1920s. I expand on a 1929 publication of the Department's data utilized by previous studies (Clingermayer, 1993; Trounstine, 2018) by combining it with later zoning surveys from the Department as well as the National Resources Board, through 1936. I also rely on city and individual level census data from the 1900, 1910, and 1920 censuses

I use instrumental variables to identify the effects of both low density fringe development and Black migration from the South on zoning adoption between 1920 and 1936. To causally identify the effect of fringe development on zoning adoption I use the amount of locally available developable land as an instrument. Naive OLS estimates might suffer from reverse causality, with real estate activity rising in anticipation of zoning, or unobserved confounders affecting both real estate development and zoning uptake. Due to a lack of records directly measuring the extent of low density, speculative development, I depend on real estate employment per capita as a proxy.[2] My instrument relies on the assumption that larger endowments of developable land should increase fringe development, as measured by real estate employment, but otherwise be uncorrelated with cities' zoning decisions conditional on controls. Intuitively, city founders did not make settlement choices based on peripheral land which would only become suitable for urban use after the spread of the automobile, so the availability of fringe land for subdivision and development should be independent of other city characteristics influencing zoning adoption

To causally identify the effect of Black migration in non-Southern cities my paper uses a shift-share instrumental variables (SSIV) strategy common in studies of the Great Migration (Boustan, 2010; Derenoncourt, 2022). If exclusionary motives fueled early zoning efforts, then

[2] Compared to other segments of the real estate market, trade in fringe land had fewer barriers to entry, and accounts of the 1920s real estate boom characterize the industry as inundated with newly minted operators subdividing, selling, and investing in small properties on the urban fringe (Whitten, 1927; Bodfish, 1929; Fisher, 1933; Simpson, 1933).

OLS estimates from regressing zoning adoption on Black population share may be biased downwards. Municipalities with greater racial animus would be more likely to pass zoning laws, but also more likely to exclude black residents through other means, obscuring the relationship between growing Black population shares and zoning. The SSIV identification strategy relies on the pre-existing distribution of black migrants (shares) and out-migration from Southern origin counties (shifts) to resolve the non-random destination choices made by migrants and isolate their impact on destination cities. I follow Bazzi et al. (2023) and use census linking procedures developed by Abramitzky et al. (2020b) to identify black migrants leaving the South and predict the number of black migrants arriving in each non-Southern city between 1900 and 1920. I then use predicted number of black arrivals to instrument for actual Black population share in 1920.

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My paper presents two main findings. First, real estate employment had a large, positive, and statistically significant effect on zoning adoption during the period of study. A one standard deviation increase in instrumented real estate employment raises the probability of zoning by 65 to 75 percentage points. Notably, the IV estimates are substantially larger than those estimated using OLS, which find a standard deviation increase in real estate employment raises a city's zoning probability by 10 to 20 percentage points. The instrument isolates variation in real estate employment attributable to developable land supply, better capturing the influence of operators dependent on land-intensive development strategies like those speculating in fringe real estate. Conversely, the instrument is largely orthogonal to the influence of those pursuing capital-intensive development, such as developers of downtown real estate who frequently opposed zoning (Slimp, 1924). Thus, the increase in effect size is consistent with the distribution of pro-zoning sentiment within the real estate sector.

My second main finding is Black migration also had a statistically significant and large positive impact on zoning adoption. A one standard deviation increase in SSIV predicted Black population share raises the probability of zoning by 23 percentage points. The effect estimated using SSIV stands in contrast with the OLS results that show no significant correlation between Black population share and zoning. The increase in the coefficient's size and significance suggests that exclusionary motives in non-Southern cities increased the probability of zoning and independently reduced Black population share. Of other proposed zoning determinants, manufacturing employment and measures of segregation between renters and homeowners exhibit no significant conditional correlation with zoning uptake. Thus, zoning was not more likely to occur in places with more industrial nuisances or in places where neighborhood barriers between renters and homeowners were breaking down. Progressive support is significantly and positively correlated with zoning adoption, aligning with the popular perception of early zoning laws as a Progressive reform

Estimates for the effects of real estate employment and Black migration remain robust in regression models with two endogenous variables and two instruments. Additionally, alterations to the developable land instrument produce results consistent with the theory that fringe development contributed to zoning adoption. Namely, expanding the area over which developable land is measured to include land cities could not feasibly annex attenuates the estimated effect size. Finally, geographic features impacting land supply, such as mountains or bodies of water, that might also affect zoning through alternate channels, like amenities or access to transportation networks, do not drive results.

My paper contributes to three literatures. The first is the literature on the initial causes of zoning in the United States. A large body of historical work has advanced several reasons for the advent of American zoning but has not empirically tested these motivations in isolation or quantified their comparative importance (Fischel, 2004; Fischler, 2019; Silver, 1991; Toll, 1969). On the other hand, quantitative economic studies of the origins of zoning focus on the tightening of zoning controls after World War 2 (Schuetz, 2008; Krimmel, 2021) or infer historical explanations of zoning based on variation in modern zoning laws (Hilber and Robert-Nicoud, 2013; Glaeser and Ward, 2009). Finally, direct examinations of early zoning patterns, primarily by political scientists, limit themselves to larger cities and consider the roles of governmental structure and public goods provision rather than the tradeoffs faced by private property owners discussed in this paper (Clingermayer, 1993; Trounstine, 2018). My paper advances and causally supports a novel theory for the initial spread of zoning in the United States using newly digitized data on interwar zoning adoptions.

Second, I contribute to the economic literature studying the circular relationship between land use regulations and actual land use (Turner et al., 2014; Hilber and Robert-Nicoud, 2013; Dehring et al., 2008). Given the century long co-evolution of zoning and urban land use as well as the sheer variety of modern regulations, the emergence of zoning in the early twentieth century offers a unique opportunity for clean identification. Whereas other papers have leveraged pre-zoning land use surveys and original zoning ordinances to identify zoning's effect on later land use in individual cities (Shertzer et al., 2018; Twinam, 2018), this paper studies the impact of changing land use patterns on zoning adoption in a large sample of U.S. municipalities.

Third, I add to a growing literature interested in how the Great Migration influenced municipal policies in non-Southern cities (Boustan, 2010; Derenoncourt, 2022). Most directly, my paper complements studies of the second wave of the Great Migration (1940-1970), which also find a connection between the number of Southern black arrivals and zoning intensity. These papers focus on how later inflows of Southern black migrants influenced zoning on the intensive margin, whether by reducing the amount of land zoned for multi-family residential use (Sahn, 2023) or by raising required minimum lot sizes (Cui, 2024). My paper estimates new causal effects of Southern Black migration on the extensive margin of zoning and provides further evidence for the exclusionary motives of zoning in an earlier time period.

1.2 Historical Background

The proliferation of zoning ordinances in the 1920s fundamentally altered how municipalities managed land use and set the stage for even tighter restrictions in the following decades. Zoning managed to not only supersede centuries-old approaches to urban land use regulation but also outshone contemporary alternatives with similar aims and backers. City planners bridging the public and private sectors proposed an extensive package of reforms to improve urban conditions, of which zoning was a valuable but ancillary component. However, the economic interests of property owners ultimately shaped land use regulation in this era, explaining not only the timing of zoning's popularization but also why it outpaced other city planning efforts. The burst of automobile-oriented development during the 1920s real estate boom created a large class of property owners whose economic interests aligned with zoning and facilitated compromise with anti-zoning property owners geared towards denser development

The city planning movement that originated zoning emerged at the turn of the twentieth century. While the layouts of municipalities ranging from Washington, D.C. to small railroad towns followed pre-written plans, the city planning movement desired the active and rational direction of public investments and private development by central authorities. Through their focus on eliminating waste, professionalizing government, and raising living standards, the city planners aligned with the broader Progressive movement. Moreover, membership drew heavily from educated professionals sympathetic to Progressivism; mainly civil engineers, lawyers, and (landscape) architects (Burgess, 1994; Hubbard and Hubbard, 1929, p.59-65,p.4-11). They believed proper city planning could alleviate the evils of slums, eyesores, congested streets, and wasteful spending which would otherwise breed, "physical disease, moral depravity, discontent, and socialism" (Morgenthau, 1909, p.59)

By the first National Conference on City Planning in 1909 planners had identified zoning as a key element of urban improvement alongside tenement-house laws and the provision of adequate transit, parks, and playgrounds Morgenthau (1909). Ideally, cities would package these reforms in empirically grounded, comprehensive city plans that delineated future growth and effectively targeted public investments. By zoning, i.e., specifying acceptable land uses and densities by district, planners could better match resources to populations knowing that, for example, commercial districts needed wider streets than single-family neighborhoods (Burgess, 1994, p.78-79). However, it remained unclear in 1909 whether zoning or city planning more broadly could achieve public support, sufficient funding, or legal legitimacy. Moreover, of all the elements of the city planning program, zoning faced the greatest practical and legal hurdles because it entailed a vast expansion of public control over private property.[3] Very few municipalities had experimented with zoning to the degree proposed by city planners, and negatively affected landowners frequently sued, leaving a mixed record in state courts.[4] The Supreme Court set a salient precedent in 1917 by outlawing racial segregation ordinances using a rationale that could easily apply to use and density zoning.[5]

In the twenty years following the 1909 National Conference on City Planning the city planning movement advanced its goals by drafting policy, propagandizing to the public, and disputing legal challenges. Zoning would prove the most successful element of its agenda with New York City's 1916 ordinance serving as the template for later zoning laws.[6] Reformers in New York spent over three years building consensus and minimized opposition by conceding influence to civic groups and real estate interests. They also obtained explicit permission to zone, commonly called zoning enabling legislation, from the state legislature

[3]American cities had a long history of controlling the locations of slaughterhouses, tanneries, and other nuisances through common law. Enforcement could come through statute, which often relegated nuisances to the city's edge, or by private citizens filing lawsuits (Rosen, 2003). Zoning differed from previous nuisance laws in both the number of uses it restricted and in the preemptive application of restrictions throughout the entire city.

[4]For example, the 1924 New Jersey case *State v. Nutley* ruled that zoning ordinances could not dictate the location of stores since such uses did not threaten health or safety, although the case was ultimately superseded by a state constitutional amendment in 1929 (Fischel, 2015, p.77)

[5]Racial segregation ordinances barred individuals from residing in neighborhoods predominately of a different race. Baltimore, MD passed the first such law, also called racial zoning, in 1910, and roughly two dozen cities in Southern and Border States followed suit. The Supreme Court ruled racial segregation ordinances unconstitutional in the 1917 case *Buchannan v. Warley* based on a property rights argument (Troesken and Walsh, 2019). The application of *Buchanan* to use and density zoning was apparent to many. For example, the lower court judge in the famous *Euclid v. Ambler* case that eventually confirmed zoning's legitimacy cited *Buchanan* in his anti-zoning decision Chused (1997).

[6]A handful of piecemeal zoning laws preceded the New York ordinance. Los Angeles (1909), Milwaukee (1913), and Minneapolis (1913) all classified some neighborhoods as exclusively residential districts, but did not zone citywide. Courts tended to frown on piecemeal zoning compared to comprehensive, citywide zoning (Bassett, 1936). For example, Minneapolis retracted its 1913 law after unfavorable verdicts from the State Supreme Court (Bartholomew, 1919).

Toll (1969). The ordinance divided the entire city, including undeveloped areas, into overlaid districts of use, height, and area. Use districts classified properties as residential, commercial, or industrial while height and area districts set maximum limits for height and lot coverage. Districts were hierarchical, and low-density residential uses topped the hierarchy. The original ordinance allowed single-family homes everywhere, but imposed progressively more constraints on multifamily homes, commercial enterprises, and factories Toll (1969). Framers of the New York law became prominent figures in the movement for planning and zoning.[7] Most notably, in 1922 several men responsible for the New York ordinance helped the Department of Commerce write model zoning enabling legislation for state legislatures, which served as both legal cover and a set of best practices for zoning in several states (Ball et al., 1926a)

Coincident with the publication of model legislation, zoning began to spread rapidly before peaking in 1929 and then falling off with the onset of the Great Depression (see Figure 1). Larger cities zoned at higher rates, though in lower absolute numbers, and only the South meaningfully lagged other regions (see Figure 2). An energetic public relations campaign accompanied the flood of new ordinances. Proponents framed zoning as a commonsense solution to wasteful, haphazard development as well as a guarantor of health and well-being. Pamphlets and zoning proposals belabored the unfairness of land uses that harmed neighboring properties, especially those that deprived residences of light, air, and quiet. Zoning advocates printed images of apartments, laundries, and public garages abutting single-family homes with captions of horror and derision (Ball et al., 1926b; Whitten, 1922; Whitten and Fisher, 1923). Besides gains to health and welfare, zoning boosters also argued zoning would stabilize property values and raise them in the aggregate. Some even went so far as to claim a properly written ordinance would raise the value of all properties (Studensky, 1925).

The attention paid to health and welfare on the one hand and property values on the other was strategic. Zoning ordinances following New York's example depended on their state governments' police power; the legal authority to regulate behavior for the benefit of

[7] Edward Bassett, a reformist lawyer and politician at the center of the New York zoning process, became the policy's foremost advocate. He toured the country, proselytizing zoning and consulting on the creation of new laws (Toll, 1969, p.194-202). Bassett and two other New York framers, Lawrence Veiller and Nelson P. Lewis, were appointed to the Advisory Committee on Zoning in the Department of Commerce (Toll, 1969, p.201).

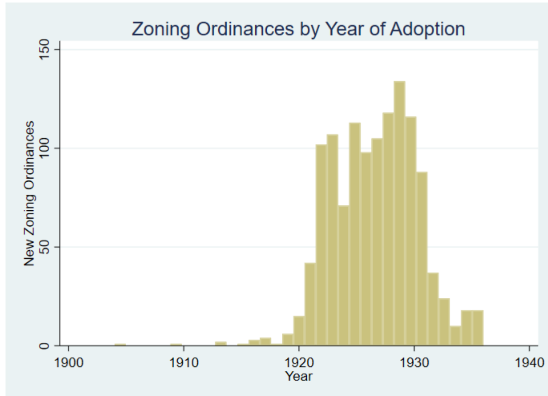


Figure 1: New Zoning Adoptions Over Time

Notes: Data on zoning adoptions were originally gathered by the Division of Building and Housing (DBH) within the Department of Commerce and the National Resources Committee (NRC) (a New Deal agency also referred to as the National Resources Board). I rely on threes sources; a 1929 article in *American City* (DBH), a 1933 memo *Zoned Municipalities in the United States* (DBH), and a 1937 memo *Circular X: Status of City and County Planning in the United States* (NRC). DBH sources report years of adoption and amendment while the NRC only reports year of most recent amendment. Figure (1) reports a raw count of zoning ordinance. Zoning ordinances are only included in the count if they also appear in later sources. The year of adoption is taken from the earliest source if there are disagreements, and I assume that the year of adoption and the year of most recent amendment are identical for ordinances only appearing in the 1937 NRC report.

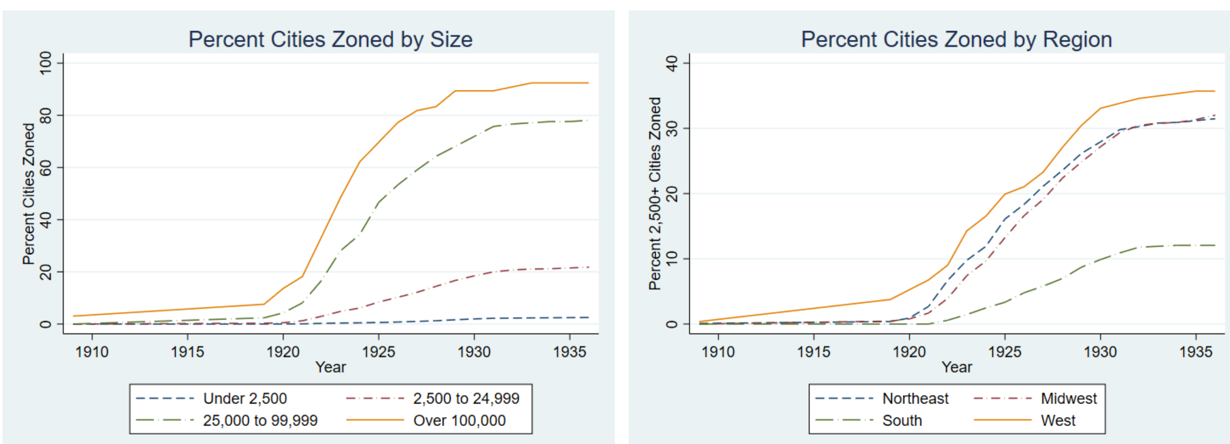


Figure 2: Zoning by City Size and Region

Notes: Population bins based on 1920 population. Sample restricted to census-designated urban areas in right panel.

health, safety, morals, and general welfare. Crucially, grounding ordinances in the police power as opposed to eminent domain meant municipalities had no obligation to compensate owners whose properties lost value due to zoning (Ball et al., 1926a; Studensky, 1925). Thus, zoning's legality depended on promoting health and safety, and those fearing uncompensated losses would be the most likely to challenge its enactment. Moreover, when owners and real estate operators believed zoning would enhance property values they vigorously backed the policy. Zoning found support from the trade organization for real estate agents, the National Association of Real Estate Boards (NAREB), as well as most nationally prominent residential developers (Weiss, 1987). William Munro, a contemporary expert on municipal administration, asserted support from real estate agents and promoters was both responsible for zoning's success and premised on economic self-interest (Munro, 1931)

Despite endorsements from NAREB and other industry leaders, support for zoning among real estate professionals remained stubbornly tied to individual concerns. Against a backdrop of rapid adoption, lawsuits citing improper use of the police power and confiscation without due process did succeed in several cities.[8] Real estate operators in cities such as St. Louis, Philadelphia, and Houston opposed zoning as a threat to citywide prosperity, and the local real estate board of Quincy, MA went so far as to hold a parade to celebrate their victorious anti-zoning campaign (Boston Globe, 1926b).[9] While the Supreme Court ultimately affirmed the legality of zoning in the 1926 case Euclid v. Ambler Realty Company, these conflicts offer insight into how zoning furthered some economic interests at the expense of others, and, by extension, why the policy had its moment in the 1920s.

Like many opponents of zoning, the Ambler Realty Company challenged the policy because zoning lowered the value of property it held, specifically a lot purchased for industrial development that the village of Euclid, OH zoned within a residential district (Bassett, 1936). More generally, downtown property interests offered the most consistent opposition to zoning laws because of their distaste for height and area restrictions (Hubbard and Hubbard, 1929). In the words of Herbert Book, a Detroit skyscraper developer, "the effect of the proposed

[8]For example, New Jersey courts issued dozens of decisions curtailing the ability of cities to zone. However, pro-zoning interests ultimately succeeded, and New Jersey affirmed zoning by constitutional amendment in 1929 (Costin, 2019).

[9]In St. Louis real estate interests managed to overturn an ordinance they considered too restrictive in 1923 only to help pass a new ordinance in 1925 after acquiring building permits that exceeded the previous height limit (Flint, 1977). Powerful apartment developers managed to delay zoning in Philadelphia until 1933 (Hubbard and Hubbard, 1929; National Resources Committee, 1937), and Houston still does not have a zoning ordinance after a group of property owners shouted down the city council in 1929 (Henderson, 1987).

[zoning] ordinance on downtown Detroit would be to curtail development as high values of the land requires large buildings if the owner is to realize on his investment" (Detroit Free Press, 1922, p.4). Similar concerns existed for building at smaller scales. Horace Groskin, the Director of the Philadelphia Real Estate Board, argued that businesses entering residential areas increased rather than depreciated real estate values as homeowners cashed in on the transition to higher value land uses (Allentown Morning Call, 1928, p.21). Although many homeowners supported zoning, some echoed Groskin's belief in their petitions for variances and upzonings (Flint, 1977; Boston Globe, 1926a)

Some opposition to zoning could be offset through compromises with negatively affected landowners. Nearly all zoning ordinances allowed established non-conforming land uses to continue and created boards of appeal to allow for reasonable exceptions to zoning designations. Appeals tended to be more frequent and successful in central neighborhoods, where land uses already mixed, compared with newly developed residential tracts (Burgess, 1994). Resistant landowners also frequently managed to upzone districts during the drafting process. For example, downtown owners in Cincinnati effectively rewrote an ordinance first produced by planning professionals. They more than doubled the height limit in the central business district, greatly expanded industrial zones, and left "little of the original draft with exception of the title heads and the section numbers" (Slimp, 1924, p. 25). These concessions dampened city planners' enthusiasm for zoning, which they increasingly viewed as divorced from the common good and captured by private interests

From the perspective of planning professionals, a zoning ordinance needed to be enmeshed within the framework of a comprehensive plan that accounted for trends in population and land use as well as the placement of infrastructure and public facilities in order to be effective. Without the well-defined goals and accurate data provided by comprehensive planning, zoning would become arbitrary, unstable, and unable to contribute to a community's general welfare (Hubbard and Hubbard, 1929, p.165). Despite zoning's theoretical subordination to well-researched, forward-looking city plans, only 140 of over 1200 zoned municipalities had enacted comprehensive plans by the mid-1930s (National Resources Committee, 1937). The New Jersey State Planning Board grumbled, "zoning ordinances, in most cases, have been set up to meet some immediate consideration, with too little regard for future needs or advantages" (New Jersey State Planning Board, 1936, p.105), and Harland Bartholomew, one of the most prolific planners of the period, blamed the meddling of "selfish property owners and high-powered real estate promoters" (Bartholomew, 1931, p.104). In 1931, William Munro expressed similar concerns that zoning had become an arena of private interests, prone to political favoritism and corruption (Munro, 1931)

Given divides between property owners and within the real estate sector, why did a pivotal share come to see zoning as worthwhile in the 1920s? The groundswell in support did not hinge on judicial approval. Hundreds of municipalities had zoning ordinances before *Euclid* settled the issue, and real estate groups, along with city planners, took an active role in early court battles.[10] Zoning reformers claimed that accumulated negative externalities raised the value of zoning protections for most properties and thus most real estate men. However, urban conditions were not notably worse during the first wave of zoning compared to previous decades (Fischel, 2004). Instead, falling transportation costs rapidly expanded the reach of urban settlement, reduced incentives for infill development, and created large numbers of landowners in new residential subdivisions that would unambiguously benefit from zoning.

During the 1920s burgeoning urban populations, increased credit access, and deferred construction from World War 1 set the conditions for a nationwide housing boom while automobile ownership more than tripled (Brocker and Hanes, 2013; Eli et al., 2022). Abundant motor transportation meant new development could spread over far more land than in prior housing booms, and much new development took the form of partially built residential subdivisions. Most cities still contained sizable vacant areas, so new real estate activity primarily located within municipal boundaries, on adjacent unincorporated land, or in directly bordering towns (Whitten, 1927; Bartholomew, 1932). The housing supply chain lacked vertical integration, and the jobs of subdivision, brokerage, finance, and construction were irregularly divided between several businesses and individuals. The practical consequence of this decoupling was that subdivision of new land on the urban fringe outpaced later stages of development. Subdivision consists of purchasing land wholesale and carving it into smaller

[10] The prevalence of zoning was actually used as an argument for the policy's constitutionality in the *Euclid v. Ambler* case (Bettman, 2006).

lots for resale. Beyond the necessary work of surveying and platting lots some subdividers also imposed deed restrictions or built basic improvements to increase the value of their inventory. However, these "community builders" were exceptional, municipal debt financed most improvements, and deed restrictions suffered from both a lack of scale and a failure to coordinate with neighboring developments (Field, 1992; Weiss, 1987; Bodfish, 1929)

Housing construction reached new heights in the 1920s but never matched the number of lots being subdivided. In the excitement of the boom, this surplus fed a large speculative market in vacant homesites. Newspaper advertisements, most infamously in Florida, promised fantastical returns and investors as well as aspiring homeowners bid up prices in cities throughout the country (Whitten, 1927; Simpson, 1933; Bodfish, 1929; Fisher, 1933). The market collapsed with the 1929 crash, leaving many cities saddled with worthless, tax delinquent properties of unclear ownership. Indeed, studies motivated by municipal debt crises in the 1930s offer the best window into the extent of speculative subdivision in the 1920s. In 1938 New Jersey still had over a million excess lots, enough to accommodate a doubling of the state's population (New Jersey State Planning Board, 1938). As of 1935, there were 785 thousand vacant lots in the Detroit metropolitan area (Michigan Planning Commission, 1939). In Chicago, 31% of subdivided lots remained vacant in 1931 compared to 69% in its surrounding suburbs (Simpson and Burton, 1931). As late as 1946, a federal review estimated between 20 to 30 million surplus lots remained undeveloped from the 1920s boom (National Housing Administration, 1946)

Throughout the country, a significant amount of land transitioned into urban use but realized only scant development. These tracts provided fertile ground for pro-zoning sentiment. Properties uniformly consisted of either unbuilt or newly built homes with slim prospects for intensive redevelopment. Early zoning ordinances placed few if any restrictions on the siting of single-family housing, so zoning constraints would likely not bind for decades to come in new subdivisions (Bassett, 1936). Moreover, the value of undeveloped lots depended heavily on the promise of residential exclusivity. Property holders in these sections, often speculators or original subdividers rather than long-term owners, could thus reach agreement on a common single-family designation without worrying about forgone profits from intensive development (Fisher, 1933). Further, their distance from central areas suited for intensive development meant they could create zoning districts large enough to effectively protect their own properties while avoiding the inclusion of owners with clashing incentives. Herbert Book articulated the disproportionate benefits newly subdivided areas would receive in a quote to the Detroit Free Press.

> Zoning ... might be of value in outlaying areas, which commercial and industrial development is not likely to strike for years, if ever, and it certainly will be of immense benefit to realty dealers with holdings on the outskirts of the city and in neighboring communities. Almost all of the vigorous agitation for the city plan commission's scheme that has come to my attention has emanated from interests of this sort. But I believe that the welfare of the city as a whole is more important than the private interests of a comparatively few individuals who want to see the city forced to expand in area and occupy the land they held speculatively.(Detroit Free Press, 1922, p.4)

Detailed data on new subdivisions as well as zoning maps are lacking in this period. However, a detailed land use survey of Flint, MI allows for the analysis of how zoning designations related to the subdivision boom in a single city (Bacon, 1940). In 1938 Flint hired Edmund Bacon, the city planner of Philadelphia, to study the city's problems of excess subdivision and property tax delinquency. Bacon surveyed the locations of all vacant lots and single-family homes in Flint and also collected measures of housing quality and tax delinquency. In 1938 44% of subdivided lots in Flint remained vacant, which Bacon describes as typical of mid-sized cities. Vacancies concentrated in new subdivisions ringing the city's outer edge and continuing beyond its boundaries. Although he did not produce detailed maps of Flint's immediate surroundings, Bacon did survey subdivisions outside the city, and their inclusion raises the vacant share to 53%. Bacon estimated that the surplus of subdivided land could absorb a near doubling of Flint's population spread over decades of expected population growth.

I georeference Bacon's land use surveys and overlay them with the original draft of Flint's zoning map (see Figure 3) (Nolen and Arnold, 1920). Flint prepared a zoning ordinance as part of a comprehensive plan in 1920, but the city did not implement zoning until 1927. Despite the gap between drafting and enactment, Flint zoned according to the original 1920 plan with few changes (Zimmer, 1959). Notably, Flint only passed its zoning ordinance after the subdivision boom reached its peak of at least 53 thousand vacant lots between the city and the surrounding area (Bacon, 1940). The ordinance divided Flint between two residential districts, a business district, and an industrial district. The first residential district allowed only single-family housing while the second also permitted duplexes and small apartments. The first residential zone occupies the most space, covering 56% of the city's area compared to the 28% zoned for other uses.[11]

Combining Bacon's land use maps with the zoning map reveals a stark contrast between the treatment of new, sparsely developed subdivisions and established neighborhoods. As a class of property vacant lots received disproportionate zoning protections compared to single-family homes. In the first residential district vacant lots (2132 acres) occupy more land than single-family homes (2034 acres). Newly subdivided lots were not meaningfully larger than older lots, so the difference in total area is not attributable to differences in the size of properties. Additionally, while the first residential zone contained 60 percent of lots occupied by single-family homes it contained 78 percent of vacant subdivided lots (Bacon, 1940). If Flint's annexations of neighboring land had not been halted by the Great Depression, then the disparity would likely have been even larger

The sorry state of most new subdivisions makes it clear that the main effect of single-family zoning in Flint was not the protection of high quality homes or high amenity neighborhoods. Despite their newer construction, homes in the outlying subdivisions were of poorer condition than older houses, a state Bacon attributes to shoddy construction. On the other hand, older neighborhoods more likely to be excluded from the first residential zone were filled with single family homes of generally good condition (Bacon, 1940, p.75-77). The first residential zoning designation also failed to preserve land values of vacant sections. Despite the benefit of costly utility connections, the first residential zone contained the overwhelming majority of abandoned, tax delinquent properties. In short, the majority of land in Flint zoned for single-family residential housing was not defined by its suitability for that purpose but by its peripheral location and its inability to support intensive development

[11] The remaining 16 % of Flint consists of parks, schools, and other public land.

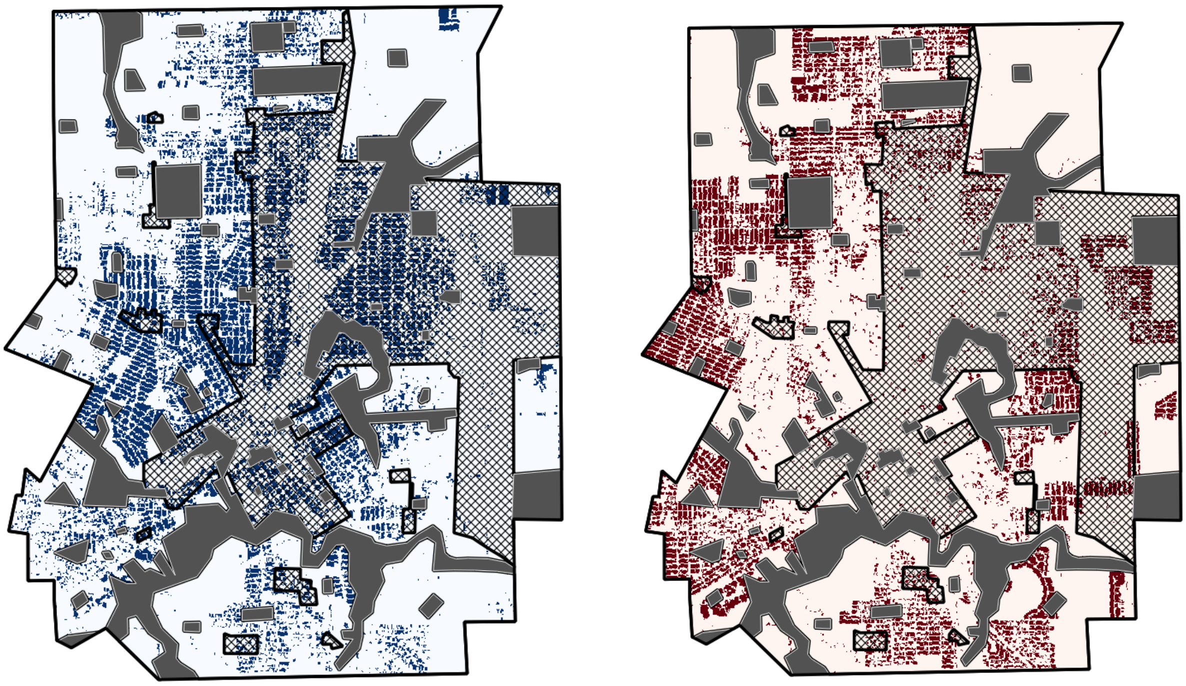


Figure 3: Single Family Homes and Vacant Lots in Relation to Zoning Designations

Notes: Zoning designations are split between public land (gray), the first residential single-family zone (clear), and remaining zones (hashed). Zones were traced from Nolen and Arnold (1920). The left panel (blue) depicts the locations of lots with single-family homes, and the right panel (red) depicts the locations of subdivided vacant lots. Land uses were scanned from maps in Bacon (1940).

1.3 Data

1.3.1 Zoning Outcomes

The Division of Building and Housing within the Department of Commerce was the first federal agency to systematically survey cities on zoning policy and recorded its findings in a series of memos from 1927 to 1933. After 1933 this responsibility passed to the National Resources Board (NRB), which operated in conjunction with state planning boards. I construct my data-set of zoning ordinances based on a 1929 list of zoned municipalities published in *American City* magazine by the Division of Building and Housing (Knauss, 1929), the Division's final 1933 memo on zoned municipalities (Knauss, 1933), and the NRB's 1937 circular on the status of planning in the United States (National Resources Committee, 1937). Previous studies of zoning adoption (Clingermayer, 1993; Trounstine, 2018) have relied solely on the 1929 *American City* article to measure zoning's initial spread. The inclusion of the latter two studies not only enables me to observe zoning adoption through 1936 but also allows me to confirm zoning status with multiple sources.[12]

The Division of Building and Housing reports the year of initial adoption, dates of later amendment, and whether the most recent ordinance regulates use, height, or area. An ordinance regulating all three is labeled as comprehensive. The NRB circular only records the year of most recent amendment and the subjects regulated by the ordinance. My primary outcome of interest is a a binary variable which takes on a value of 1 if a city zones by 1936 and 0 otherwise. To maintain consistency I code cities as 0 if they fail to appear in later surveys, so a city recorded as zoned in 1933 must also appear in the 1937 survey and a city recorded in 1929 must appear in both later surveys.

1.3.2 Census Variables and Other Controls

I rely on individual census data from the 1910, 1920, and 1930 censuses to measure the economic and demographic characteristics of cities (Ruggles et al., 2021). As I discuss below, I use per capita employment in the real estate industry to proxy for low-density development and include city level controls for black share, foreign born share, share of households owning homes, mean occupation income score of household heads, and per capita manufacturing employment as well as the share of county population living in census defined urban areas.[13] Given the close associations between city planning and the Progressive political movement, I also control for the Progressive Party's county-level presidential vote share in 1912, the only presidential election it seriously contested (Clubb et al., 2006)

I include city-level geographic controls for elevation, ruggedness (the standard deviation of elevation within 20 kilometers), distance to the coast, distance to a river, distance to a state border, and the number of nearby cities. I rely on Department of the Interior and Geological

[12]The 1929 list suffers from both false negatives as a result of non-responses and a small number of apparent false positives. Based on dates provided in the 1933 memo, the 1929 list omits 87 zoning ordinances passed before 1929. The 1929 list also includes 8 zoning ordinances that do not appear in later surveys.

[13]The census did not ask respondents about their income prior to 1940. Occupation Income Score is a widely used proxy for income based on the individual's reported profession

Survey (2020a) for elevation data and the Census Bureau's TIGERline shapefiles for data on other geographic features U.S. Census Bureau (2020). To measure land available for development I depend on the 2011 National Land Cover Database (water and wetlands) and the LANDFIRE database (steepness of slopes) (Department of the Interior and Geological Survey, 2020b; Dewitz, 2014)

Table 1: Summary Statistics

	Count	Mean	SD	Min	Max
Zoned by 1936	2568	0.283	0.451	0.000	1.000
Developable Land Share 0-4 km	2568	0.785	0.198	0.000	1.000
Developable Land Share 0-8 km	2568	0.753	0.206	0.037	1.000
Developable Land Share 0-12 km	2568	0.735	0.210	0.034	1.000
Developable Land Share 0-16 km	2568	0.720	0.212	0.033	0.998
Developable Land Share 0-20 km	2568	0.707	0.214	0.035	0.998
Log 1920 Population	2568	8.842	0.976	7.824	14.798
1920 County Urban Share	2568	0.474	0.251	0.000	1.000
1920 Black Share	2568	0.070	0.127	0.000	0.672
1920 Foreign Born Share	2568	0.120	0.102	0.000	0.539
1920 Manufacturing Workers Per Capita	2568	0.074	0.062	0.000	0.369
1920 Mean Occupation Income Score	2568	17.743	2.561	0.000	29.456
1920 Home Ownership Rate	2568	0.503	0.120	0.002	0.845
1920 Real Estate Employment Share	2568	0.002	0.002	0.000	0.015
1912 County Progressive Pres. Vote Share	2568	0.251	0.135	0.000	0.634
Distance to Coast (km)	2568	243.353	260.087	0.064	1310.639
Distance to Rivers (km)	2568	2.468	5.583	0.007	218.232
Distance to State Line (km)	2568	44.590	44.648	0.024	279.886
Elevation (meters)	2568	246.930	292.453	-34.000	3097.000
Elevation Standard Deviation (within 20 km)	2568	140.904	556.116	0.696	4896.849
# Municipalities with 25 km	2568	15.389	20.233	0.000	131.000

1.4 Empirical Strategy

The first zoning laws were enacted by democratically elected local governments and resulted from compromises between strategic actors that could reasonably anticipate the effects of zoning. Therefore, plausibly identifying the effect of any city characteristic on zoning adoption requires variation in that characteristic exogenous to the immediate zoning process. My primary identification strategy employs an instrumental variables (IV) approach in which I use land available for urban expansion to instrument for the volume of speculative, low-density real estate activity. In a separate analysis, I construct a shift share instrumental variable (SSIV) to identify the effect of Southern black migration on the zoning decisions of non-Southern cities, leveraging variation in existing migrant networks in non-Southern cities and push factors in Southern counties. Regardless of the explanatory variable, I estimate effects using cross-sectional data within the framework of a linear probability model:

$$zone_{i,1936} = \beta \cdot C_{i,1920} + \mathbf{X}_i'\gamma + \eta_s + \varepsilon_i, \tag{1}$$

where $zone_{i,1936}$ is an indicator variable that takes on a value of 1 if municipality i zones by 1936 and 0 otherwise. $C_{i,1920}$, the regressor of interest, is a municipality-level characteristic in 1920, the last census year before significant zoning adoption. In my primary analysis $C_{i,1920}$ reflects real estate workers per capita in 1920, but within other analyses it represents 1920 black population share or within-city measures of segregation. All models include state fixed effects η_s and controls $\mathbf{X}_i$ detailed in the data section. Baseline controls consist of city characteristics in 1920, time-invariant geographic characteristics, and electoral results from 1912. In some robustness checks I also include lagged characteristics from 1910. My primary sample consists of 2,568 municipalities in the Continental United States that have at least 2,500 inhabitants in 1920 and appear in all decennial censuses from 1910 to 1940. All specifications use robust standard errors. As a baseline, I do not cluster standard errors, but my results' remain statistically significant when using standard errors that account for spatial autocorrelation (Conley, 1999).[14]

[14] Abadie et al. (2023) recommend clustering standard errors when sampling is clustered or treatment assignment is clustered. In my case, sampling is not clustered as I observe the universe of relevant U.S.

1.4.1 Real Estate Activity and Developable Land Instrument

I argue zoning found popular support during the 1920s because the opportunity cost of waiving development rights fell for the median urban property owner in most municipalities. The first boom in automobile-oriented development swelled the ranks of low-density, peripheral landowners and reduced demand for redeveloping central properties more intensely. These outcomes align with the predictions of the monocentric city model, which predicts that less costly transportation should redirect new urban growth away from infill development and towards undeveloped land on the urban frontier (Brueckner et al., 1987; Alonso, 1964; Muth, 1969; Mills, 1967). In reaction to these trends, forward-looking owners would anticipate smaller returns from intensely developing their properties, effectively lowering the price paid for desirable zoning protections.

Other theories also cite falling transportation costs as the ultimate cause of zoning's establishment but propose alternative mechanisms. Fischel (2004), for example, argues that cheap motor transportation increased the incidence of land use conflicts and, by extension, the value of zoning protections. As a result, even if transportation costs could be randomly assigned to different cities, it would remain an open question whether they affected zoning adoption by weighting new development towards landowners whose interests aligned with zoning, as I propose, or by increasing existing property owners' willingness to pay for the policy. The goal of my empirical strategy is to the measure the presence of speculative, low-density landowners, i.e., those that lost the least from zoning restrictions, and leverage random variation in their prevalence to causally identify their impact on zoning adoption in the 1920s and 30s

I rely on city level real estate employment to proxy for the extent of low-density, speculative development on the urban fringe. As I detail in the background section, this mode of development exploded during the 1920s, occurred in peripheral areas with minimal prospects for intensive development , and featured landowners and investors vocally supportive of zon-

municipalities. My primary treatment of interest depends on differences in local geography, so clustering at the state level would be inappropriate, and differences in state-level institutions are already captured by state fixed effects. Clustering at the county level results in many singleton clusters and does not alter statistical significance compared to unclustered robust standard errors.

ing ordinances (Fisher, 1933).[15] Due to sheer number of these properties and the near-zero opportunity costs they faced from accepting zoning restrictions, the extent of speculative development in a city should strongly correlate with the median landowner's opportunity cost, especially after controlling for other economic and demographic characteristics

There are several reasons to believe real estate employment effectively proxies for the extent of speculative development in the 1920s. Real estate dealing was a competitive industry with low start-up costs, and only a few states required even nominal licensing (Brittain, 1925). Individuals could easily enter the business in times of elevated activity, and the subdivision and brokerage of peripheral residential lots presented the fewest hurdles for new entrants. Contemporary observers characterized real estate operators on the urban fringe as small-scale, numerous, and highly leveraged (Simpson, 1933; Fisher, 1933; Bodfish, 1929). More direct measures, such as the number of subdivided lots, are inconsistently recorded and unavailable for most places, but I can construct a dataset for comparison in a single state. In the 1930s the New Jersey State Planning Board produced aerial photographs of the entire state as well as maps of smaller areas clearly delineating undeveloped subdivisions emblematic of speculative development (Kunz, 2012; New Jersey State Planning Board, 1938, 1941). Using the subdivision maps as training data, I employ a machine learning algorithm to classify similar patterns of land use statewide based on the aerial photographs (See Appendix D). I find a strong, positive correlation between real estate employment in a municipality and the amount of undeveloped subdivisions nearby. Moreover, no such correlation exists between real estate employment and land fully developed for urban use (see Figure 4)

Using real estate employment per capita as my explanatory variable, the estimating equation becomes,

$$zone_{i,1936} = \beta \cdot RealEstate_{i,1920} + \mathbf{X}_i'\gamma + \eta_s + \varepsilon_i, \tag{2}$$

However, the OLS estimate of the real estate employment coefficient β may be biased

[15]Surveys of excess subdivision in the 1930s found that the cities studied contained enough vacant residential lots to absorb decades of projected population growth solely through the construction of detached single family homes on vacant lots (Simpson, 1933; Michigan Planning Commission, 1939; New Jersey State Planning Board, 1938). In other words, very few peripheral landowners could rationally expect that their properties would profitably support development denser than the most restrictive land use categories of early zoning ordinances.

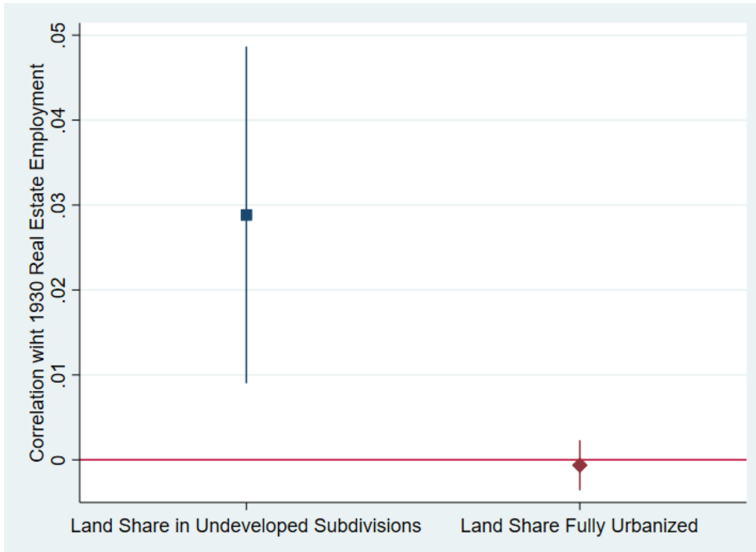


Figure 4: Correlations between Real Estate Employment and Land Use in New Jersey

due to unobserved confounders. Most obviously, reverse causality would upwardly bias the estimate if real estate activity rose in anticipation of a zoning ordinance. Alternatively, if better administered municipalities boosted local real estate activity and were more likely to zone as a matter of good governance then the estimate would also be upwardly biased. Finally, the effects of other elements of the real estate sector not associated with fringe development could bias the impact of fringe developers downwards. For example, dealers in downtown property tended to oppose zoning restrictions, so their presence in the real estate employment measure would cause it to understate the effect of fringe operators on zoning adoption

I employ an instrumental variables identification strategy to remove the influence of possible confounders and causally identify the impact of real estate employment associated with low-density, fringe development on zoning adoption. Additionally, I argue that even in the absence of confounding variables the local average treatment effect (LATE) estimated using IV better represents the influence of low opportunity cost fringe development on zoning adoption than the average treatment effect (ATE) estimated using OLS. In an ideal experiment a researcher could randomly vary cities' capacity to add low opportunity-cost fringe development, such as by placing caps on the number of new subdivisions or assigning urban growth boundaries that fixed the amount of developable land for each city. While no meaningful policy restrictions on outward expansion existed during the period of study, municipalities did face differing limits on outward growth due to geographic obstacles and state borders.[16] These barriers produced variation in the opportunity cost of intensive development as cities with more developable land could more easily substitute low-density fringe development for intensive infill once transportation costs fell.

I assemble a data-set of developable land available to U.S. municipalities based on geographic constraints and state boundaries. Municipalities consist of incorporated places in the Continental United States as well as unincorporated towns, townships, and boroughs in the states of Connecticut, Maine, Massachusetts, New Jersey, New York, Rhode Island, and Vermont.[17] I rely on IPUMS census data for the exact locations of incorporated places (Ruggles et al., 2021), and source the coordinates for unincorporated places in Mid-Atlantic and New England states from the Census Place Project (Berkes et al., 2022). I follow Saiz (2010) and categorize land as unfit for development if it is covered by water or wetlands or has a slope of greater than 15 percent. I also categorize land in a different state from the city measured as undevelopable since municipalities can neither expand across state lines nor regulate land use in neighboring states. I measure the share of developable land in circles originating from the city center. For my primary measure the circle has a radius of 4 kilometers, but I also create measures for ranges up to 20 kilometers. Figure 5 depicts developable land (in white) for Cincinnati, OH as well as land lost to extreme slopes, the Ohio river, and the neighboring state of Kentucky (in black)

After constructing measures of developable land available to different cities, I estimate the first-stage equation of my two stage least squares (2SLS) estimates

$$RealEstate_{i,1920} = \delta \cdot LandShare_{i,r} + \mathbf{X}_i'\gamma + \eta_s + \varepsilon_i, \tag{3}$$

to generate the fitted value $\widetilde{RealEstate}_{i,r,1920}$ for municipality i using available land share measured at radius r. $\widetilde{RealEstate}_{i,r,1920}$ isolates the variation in $RealEstate_{i,1920}$ explained

[16] Cities in this period had little interest in limiting the number of new subdivisions within their boundaries and lacked the ability to meaningfully control development on surrounding unincorporated land (Fisher, 1933; Crane, 1930).

[17] A significant portion of zoned places in these states are not classified as incorporated places (Ruggles et al., 2021).

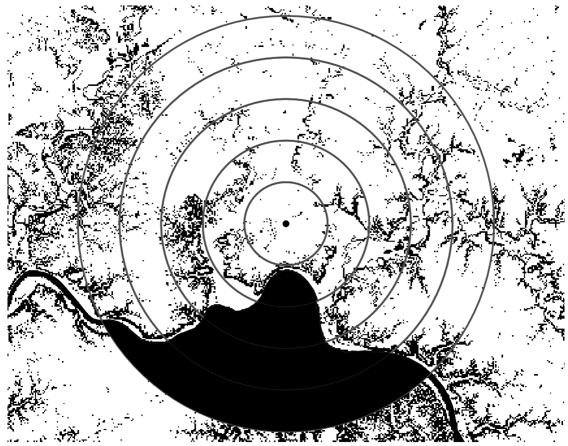


Figure 5: Available Land for Urban Expansion near Cincinnati, OH

by variation in the supply of developable land. Thus, $\widetilde{RealEstate}_{i,r,1920}$ should more accurately capture the influence of fringe real estate operators whose development strategy required disproportionate amounts land compared to capital intensive development in the urban core. I then plug $\widetilde{RealEstate}_{i,r,1920}$ into my second-stage equation,

$$zone_{i,1936} = \beta \cdot \widetilde{RealEstate}_{i,r,1920} + \mathbf{X}_i'\gamma + \eta_s + \varepsilon_i, \tag{4}$$

A causal interpretation of the 2SLS estimates relies on the identifying assumption that conditional on controls, unobserved factors influencing zoning adoption are not correlated with the availability of developable land. Endogenous city siting decisions and the direct effects of geography could potentially threaten the validity of the IV identification strategy. If city founders chose locations based on factors correlated with developable land share and later zoning adoption, then the identifying assumption is violated. Mountains or bodies of water, for example, affect available land share and could also jointly influence siting decisions and zoning adoption due to amenities or access to waterborne transportation. In the results section I address these concerns through the inclusion of a robust set of geographic and economic controls. I also show that coefficient estimates remain broadly similar when I redefine my sample to exclude potentially problematic municipalities, for example, dropping newly founded municipalities that could feasibly have taken zoning and widespread automobile ownership into account when choosing locations. Finally, Appendix

A details an alternative instrument derived from historical development data that scales the radius of measurement based on the geographic footprints of different cities in order to better capture land availability on the frontier of urban expansion. Using the alternative instrument does not meaningfully alter results.

1.4.2 Southern Black Migration and Shift Share Instrument

Although race featured prominently in discussions surrounding early zoning ordinances, the importance of racial concerns relative to other factors remains unclear. On the one hand, planners, city officials, and real estate agents all expressed hopes that city planning and zoning could prevent vigilante violence and preserve property values by limiting the housing choices of black residents (Flint, 1977). Zoning also gained popularity just as significant numbers of Southern black migrants entered non-Southern cities. On the other hand, zoning laws could not explicitly create districts based on race (Troesken and Walsh, 2019), and landowners possessed alternatives that could directly maintain the color line without eliciting the opposition of others left poorer by use and density zoning. Private covenants, for example, could contain explicit racial restrictions and were popular in the 1920s (Burgess, 1994)

Because racial segregation could be enforced through means other than zoning, underlying racial animus may obscure the relationship between zoning decisions and cities' black population shares in an OLS regression, as in equation (5). A city more generally hostile to black residents would, all things being equal, have a lower black population share as black residents would be more likely to leave and black migrants would be less likely to enter. If such cities enacted zoning to reinforce segregation and further depress their black population shares, then the estimated effect of black population share on zoning would be biased downward even if growing black populations or the possibility of growing black populations served as the immediate trigger for zoning adoption.

$$zone_{i,1936} = \beta \cdot BlackShare_{i,1920} + \mathbf{X}_i'\gamma + \eta_s + \varepsilon_i, \tag{5}$$

To deal with the potentially endogenous relationship between black population share and zoning adoption I employ a shift-share instrumental variables (SSIV) strategy commonly used in literature on the Great Migration (Boustan, 2010; Derenoncourt, 2022; Bazzi et al., 2023). Variation for the instrument comes from two sources. The first source is the pre-existing share of black migrants from Southern state k living in Non-Southern city i in the baseline year of 1900, written $\pi_{ki,1900}$. The second comes from the shift in the number of black migrants born in Southern state k living outside the South between 1900 and 1920. Specifically, I use predicted shifts based on county-level push factors and aggregate predicted county outflows to a state-level measure, $\widehat{M}_{k,1920-1900}$. I calculate the predicted number of southern black migrants received in non-Southern city i from 1900 to 1920 in equation (6). Dividing $Z_{i,1920}$ by non-Southern city i's 1900 population then yields city i's predicted black population share in 1920. I then apply 2SLS using the predicted black population share, $\frac{Z_{i,1920}}{population_{i,1900}}$, to instrument for $BlackShare_{i,1920}$ in equation (5).

$$Z_{i,1920} = \sum_{k=1}^{J} \pi_{ki,1900} \widehat{M}_{k,1920-1900} \tag{6}$$

I follow the approach employed in Bazzi et al. (2023) to calculate the predicted shifts $\widehat{M}_{k,1920-1900}$. Based on linked census records from the Census Linking Project (Abramitzky et al., 2020b) I build a measure of black emigration from each origin county in the South (denoted o) to every destination city in the north (denoted i). This measure is constructed for the decades 1900-1910 (indexed as t=1910) and 1910-1920 (indexed as t=1920). I then use origin-county o push factors to predict this measure of black Southern emigration derived from linked census records, $Southern\, black\, migrants_{ot}$, in zeroth-stage regressions for both decades,

$$Southern\, black\, migrants_{o,t} = \alpha + \eta \mathbf{push}_{o,t-10} + \phi population_{o,t-10} + \varepsilon_{o,t} \tag{7}$$

Origin county predictors for out-migration include county black share, county urban share, manufacturing workers per capita, and a range of agricultural variables. Appendix C provides summary statistics of the predictors and reports the zeroth stage estimates. Total state level out-migration from 1900 to 1920, $\widehat{M}_{k,1920-1900}$, is then calculated as sum of county-decade predictions, $Southern\, \widehat{black}\, migrants_{ot}$,

$$\widehat{M}_{k,1920-1900} = \sum_{o \in k} \sum_{t=1910}^{1920} Southern\,\widehat{black}\,migrants_{ot} \tag{8}$$

Because this version of the SSIV is constructed from predicted shifts in migration rather than actual shifts it requires a weaker identifying assumption than the standard SSIV based on actual shifts. The identifying assumption of the standard SSIV is that conditional on controls, both the initial shares in destination cities and the subsequent shifts in out-migration must be uncorrelated with unobservable influences on zoning adoption. However, by using predicted shifts, my SSIV will remain valid if initial shares are endogenous to zoning, so long as the predicted shifts remain uncorrelated with destination county conditions (Borusyak et al., 2022)

1.5 Results

1.5.1 Effect of Land Availability on Zoning

Table 2 reports OLS estimates of β from equation 3, IV estimates of β from equation 4, and reduced form estimates of zoning adoption regressed directly on developable land share measured within 4 km of the city center center [18]. The OLS estimate with state fixed effects but no other controls reported in column (1) suggests that a one standard deviation increase in per capita real estate employment raised the probability of zoning in the following sixteen years by 34 percentage points (mean real estate employment is 2 workers per thousand and the standard deviation is 1.8 workers per thousand). The inclusion of baseline controls in column (2) raises explanatory power (adjusted R^2 increases from 0.16 to 0.37) and lowers the estimated effect size to 15 percentage points. However, the relationship between zoning adoption and real estate employment remains highly statistically significant regardless of whether the baseline controls are included.

Columns (3) and (4) report the results of similar regressions, but developable land share replaces real estate employment as the explanatory variable. A one standard deviation

[18] This range roughly overlaps with Flint's municipal boundaries as discussed in the background section.

Table 2: Real Estate Employment and 1936 Zoning Status

	(1)	(2)	(3)	(4)	(5)	(6)
	Zoned by 1936	Zoned by 1936	Zoned by 1936	Zoned by 1936	Zoned by 1936	Zoned by 1936
Real Estate Emp. Share 1920	0.342***	0.154***			0.649***	0.754***
	(0.0264)	(0.0243)			(0.189)	(0.194)
Available Land 0-4 km			0.0327***	0.0375***		
			(0.00966)	(0.00894)		
Estimator	OLS	OLS	Reduced Form	Reduced Form	IV	IV
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Controls		Yes		Yes		Yes
Observations	2568	2568	2568	2568	2568	2568
Outcome Mean	0.283	0.283	0.283	0.283	0.283	0.283
Adjusted R^2	0.164	0.369	0.102	0.363		
F-Statistic					30.254	29.802
Anderson-Rubin p-val.					0.001	0.000
KP underident p-val.					0.000	0.000

Notes: Dependent variable is an indicator variable for adopting a zoning ordinance between 1920 and 1936 for all regressions. Columns (1) and (2) report results for the zoning outcome regressed on 1920 real estate workers per capita, columns (3) and (4) instrument real estate employment share using the amount of developable land within 4 km of the city center, and columns (5) and (6) report the reduced form results of regressing the zoning outcome directly on the developable land share. All right hand side variables are normalized so coefficients can be interpreted as the effect of a one standard deviation change in the explanatory variable on the probability of a municipality zoning by 1936. Baseline controls include city and county level census variables from 1920, geographic controls, and county level vote share for the Progressive Party presidential candidate in the 1912 election. Census variables are log of city population, black share, foreign born share, manufacturing worker per capita, mean occupation income score of household heads, and share of household heads in owner occupied housing. Geographic controls are distance to nearest coast, distance to nearest river, distance to nearest state line, elevation, standard deviation in elevation within 20 km, latitude, longitude, and the number of other municipalities within 25 km. All regressions include state fixed effects. All regressions use robust standard errors. Reported F-statistics are effective F-statistics calculated according to **?**. The Anderson-Rubin p-value corresponds to the null hypothesis that the coefficient on the endogenous regressor is statistically significant and that the overidentifying restrictions are valid. The KP underidentification test p-value corresponds to the Kleibergen-Paap LM test whose null hypothesis is that equation is underidentified. Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

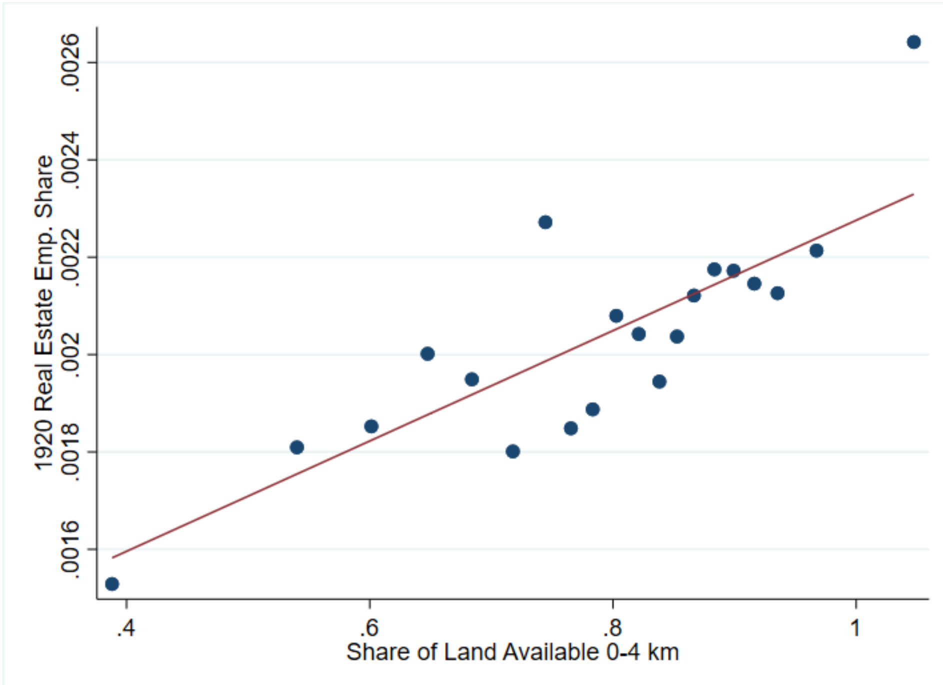


Figure 6: First Stage Regression

increase in developable land share within four kilometers of the city center raises the probability of zoning by between 3.27 to 3.75 percentage points (the mean of 4 km developable land share is 0.785 and the standard deviation is 0.198). Like the regressions in columns (1) and (2), the inclusion of controls raises explanatory power (adjusted R^2 rises from 0.102 to 0.363), but in this case the inclusion of controls marginally increases the estimated effect size

Finally, columns (5) and (6) report the IV estimates that result from using 4 km developable land share to instrument for real estate employment. Solely controlling for state fixed effects in column (5), I find a 65 percentage point increase in zoning probability, which rises to 75 percentage points with the inclusion of baseline controls in column (6). The first stage F-statistics for both IV estimates are each approximately 30, and the first stage regression for column (6) is graphically presented in Figure 6. The estimates withstand weak-instrument-robust inference (see the Anderson and Rubin (1949) p-values) and testing for underidentification (see the Kleibergen and Paap (2006) p-values)

The OLS results align with the hypothesis that falling transportation costs realigned the collective incentives of urban landowners by enabling more low density development in the aggregate and reducing average returns from high density development that would be restricted by zoning laws. Historical sources characterize real estate activity in the 1920s as swinging towards speculative, fringe development, and, accordingly, places with greater real estate employment in 1920 zoned at much higher rates. Similarly, municipalities with greater amounts of proximate developable land, and thus greater capacity to transition to sprawling automobile-oriented development in the 1920s, zoned at higher rates than geographically constrained municipalities. The reduced form result also cuts against alternative interpretations of the positive correlation between real estate employment and zoning uptake that emphasize homeowners' increased willingness to pay for zoning protections rather than a decrease in opportunity costs

Within the framework proposed by Fischel (2004), higher real estate employment could indicate more aggressive infill development in single-family neighborhoods and greater demand from affected homeowners for zoning protections. However, if this narrative explains the correlation between real estate employment and zoning adoption, then cities with more abundant developable land should have zoned at lower rates since an abundance of potential building sites would dampen potential conflicts between developers and existing neighborhoods. Saiz (2010) argues that homeowner demand for zoning protections should rise with land values, and higher real estate employment in 1920 could simply stand in for higher land values. But, if this was the case during the initial wave of zoning adoptions, then, all other things equal, cities with a greater supply of developable land should have had lower land values per acre and been less likely to zone

The IV estimates for the effect of real estate employment are substantially higher than the corresponding OLS estimates. A straightforward explanation for this gap is the LATE identified by the IV estimate better isolates the influence of fringe real estate interests who supported zoning more uniformly than downtown developers and other real estate operators. The purpose of using total real estate employment as an explanatory variable is to proxy for the volume of speculative, fringe development that could benefit from zoning protections while facing minimal losses from the attendant restrictions. However, total real estate employment will sometimes overstate the extent of fringe development by counting real estate operators dealing in other properties and sometimes understate its extent by failing to count amateur dealers that do not list real estate as their profession in the census.[19] Using variation in real estate employment predicted by the supply of nearby developable land should better pinpoint the extent of speculative, fringe development given its dependence on plentiful, unsubdivided land as an input. Consequently, the LATE should be larger than the ATE identified by OLS if those involved in fringe development could disproportionately benefit from zoning and more energetically pursued its enactment compared to other segments of the real estate sector

Table 3 reports the outcomes of several additional robustness checks. Rows 1 through 4 show that the results from columns 2 and 4 of Table 2 remain statistically significant when using standard errors robust to spatial autocorrelation based on Conley (1999) with distance cut-offs at 50 and 250 km and remain significant when using Bartlett kernels. These alternative standard errors alleviate concerns that unobserved factors affecting neighboring cities or spatial noise are responsible for my primary results. Rows 5 through 8 show that results are not driven by any single region. Row 9 limits the sample to municipalities in Core Based Statistical Areas (CBSAs), indicating that the results do not hinge on the zoning decisions of communities far from major urban centers. Row 9 drops municipalities founded after 1900 from the sample that could have feasibly made location choices with zoning policy and automobile-oriented development in mind. This foresight could threaten identification if, for example, more affluent or educated groups demanded areas with greater open space and also zoned for exclusionary reasons, but results remain robust to dropping newly founded communities.

Rows 12 and 13 include additional controls for lagged 1910 real estate employment and 1910 lags for all census variables respectively. Results remain positive and statistically significant, suggesting that the relationship between 1920 real estate employment and zoning adoption reflects the influence of real estate activity in 1920 rather than longstanding differences between cities' real estate sectors. Row 14 addresses concerns that the instrument,

[19] Many segments of the real estate sector, particularly those dealing in downtown real estate, displayed a neutral or hostile attitude towards early zoning ordinances (Slimp, 1924; Hubbard and Hubbard, 1929; Allentown Morning Call, 1928). On the other hand, many dealing in speculative real estate on the urban fringe were amateurs and small-time investors (Bodfish, 1929; Simpson, 1933).

Table 3: Robustness Checks

	(1) OLS	(2) IV
Alternative Standard Errors		
1. Conley SE 50 km	0.154***	0.754***
	(0.0227)	(0.204)
2. Conley SE 250 km	0.154***	0.754***
	(0.0103)	(0.145)
3. Conley SE with Bartlett 50 km	0.154***	0.754***
	(0.0232)	(0.197)
4. Conley SE with Bartlett 250 km	0.154***	0.754***
	(0.0184)	(0.176)
Alternative Samples		
5. Drop Northeast	0.113***	0.502***
	(0.0280)	(0.152)
6. Drop Midwest	0.159***	1.308**
	(0.0300)	(0.608)
7. Drop South	0.175***	1.018***
	(0.0304)	(0.314)
8. Drop West	0.157***	0.828***
	(0.0262)	(0.246)
9. Only Municipalities in CBSAs	0.182***	0.923***
	(0.0278)	(0.236)
10. Founded by 1900	0.167***	1.168***
	(0.0329)	(0.392)
Varying Control Sets		
11. No Controls or State FEs	0.282***	0.319***
	(0.0227)	(0.0841)
12. Control for 1910 RE Emp. Share	0.115***	1.313***
	(0.0285)	(0.508)
13. Control for all 1910 Census Vars	0.104***	1.349**
	(0.0284)	(0.584)
14. Control for Built Extent in 1920	0.143***	0.766***
	(0.0261)	(0.221)
Nonlinear Model		
15. Fit Available Land Share Instrument to Built Extent	0.147***	0.761***
	(0.0264)	(0.180)
16. Probit Model	0.663***	2.623***
	(0.110)	(0.385)

This table reestimates columns (2) and (4) from Table 2 using a variety of specifications to check for robustness. See Table 2 for the list of baseline controls. Unless explicitly noted all regression in this table include state fixed effects. Column (1) reports OLS estimates of regressing zoning adoption on 1920 real estate employment per capita and Column (2) instruments for real estate employment using the amount of available land within 4 km of the city center unless otherwise stated. Rows 1 through 4 report the change in standard errors based on Conley (1999) spatial HAC with bandwidths of 50 km or 250 km. The Bartlett adjustment allows for spatial correlation to fade with distance within the given bandwidth. Rows 5 though 8 drop each of the four census regions in the Continental United States from the sample. Row 9 drops all municipalities outside of Census-defined Core Based Statistical Areas, i.e., drops especially isolated municipalities. Column 10 drops all municipalities in the primary sample founded after 1900. Row 11 drops all controls and state fixed effects, rows 12 and 13 add lagged variables from 1910, and row 14 controls for the built extent of municipalities based on historical development data from Leyk and Uhl (2018). Specifically, row 14 controls for the radius of the minimum bounding circle of the largest contiguous patch of developed land within the city. Row 15 uses the same historical development data to create a new land availability instrument that scales in size based on a city's geographic footprint [SEE APPENDIX for details on historical development data and construction of the instrument]. Row 16 estimates the effect using a probit model rather than a linear probability model. Unless otherwise stated, regressions use robust unclustered standard errors. Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

constructed based on land availability within 4 km of the city center, does not accurately capture the urban frontier for very small and very large municipalities. After controlling for the built extent of municipalities in 1920 using historical development data from Leyk and Uhl (2018), results remain similar. In the same vein, Row 15 reports results from using an alternative instrument that scales the circle in which developable land share is measured based on the city's built extent in 1920 (see Appendix A for details on the alternative instrument's construction and additional results). Finally, Row 16 shows coefficients estimated using a probit model rather than a linear probability model

Table 4 presents additional evidence against the relevance of unobserved confounders correlated with the developable land share instrument. While the influence of geographic features or economic activity decrease with distance, they do not experience the same sharp discontinuities as municipal boundaries which cannot cross state lines and face several constraints on expansion. If geographic or economic factors correlated with the supply of developable land but unrelated to patterns of real estate development spurred zoning adoption, then estimates should not be sensitive to small changes in the geographic range covered by the instrument or the inclusion of out-of-state land. If, however, the demands of fringe developers working within city boundaries or on easily annexed surrounding land formed the primary impetus for zoning, then the inclusion of irrelevant land unable to be feasibly annexed should attenuate estimates. Panel (A) of Table 4 shows the effect of increasing the area used to measure developable land share and Panel (B) carries out the same exercise but treats out of state land as developable. While results remain positive and significant, the magnitude drops sharply as more land beyond the urban fringe is added. Moreover, as shown in Appendix Table 25, the downward trend is even sharper when the developable land instrument is scaled to city size

Table 4: Vary Measurement Region of Available Land Instrument

	(1)	(2)	(3)	(4)	(5)
	4 km Range	8 km Range	12 km Range	16 km Range	20 km Range
Panel A: Out-of-State Land Excluded from Instrument					
Real Estate Employmnet Share 1920	0.754***	0.624***	0.508***	0.469***	0.447***
	(0.194)	(0.157)	(0.133)	(0.128)	(0.129)
Estimator	IV	IV	IV	IV	IV
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Observations	2568	2568	2568	2568	2568
Outcome Mean	0.283	0.283	0.283	0.283	0.283
F-Statistic	29.802	47.247	69.585	72.621	71.417
Anderson-Rubin p-val.	0.000	0.000	0.000	0.000	0.001
KP underident p-val.	0.000	0.000	0.000	0.000	0.000
Panel B: Out-of-State Land Included in Instrument					
Real Estate Employmnet Share 1920	0.646***	0.501***	0.370***	0.317**	0.286**
	(0.193)	(0.159)	(0.138)	(0.139)	(0.142)
Estimator	IV	IV	IV	IV	IV
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Observations	2568	2568	2568	2568	2568
Outcome Mean	0.283	0.283	0.283	0.283	0.283
F-Statistic	24.218	37.755	56.052	59.668	60.243
Anderson-Rubin p-val.	0.000	0.001	0.009	0.025	0.049
KP underident p-val.	0.000	0.000	0.000	0.000	0.000

This table reestimates column (4) from Table 2, but alters the definition of land availability used to instrument for 1920 real estate employment. Each column reports an estimate based on land availability defined from a minimum 4 km radius, as in Table 2 up to 20 km. Panel A counts out of state land as unavailable while Panel B treats it as available for development. All regressions include state fixed effects and baseline controls detailed in 2. Regressions use robust unclustered standard errors. Reported F-statistics are effective F-statistics calculated according to **?**. The Anderson-Rubin p-value corresponds to the null hypothesis that the coefficient on the endogenous regressor is statistically significant and that the overidentifying restrictions are valid. The KP underidentification test p-value corresponds to the Kleibergen-Paap LM test whose null hypothesis is that equation is underidentified. Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

1.5.2 Effect of Black Migration on Zoning

The results of the previous section suggest that a broad shift in patterns of urban growth towards fringe, automobile-oriented development contributed to the mass adoption of zoning in the 1920s, and cities with topographies conducive to this transition zoned at higher rates. In other words, zoning adoption proved more likely in places where the share of landowners whose properties would lose value due to binding zoning restrictions fell the most. However, the decrease in the cost of zoning does not imply that landowners' willingness to pay for the policy remained static or that concurrent increases in negative externalities did not contribute to zoning adoption in the 1920s. Given the racial animus expressed by early pioneers of zoning (Whitten, 1922; Flint, 1977), the documented changes to local public policy in response to second Great Migration (Derenoncourt, 2022; Cui, 2024), and the racially disparate impacts of zoning past and present (Shertzer et al., 2016a; Rothwell and Massey, 2009), there is ample reason to believe that white backlash to the first Great Migration in the 1910s and 20s helped popularize zoning

Table 5 reports OLS and SSIV estimates of the effect of 1920 black population share, and 1920 southern black population share (of total population) on zoning adoption in non-Southern municipalities. Column (1) reports the OLS result from regressing zoning adoption on 1920 black population share with state fixed effects and the baseline controls used in Table 2. Column (2) reduces the sample to non-Southern cities for which I can construct the shift share instrument and Column (3) substitutes southern black population share for black population share [20]. All OLS estimates in the first three columns of Table 5 are positive, but none are statistically significant at conventional levels.

In columns (4) and (5) I reestimate columns (2) and (3) using the shift share instrument. The coefficients increase in magnitude and become statistically significant at conventional levels. Based on the SSIV estimates, a one standard deviation increase in 1920 black population share (mean 0.019 and standard deviation 0.037) raises the probability of zoning by 23 percentage points and a one standard deviation increase in 1920 Southern black population share (mean 0.007 and standard deviation 0.021) increases the probability of zoning by 42

[20] Non-Southern urban populations expressed greater prejudice towards newly arrived Southern black migrants than established black communities in this period (Shertzer et al., 2016a).

Table 5: Effect of Southern Black Migration on Non-Southern Zoning Adoption

	(1)	(2)	(3)	(4)	(5)
	Black	Black	Southern Black	Black	Southern Black
Black Share 1920	0.0149	0.0509		0.233**	
	(0.0119)	(0.0337)		(0.111)	
Southern-born Black Share 1920			0.0674		0.420**
			(0.0515)		(0.195)
Estimator	OLS	OLS	OLS	2SLS	2SLS
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Observations	2568	1982	1982	1982	1982
Outcome Mean	0.283	0.327	0.327	0.327	0.327
Adjusted R^2	0.369	0.360	0.359		
F-Statistic				26.723	35.358
Anderson-Rubin p-val.				0.017	0.017
KP underident p-val.				0.000	0.000

Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

percentage points. The first stage F-statistic for the SSIV estimate in column (4) is 26.7 and the F-statistic for column (5) is 35.4. Both first stage regressions are presented graphically in Figure 7. The estimates withstand weak-instrument-robust inference (see the Anderson and Rubin (1949) p-values) and testing for underidentification (see the Kleibergen and Paap (2006) p-values). Table 30 demonstrates that results remain largely robust to using spatially adjusted standard errors based on Conley (1999), and Table 31 shows that white southern migrants did not positively impact zoning adoption in the same way. Figures 23 and 24 illustrate that results remain largely similar when dropping any single destination or origin state.

In comparison to the effect of a standard deviation shift in real estate employment estimated using the developable land instrument, the SSIV estimate of a standard deviation shift in black share population share is lower.[21] Additionally, because black populations outside the South clustered in a few destinations and completely avoided many others, black

[21] Table 32 reports the results of 2SLS with two endogenous variables (real estate employment and black population share) and two instruments (land availability and predicted black share). The effects of both factors remain positive and statistically significant when considered jointly.

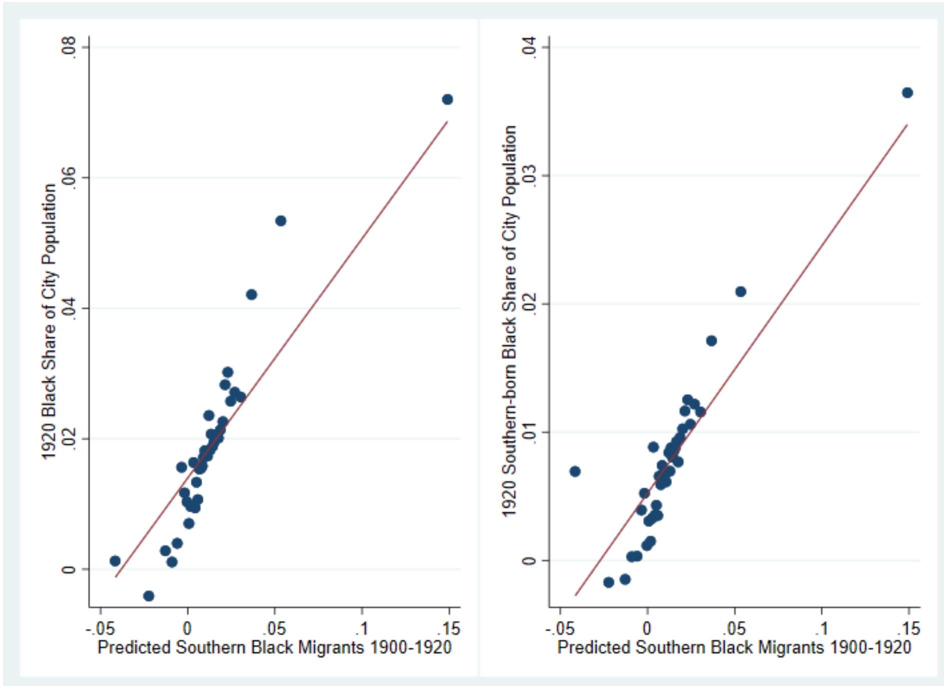


Figure 7: First Stage Regressions for Shift Share Instrument

population share has a higher coefficient of variation than real estate employment per capita. Moving from the 25th to 75th percentile of real estate employment (1.13 standard deviations) would raise the chances of a city zoning by 85 percentage points, but moving from the 25th to the 75th percentile of black population share (0.52 standard deviations) would only raise the probability by 12 percentage points

The SSIV estimates indicate that non-southern municipalities with larger black population shares in 1920 as a result of exogenous migration from 1900 to 1920 zoned at higher rates. Moreover, the effect size increases when I focus on southern-born black residents as a distinct group. The increase in effect size when switching from OLS to SSIV aligns with a narrative in which zoning ordinances and private methods of enforcing segregation arose from a common source of racial hostility. While the promise of economic opportunity pulled black migrants northward, they faced varying levels of hostility in different Northern communities ranging from housing discrimination to murder. If the most unwelcoming municipalities reduced black entry through other means and also pursued zoning most doggedly, then the causal connection between black arrivals and zoning adoption would be obscured. While zoning ordinances could not explicitly bar black occupancy, they could aid coordination between private actors, such as real estate agents, seeking to maintain the color line or exclude black residents entirely.

1.5.3 Effects of Other Factors on Zoning

In the previous two sections I have shown that black population growth in non-Southern cities and changing development patterns nationwide both causally contributed to the adoption of the first zoning laws in the 1920s and 30s. In this section, I will present additional results on the Progressive movement as well as the size and distribution of commonly cited nuisances that, while not causally identified, are strongly suggestive of the roles these factors played in early zoning adoption. Figure 8 presents a coefficient plot for OLS estimates of several potential predictors of zoning adoption. Models depicted with blue squares include only the listed variable and state fixed effects, red diamonds also include 1920 baseline controls from Table 2, and gray circles include 1920 baseline controls and 1910 lags as in row 13 of Table 3.

Across a range of specifications, log of population and real estate employment remain the strongest predictors of zoning adoption in the 1920s and 30s. The strength of the Progressive movement, as measured by presidential vote share in the 1912 election, also remains robustly and positively correlated with zoning adoption, although the magnitude of the effect is smaller. Zoning advocates self-consciously positioned themselves as Progressive reformers (see background), and it appears that they found more success in places with more receptive electorates. This result aligns with the experiences of contemporary observers and advocates. In explaining the lack of opposition for zoning in his city of Scranton, PA, planning commissioner R. H. Martin reasoned, "Our people seemed to have taken the stand that this was a progressive movement for improved living conditions in the city" (Martin, 1927, p.15).

No such positive relationship exists between manufacturing employment, a widely used proxy for industrial nuisances (Trounstine, 2018; Clingermayer, 1993), and zoning adoption. Depending on the set of controls, higher manufacturing employment seems to have either

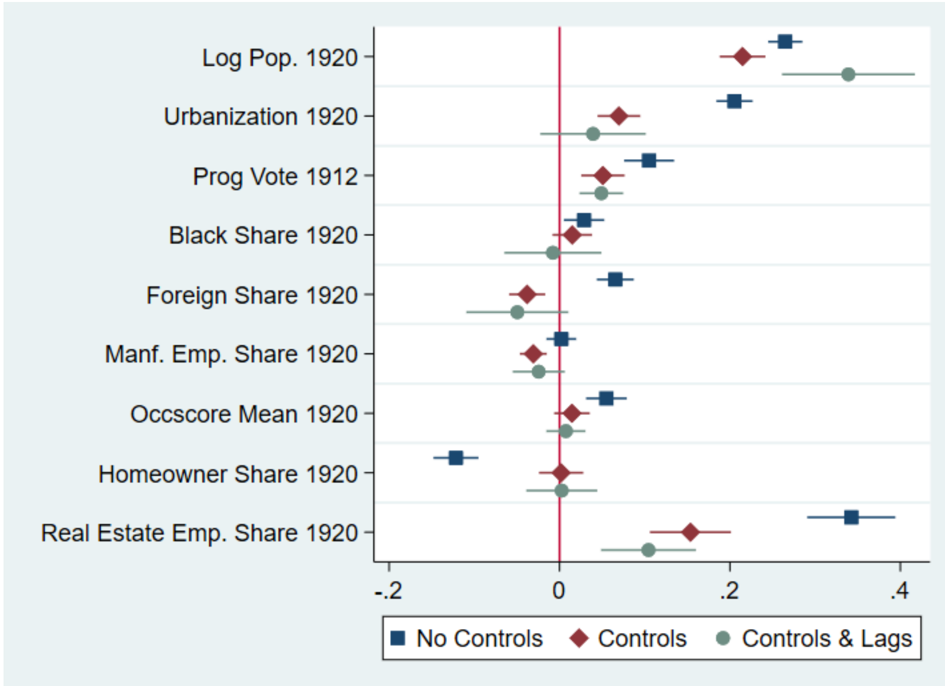


Figure 8: Correlations between City Characteristics and Zoning

no conditional correlation or a negative relationship with zoning adoption. These estimates cut against the traditional narrative that zoning arose in response to mounting industrial nuisances as well as results from earlier studies with smaller sample sizes and fewer controls (Clingermayer, 1993). Although the overall level of industrial nuisances displays no relationship with zoning adoption, other theories emphasize changes in the spatial distribution of nuisances within cities as the primary cause of zoning adoption. Fischel (2004) argues that the credible entry of apartments, shops, and light industry into exclusive single family neighborhoods facilitated by trucks and buses elicited backlash from homeowners. Whereas homeowners could previously exclude potentially deleterious land uses from their neighborhoods through less stringent means than zoning, the sheer volume of potential land use conflicts enabled by trucks and buses compelled them to demand heavier regulation in the form of zoning

If this account is correct, then cities where the number of land use conflicts rose more drastically prior to mass zoning adoption should zone at higher rates. I use the Logan-Parman Segregation Measure to quantify the dispersion and spread of potential nuisances within cities (Logan and Parman, 2017). The Logan-Parman Segregation Measure exploits the fact that concurrent households listed in census manuscripts have a high chance of being neighbors based on the routes of census enumerators. The Logan-Parman Segregation Measure then seeks to measure the probability that two household heads listed concurrently in the census differ on a given binary trait. A segregation measure of zero corresponds with random assignment of the trait or no segregation, and a measure of one corresponds with complete segregation, i.e., only a single pair of neighbors on the border of their respective groups do not match on the chosen trait. To check for land use conflicts and the spread of potential nuisances I distinguish between owner-occupiers and renters in one analysis and between manufacturing workers and non-manufacturing workers in a second analysis. The first measure is meant to capture the entry of apartment buildings and other multi-family housing into predominately owner-occupied neighborhoods. The second measure is meant to capture the spread of light industry on the assumption that manufacturing workers will tend to locate near their places of work.

Table 6 reports results with Panel (a) dedicated to segregation between owners and renters and Panel (b) dedicated to segregation between manufacturing workers and everyone else. Column (1) reports regressions of zoning on the 1920 measures of segregation with only state fixed effects included as controls, and column (2) adds the respective 1910 lags of the segregation measures. With lags included, the coefficients on the 1920 segregation measures in column (2) can be interpreted as the impact of changes in segregation after 1910. The two relationships are statistically significant and oppositely signed. Based on column (2), zoning became less likely as homeowners and renters became more intermixed and, on the other hand, more likely as manufacturing workers became more intermixed with everyone else. However, columns (3) through (5) demonstrate that both coefficients decrease in magnitude and statistical significance once other controls are included. The relationship between homeowner segregation and zoning remains marginally significant in column (4), but the sign still indicates that zoning adoption became less likely as segregation decreased

The results from this section suggest that Progressive political preferences made zoning adoption more likely but the growth and spread of commonly cited negative externalities, such as apartments and factories, did not. Indeed, lower levels of manufacturing and greater

Table 6: Relationship between Zoning and the Dispersion of Nuisances

	(1)	(2)	(3)	(4)	(5)
Panel A					
Segregation Owners and Renters 1920	0.171***	0.159***	0.0261	0.0348*	0.0213
	(0.0181)	(0.0213)	(0.0159)	(0.0185)	(0.0189)
Segregation Owners and Renters 1910		0.0280		-0.0205	-0.00581
		(0.0268)		(0.0188)	(0.0191)
Estimator	OLS	OLS	OLS	OLS	OLS
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
1920 Controls			Yes	Yes	Yes
1910 Controls					Yes
Observations	2568	2568	2568	2568	2568
Outcome Mean	0.283	0.283	0.283	0.283	0.283
Adjusted R^2	0.134	0.134	0.370	0.369	0.372
Panel B					
Segregation Manf. Workers and Others 1920	-0.131***	-0.121**	-0.0444	-0.0399	-0.0425
	(0.0489)	(0.0498)	(0.0391)	(0.0395)	(0.0397)
Segregation Manf. Workers and Others 1910		-0.0245		-0.0120	0.00168
		(0.0232)		(0.0138)	(0.0150)
Estimator	OLS	OLS	OLS	OLS	OLS
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
1920 Controls			Yes	Yes	Yes
1910 Controls					Yes
Observations	2568	2568	2568	2568	2568
Outcome Mean	0.283	0.283	0.283	0.283	0.283
Adjusted R^2	0.101	0.101	0.369	0.369	0.372

Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

separation between renters and homeowners in the decade preceding mass zoning adoption are positively associated with zoning in some specifications. These findings provide evidence that zoning adoption was not primarily determined by backlash against growing or novel negative externalities. While homeowner anxieties were certainly present and widely referenced in pro-zoning literature during the 1920s (Whitten, 1922; Whitten and Fisher, 1923; Flint, 1977), manufacturers, apartment builders, and other pro-development interests served as a counterbalance. Consequently, zoning adoption was not necessarily more likely in places with frequent or bitter land use conflicts, but instead found greater success in municipalities where, on balance, new development could disproportionately benefit from zoning.

1.6 Discussion and Conclusion

Land use regulation has evolved considerably since the first wave of zoning ordinances, but zoning has maintained its status as the prime means by which cities control the built environment. Moreover, zoning laws passed in the 1920s still exert a measurable effect on land use today (Twinam, 2018; Shertzer et al., 2018). Thus, understanding the factors that underpinned American cities' embrace of zoning a century ago is not just a matter of historical interest but present importance. While other studies of zoning have established the significance of local property owners and the financial trade-offs which motivate them, the primary contribution of this paper is to show that the policy's appearance and spread in the early twentieth century is best explained by the falling cost of zoning restrictions rather than the rising value of zoning protections.

Private interests, particularly those working in real estate, interjected themselves at every step of the zoning process; informing or outright directing the drawing of zoning maps, advocating to the public and the courts, and volunteering on boards of adjustment to administer enforcement (Burgess, 1994; Munro, 1931; Weiss, 1987). This involvement did not arise from civic-minded altruism but from a clear-eyed pursuit of profit, and the reason why so many brokers, agents, and subdividers could profit from zoning was because the automobile radically altered the path of urban growth in the 1910s and 20s. Falling transportation costs relieved pressure to intensify land uses in settled areas and redirected new development towards relatively inexpensive land on the urban fringe. As a result, the share of landowners who could benefit from zoning grew enormously as the opportunity costs of core landowners fell and the number of suburban, fringe landowners multiplied. This paper empirically demonstrates that municipalities with elevated real estate activity and topographies conducive to automobile-oriented development zoned at higher rates. A great irony is that many properties hypothetically protected by newly passed zoning laws, such as vacant residential lots in new subdivisions, crashed in value anyway due to over-production and the general effects of the Great Depression

Although this paper centers the role of private real estate interests, the influence of Progressive reformers is also important. Zoning found more success in counties with Progressive electorates, and planning experts like Edward Bassett engaged in a highly successful campaign of elite persuasion, convincing legislators, bureaucrats, and judges of zoning's fundamental validity. Given the failure of explicit racial zoning after the Supreme Court ruled it illegal in 1917, similar hostility from the courts would have likely stymied the spread of use and density zoning. In many ways the zoning movement parallels other successful Progressive Era reforms, such as workers' compensation and the regulation of food and drugs, in that its success depended on cooperation between reformist regulators and allies within the regulated industry (Law, 2004; Fishback and Kantor, 1998)

Despite their frustrations with the laxity of early ordinances (Bartholomew, 1931), zoning experts idealized suburban, single-family neighborhoods and viewed their creation and protection as central goals of zoning policy. However, for much of its history this ideal has implied the exclusion of black residents, and this paper shows that non-Southern cities with greater exposure to the opening wave of the Great Migration zoned at higher rates. However, many questions remain as to the exact role early zoning ordinances played in enforcing racial segregation. It remains unclear exactly how early zoning laws reinforced segregation, to what extent they achieved this goal, and whether they served to complement or substitute for other forms of housing discrimination. Additionally, the racial dynamics of zoning in the South, a region home to nearly all two dozen of the short-lived racial zoning ordinances (Troesken and Walsh, 2019) but which lagged in the adoption of use and density zoning, are beyond the scope of this paper

Beyond the relationship between zoning and race, several other topics remain open to future research. First, using a binary zoning measure obscures differences between cities' zoning ordinances, such as the share of land zoned for single family housing, that could nuance the primary result of this paper. Additionally, this paper did not explore how different decision mechanisms (referendum or city council vote) or different governmental structures (council governments or commission governments) affected zoning adoption. Nor did this paper consider how fiscal concerns may have motivated and in turn been affected by zoning (see Trounstine (2018)). Finally, given the long run effects of cities' initial zoning ordinances (Twinam, 2018) and the influence of real estate markets on zoning adoption, it would be interesting to examine differences in zoning ordinances and long term outcomes for cities zoned immediately before and after the onset of the Great Depression.

2.0 Hell with the Lid Off: Locational Sorting in America's Most Polluted City

2.1 Introduction

A large body of research documents patterns of racial inequity that were entrenched in U.S. cities prior to World War II. In northern cities, much of this inequity was tied to the high levels of racial segregation which were established over the course of the first wave of the great migration, 1910-1940 (Cutler et al., 1999). These inequities permeated society, including the markets for housing, education and labor (e.g. Massey and Denton, 1993; Derenoncourt et al., 2022; Akbar et al., 2023; Fishback et al., nd; Bondy and Sager, 2020; Collins and Margo, 2006, 2011). In this work, we consider a largely unstudied channel through which likely contributed to the establishment and maintenance of these disparities, namely disparate exposure to air pollution. Utilizing newly digitized historical data on the spatial distribution of air pollution in Pittsburgh, arguably the most polluted city in the pre-war United States, we find race and nativity to be much stronger predictors of exposure to pollution than income. For black Pittsburghers in particular, our analysis shows that this relationship grew sharply as levels of segregation rose over this time period. A driving force behind these increasing correlations was the differential impact of within-city moves on the pollution exposure of black and white residents - white movement patterns were associated with decreasing pollution levels while black movement led to increasing pollution exposure.

A large literature documents the link between pollution exposure and a range of outcomes including, health (e.g. Currie et al., 2014; Deryugina et al., 2019; Schlenker and Walker, 2016), cognitive function and mental wellbeing (e.g. Bishop et al., nd; Kioumourtzoglou et al., 2017; Lavy et al., 2014), labor productivity (e.g. Borgschulte et al., 2022; Graff Zivin and Neidell, 2013; Hanna and Oliva, 2015)) and crime (e.g. Burkhardt et al., 2019; Bondy and Sager, 2020). Over the last 40 years, correlations between race, poverty and pollution have also been clearly documented in a wide range of contexts (see Banzhaf et al., 2019, for an overview). However, largely due to data challenges, we know very little about these relationships prior to roughly 1980. One notable exception to this paucity is work by Heblich, Trew and Zylberberg (2021) which considers the long-run implication of pollution exposure in 70 English cities between 1880 and 1900. Combining wind direction data with the location of 5,000 industrial chimneys they document a significant correlation between worker skill-level (a proxy for income) and pollution exposure. In our work, we focus on a single U.S. city (Pittsburgh) and a unique panel of spatially delineated pollution data which is based on repeated measurements of sootfall between 1909 and 1938, and which we link to the full count decadal Censuses. By focusing on a unique data set that is available for this single highly polluted city, we are able to provide a much richer treatment of the relationship between demographics and pollution exposure than could Heblich et al. (2021). We are also able to track individual movements and assess the salience of our pollution measure in housing markets via an hedonic analysis of self-reported rents and home values from the 1930 and 1940.

We find that as early as 1910, correlations between pollution, income, race and nativity had been established in a manner that likely reinforced societal inequities. However, somewhat in contrast to modern data, we find race and nativity to be markedly more important than income for predicting pollution exposure. Further, racial inequity in exposure to air pollution increased significantly between 1910 and 1940. By 1940, on average, black Pittsburghers where exposed to more than 1/2 a standard deviation more pollution than were their white counterparts of similar income, age and marital status

Focusing on gender, we find that the concentration of single women working as domestic servants created perhaps unexpected interactions between pollution, income and labor force participation. When we include all single women in our analysis, we find that income is positively correlated with pollution exposure and labor force participation is negatively associated with pollution exposure. This result is exactly the opposite of that seen for single men. Further analysis shows that the relationship arises from the fact that single women living as live-in domestic servants were exposed to those pollution levels that were associated with wealthier households. Removing live-in servants from the analysis reverses this result, yielding patterns similar to those seen for single men. Finally, our work also finds evidence for the salience of air pollution in Pittsburgh's housing market. For 1930 and 1940 we are able to evaluate the relationship between air pollution and housing values/rents, finding that a 1 Standard Deviation increase in air pollution is associated with a 5 to 6 percent drop in housing price/rent.

2.2 Context

On the eve of World War I, Pittsburgh was the United States' 8^{th} largest city and ranked 9^{th} in GDP. However, where the city truly excelled was in the consumption of pollution generating fossil fuels. It was second only to Chicago in annual consumption of bituminous coal (3.8 million tons vs. 5.3 million tons) and coke (1.4 million tons vs. 2.0 million tons) and led the country in annual consumption of coal gas at 16.7 billion cubic feet.[1] Further, while consuming only 30% less coal than Chicago it was roughly a mere 1/4 of the city's size in terms of both land area and population. Adding further flames to the fire, while Chicago sits on flat ground adjacent to Lake Michigan, Pittsburgh's industry was nestled into river valleys where temperature inversions would often trap its coal smoke for days at a time. These conditions combined to create what was, at this time, likely the United State's most Polluted city – giving rise to James Parton's epigraph for Pittsburgh that was published in the Atlantic Monthly - "Hell with the lid off"

Concomitantly, like virtually every other larger northern city in the United States, over the 30 years that we study Pittsburgh experienced significant demographic change. Its population grew by over 25% going from 533 thousand in 1910 to 672 thousand in 1940. The great migration saw the city's black population more than double, increasing from 26 thousand to 62 thousand. As was typical of other other large northern and midwestern cities over this period, these increased rates of black migration were met with accelerating waves of white flight (see Shertzer and Walsh, 2019, for a discussion/evidence). The combined result of these forces was a sharp increase in segregation rates in the city. For example, the Isolation Index for Pittsburgh doubled from .23 in 1910 to .47 in 1940.[2]

[1] Production and consumption figures come from the 1914 Census of Manufacturers (U.S. Department of Commerce, 1917)

[2] Both the Isolation index and Disimilarity index rise steadily over this time period. For 1910, 1920 and 1930 calculations are based on aggregation to the Census Enumeration District. For 1940, we are forced to use Tract-level aggregates. Because Tracts are on average twice the size of Enumeration Districts, by

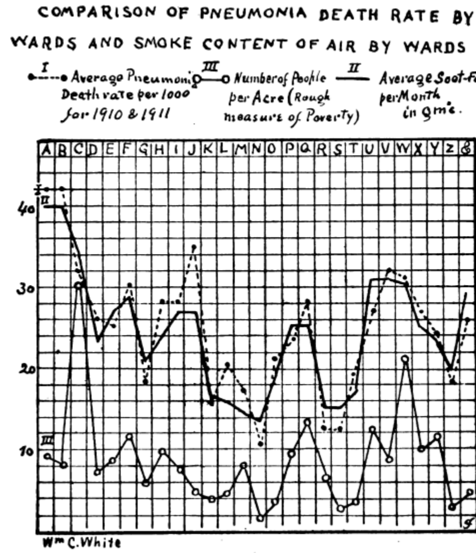
Patterns of natality were also changing over this time period. European immigration to the U.S. slowed drastically during World War I. Then, following a brief uptick following the war, slowed markedly as a result of federal restrictions on immigration flows under the quota acts of 1921 and 1924 (see Abramitzky and Boustan, 2017, for a discussion). As a result, Pittsburgh's foreign born population declined sharply over this time period from 141 thousand in 1910 to 85 thousand in 1940. As a percent of the population, levels fell in half from 26 percent to 13 percent. Further, not only were their numbers greatly reduced, but this smaller group of foreign born Pittsburgers would have, on average, been in the country for a longer period of time. This last point is important because, as we will show below, assimilation (speaking English) served to significantly reduce the pollution penalty paid by non-native residents

2.3 Data

For our analysis, we pull together data from a broad variety of sources. Air pollution data come primarily from a unique set of "Sootfall" measurements that were collected over several decades in the city of Pittsburgh. The main sources of demographic and income data are the full-count U.S. Decennial Censuses, which we augment with data on the incomes of county employees taken from annual reports of the Allegheny County Controller's Office. We also take advantage of the Census Linking Project (Abramitzky et al., 2020a) to track individuals across census waves. Finally, for our hedonic analysis, we match house characteristics from current day Assessor's records to self-reported house values and rents from the 1930 and 1940 Censuses.

construction, our 1940 segregation measures are smaller than we would have estimated using Enumeration District-level aggregates(see Shertzer et al., 2016b, for a discussion).

(a) Ward-Level Sootfall



(b) Pneumonia and Sootfall

Figure 9: Early Sootfall Measurement in Pittsburgh

Note: Left Panel depicts ward-level sootfall and right Panel depicts relation between sootfall and pneumonia. Figures reproduced from: White, Charles William and C.H. Marcy, "A Study of The influences of Varying Densities of City Smoke on The Mortality From Pneumonia and Tuberculosis" in Transactions of the Fifteenth International Congress on Hygiene and Demography (1912).

2.3.1 Sootfall Data

Our primary measure of air pollution comes from a series of "smoke studies" undertaken by the Mellon Institute of Research.[3] One earlier study (1910) was undertaken prior to the founding of the Mellon Institute. That study was done by White and Marcy (1912) at the University of Pittsburgh with support from Richard B. Mellon. Finally, the City of Pittsburgh's Bureau of Smoke Regulation (part of the Department of Public Health) undertook a large scale sootfall study during the years 1938 - 1939 with support from the Works Progress Administration. These studies were conducted by placing jars throughout the city

[3]The Mellon institute of Research was part of the University of Pittsburgh from its inception in 1913 until 1928 when it became a not for profit independent research institute. It became part of Carnegie Mellon University in 1967. Data from the Mellon Institute Studies as well as the 1938 Study undertaken by Pittsburgh's Bureau of Smoke Regulation were located in the Archives of the University of Pittsburgh (Ref# US-PPiU-ais198307). For a broader discussion of the genesis of these data collection efforts, see: Banzhaf and Walsh (2023).

of Pittsburgh, collecting them monthly, and weighing them for ash and other particulate.[4] The earliest of these studies was done by White and Marcy (1912). For their report, they collected one year's worth of spatially delineated sootfall data during the year 1910 and reported annual averages for each of Pittsburgh's 26 Wards. Figure 9 reproduces the two key figures from their report. Panel A records the spatial distribution of sootfall in the city (with darker shading corresponding to higher levels of sootfall) and Panel B reports measured sootfall levels along with Ward-Level data on pneumonia death rates and population density. This second panel highlights a main motivation for the sootfall studies, documenting the link between smoke and mortality.

Table 7: Sootfall Studies

Study Sponsor/Author	Years	No. of Months	No. of Sites
White & Marcy (1912)	1910	Annual Average	26 Wards
Mellon Institute	1912-13	12	12
Mellon Institute	1923-24	11	12
Mellon Institute	1929-30	12	19
Works Progress Administration	1938-39	12	100

While the exact location and number of sampling locations varied across studies, the basic approach was the same for all of them. Researchers placed metal cans on rooftops throughout the city to collect particulate matter issued from smokestacks and chimneys. They then gathered and recorded the cans' contents each month, measured in tons of soot per square mile per month. Table 7 reports the duration, scope, and organization responsible for each soot study in our data-set. For our analysis, we digitized each of these studies. To assign this pollution data to census divisions (Tracts in 1940 and Enumeration Districts in 1910, 1920 and 1930) in a given census year we follow a 3-step process. First, we collapse every station in each soot study to a monthly average, dropping missing values. Next, limiting ourselves to pollution readings within five years of a census year, we take an inverse-distance-weighted average of the 3 closest stations' monthly average to a census division's centroid. This step potentially leaves us with multiple pollution estimates for a census

[4]Except for the 1910 study, the sootfall data also include chemical analyses to help distinguish pollution from other forms of particulate matter.

Table 8: Regressing Sootfall on Heavy Smoke Days

	City-Wide Soot Average	Downtown Soot
Heavy Days	-0.734	16.47***
	(4.092)	(5.092)
Constant	110.4***	123.5***
	(26.32)	(32.21)
N	40	39
R^2	0.071	0.432
adj. R^2	-0.342	0.169

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: Model estimated with Month Fixed Effects and Drops one extreme outlier (November, 1929).

division. For example, in 1910 we have pollution estimates based on both the 1910 and 1912 soot studies. Therefore, as a final step we take an average of the different estimates for every census division.

In addition to the soot study data, we also collect time series data recorded in the U.S. Weather Bureau's meteorological reports from 1905 to 1930. Observers reported daily whether they detected light or heavy smoke from their meteorological station in downtown Pittsburgh.[5] We aggregate these observations to the monthly level to allow comparison with the soot study data. There are 41 months in which air pollution is measured by both the Mellon Institute soot studies and the U.S. Weather Bureau's daily reports for downtown Pittsburgh.[6] To facilitate comparison, in Table 8 we regress monthly sootfall data on the number of heavy smoke days reported at the Pittsburgh Meteorological Station.

[5]These data are taken from "United States Weather Bureau Report of the Chief". These annual reports are available through the Carnegie Library of Pittsburgh's Archives.

[6]Beginning in 1935, the Pittsburgh Meteorological Station moved from downtown Pittsburgh to the airport in Moon Township outside of the city limits. As a result, we limit our smoke days comparisons to pre-1935 months with sootfall data.

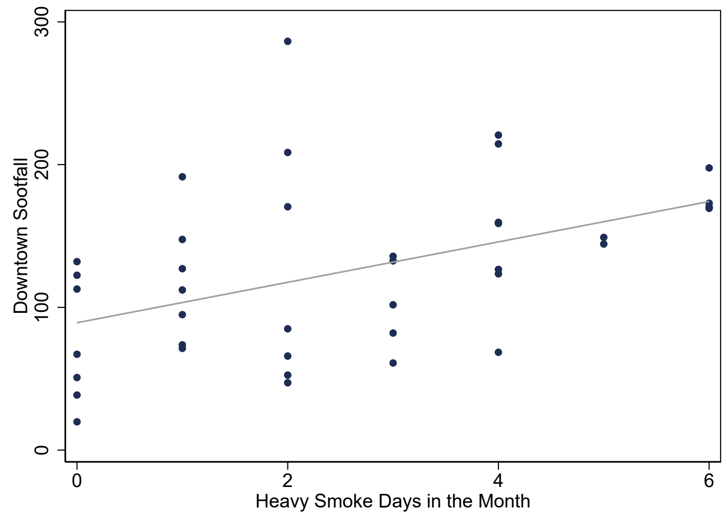


Figure 10: Downtown Sootfall and Heavy Smoke Days

Note: One extreme outlier is dropped (November, 1929).

In the first column of the table, the dependent variable is the average across all sootfall stations, while in the second column we only use data from the monitoring location closest to the Meteorological Station. We find no statistically significant relationship between city-wide soot averages and reports of heavy smoke downtown. However, focusing on sootfall in downtown, we find a very strong statistical relationship. Here, one extra heavy smoke day is associated with an increase in sootfall rate equal to 16.47 tons per square mile per month. In this sample, we average just over 7 heavy smoke days a year and the average measured rate of downtown sootfall was roughly 123 tons per square mile per month. While not dispositive, these results suggest both that our sootfall measures are correlated with observed air pollution and that they capture at least some level of spatial variation. Figure 10 provides a scatter plot of the data underlying the regression in column 2 of Table 8.

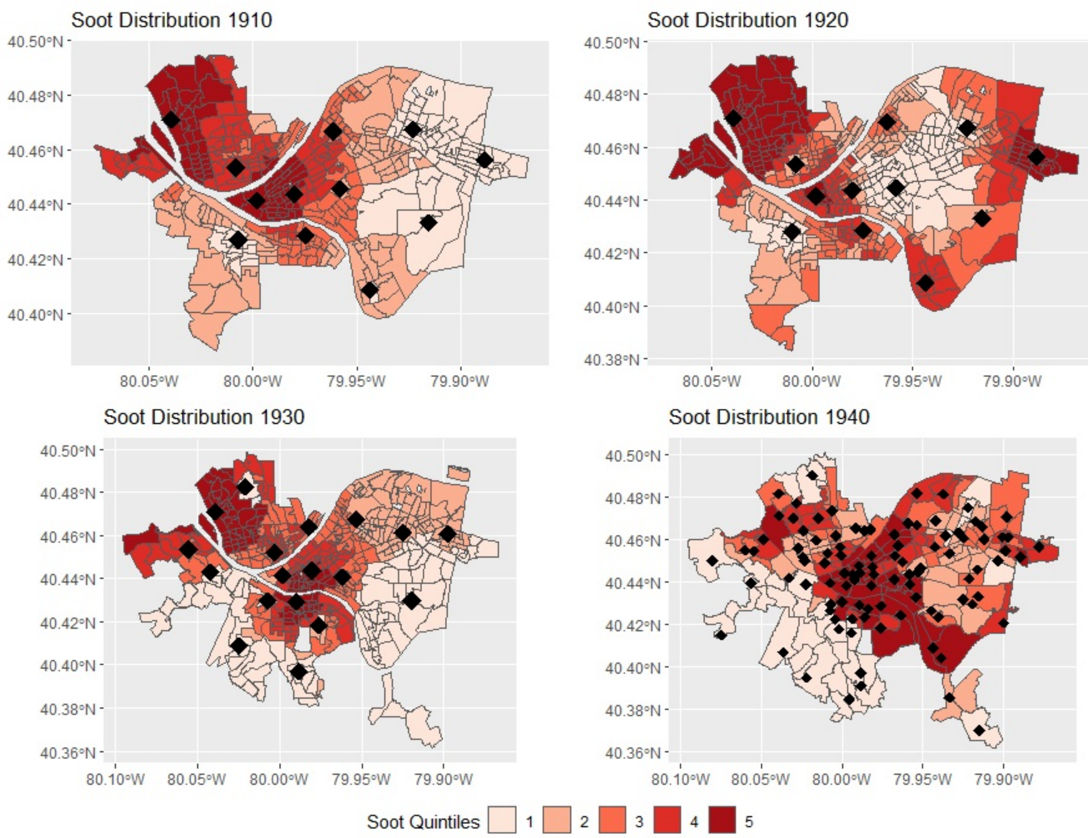


Figure 11: Spatial Distribution of Sootfall as Attached to Census Geography

Note: Each diamond shows the location of individual sootfall stations. For 1920, 1930 and 1940, the interpolations are based solely on the 1923/24, 1929/1930 and 1938/39 studies respectively. For 1910, we report the average of the Ward-Level data for 1910 and the interpolated station data for 1912/13. We report the within Census quintiles of sootfall. For 1910 - 1930, sootfall is interpolated to the Enumeration District Level. For 1940 it is at the Census Tract level.

In figure 11 we present both the interpolated spatial distribution of sootfall and the location of the individual sootfall collection stations. The interpolated data is reported in terms of within Census year quintiles. Overall, the spatial distribution of pollution is fairly stable. The one exception being a relative decrease in pollution that occurred in Pittsburgh's Hill District (very center of the map) in 1920. At the time, the Hill District was the heart of the city's black community. This short-lived relative decrease came about because pollution in the Hill District didn't increase as rapidly between 1910 and 1923 as it did in other parts of the City. By 1930, this relatively short-lived differential change was gone.

2.3.2 Demographic Data

Our primary source of demographic data are the full-count U.S. Censuses for the years 1910, 1920, 1930 and 1940. We augment this data with income data for public employees of Allegheny County who lived inside the City of Pittsburgh.

2.3.2.1 Census

Full count US Census demographic data was taken from IPUMS for all Pittsburgh residents between the years 1910 thru 1940. We utilize the smallest possible (digitized) census geography for the attach pollution data. For 1910-1930 we utilize enumeration district shapefiles originally digitized by Shertzer et al. (2016b). For 1940, we use Census Tract shapefiles downloaded from NHGIS. For each individual, we take information on race, nativity, home ownership, labor force participation, marital status and relationship to head of household. For 1930 and 1940, we also take tenure and self-reported rent or home value. Finally, because the Census doesn't report income prior to 1940, we proxy for income, utilizing Occupational Income Scores. These scores are based on analysis of income, occupation and industry data from the 1950 census. Each point in the Occupational Income Score represents $100 in 1950 income. Summary statistics, broken out by gender and marital status are presented in Appendix Tables 36 - 38. We also utilize the Census Linking Project (Abramitzky et al. (2020a)) to generate linked samples of men across the 1910 and 1940 Censuses and also across the 1930 and 1940 Censuses. For these linked samples, we start with the universe of

Table 9: Regressing Income on Occupation Scores

	1910 Income	1920 Income
Occupation Income Score	107.6***	60.12***
	(16.44)	(6.990)
Constant	685.3	679.1***
	(455.1)	(207.2)
N	224	235
R^2	0.162	0.241
adj. R^2	0.158	0.238

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Nominal incomes are converted to 1950 Dollars using the Bureau of Labor Statistics' CPI Series.

men living in Pittsburgh who appear in the 1940 Census and then link backwards to the 1910 and 1930 Censuses respectively.

2.3.2.2 Allegheny County Employee Data

Although widely used in the historical literature, occupational income score is a noisy measure of income. To augment these scores and provide some validation of their use as a proxy for income, we digitized data on the incomes of Allegheny County (where Pittsburgh is located) employees taken from the 1910, 1920 and 1926 reports of the Allegheny County Controller.[7] For the 1910 and 1920 reports, we hand match the individuals to census records using their names and occupations. For 1910 (1920) we were able to uniquely match 226 (437) of the 751 (1,252) individuals included in the report. For these two years, we recover location (Enumeration District), race and nativity for each of our matched individuals from their census records. We also recover Occupational Income score for 224 (235) of these

[7] 1926 was the last year for which individual salaries are reported in these reports. It is also unique in that is the only report we could find that actually listed each individual's address.

County employees. For the 1926 reports, we are between census years, so don't attempt to match to census records. However, in this case we have actual addresses. We successfully geocoded the addresses for 1,381 of these 2,530 individuals. Because we didn't link them to census records, we are unable to recover demographic data or occupational income scores for the 1926 County employees. Because all of the sootfall stations are located within the City of Pittsburgh, we limit our sample to those county employees that we are able to match to locations inside the city.

In Table 9 we utilize the 1910 and 1920 County employee data sets to provide a rough assessment of the use of occupational income scores as a proxy for income. We first use the Bureau of Labor Statistics CPI series to convert the 1910 and 1920 incomes to 1950 dollars. Then, separately by decade, we regress each individual's actual income (as reported by the County) on their occupational income score (as reported in the IPUMS version of the decennial Census). If relative wages across incomes and occupations remained unchanged between 1910/1920, County employees are paid market wages, *and* the CPI adjustments to 1950 dollars are perfect, then the estimated coefficients should equal exactly 100. The coefficients estimates are 107.6 and 60.12 for 1910 and 1920, respectively. For both decades the estimates have a high degree of statistical significance. Taken together, these estimates suggest that Occupational Income scores are likely to be a good proxy for income in our pollution analysis.

2.3.3 Housing Characteristics

For the first time in 1930, the Decennial Census collected data on self-reported housing values and rents. To provide controls for housing characteristics, we match household head observations from the 1930 and 1940 censuses to the 2022 Allegheny County Assessor's roles. In this process, we are extremely conservative in an effort to minimize the number of false matches. To this end, for the Census data, we restrict the sample to locations with a single head of household and for the Assessors data we restrict the sample to the set of single family homes that were built before 1930/1940. From both sides of the match, we begin by standardizing the addresses for how type of road (i.e. street, avenue, road, etc.), numbered streets (i.e. 1st avenue) and cardinal directions are delineated. We then limit the matched sample to only those matches where the street name match was essentially exact and completely unambiguous. Next, we drop any match whose location as identified in the Assessor's data set lies outside its reported Enumeration District (1930) or Census Tract (1940). This step provides a rough evaluation of the veracity of our matching procedure. For 1930 roughly 4% of our matches fail this filter. For 1940, the failure rate is just under 10%. As a last step, we drop observations that have incomplete assessor's data. Statistics for the matching process are presented in Appendix Table 39. Finally, we note that one might be concerned about potential bias in self-reported house values. However, we note that in other work, In order to test the veracity of self-reported housing values, Akbar et al. (2023) hand match a subset of 1930 and 1940 census data to assessor records of contemporaneous transactions. They find That self-reported house values from the U.S. Census provide an unbiased estimate of actual sale prices for 1930 and 1940.

2.4 Empirical Analysis

2.4.1 County Employees

We begin with an evaluation of the relationship between income, demographics and air pollution in our Allegheny County employee data. These regressions have small sample sizes relative to the work we present below using census data. The upside of the county employee data is that it enables us to measure actual incomes (vs. occupational income scores) and, by focusing on a set of individuals who all work for the same employer, we likely increase the "apples to apples" notion of our comparisons. Unfortunately, these small sample sizes limit the number of demographic variables that we can include in our models. At its core, the goal of this analysis is to identify how pollution exposure varied as a function of demographics. We do so by estimating the simple linear model presented in equation 9 using our matched samples of county employees.

$$\text{Std. Pollution}_i = \alpha + \beta \cdot ln[\text{income}]_i + \gamma \cdot \text{Black}_i + \delta \cdot \text{Foreign Born}_i + \varepsilon_i \tag{9}$$

Table 10: Regressing Pollution on County Employee Characteristics

	1910	1920	1926
Log Annual Income	-0.336**	-0.0126	-0.142**
	(0.132)	(0.121)	(0.0640)
Black	0.372	-0.371*	
	(0.370)	(0.200)	
Foreign Born	0.108	0.0790	
	(0.210)	(0.150)	
Constant	6.116***	4.104***	5.618***
	(0.937)	(0.894)	(0.482)
N	226	437	1381
R^2	0.037	0.009	0.004
adj. R^2	0.024	0.002	0.003

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Pollution levels are expressed in terms of within study standard deviations.

Here, Std. Pollution_i is the interpolated level of pollution either at the Enumeration District centroid where individual i lived (1910 & 1920) or at their exact address (1926). For each of our three time slices, pollution levels are normalized by the standard deviation of pollution across within year observations. Income is the annual income (aggregated up for hourly employees based on 40 hours/week and 50 weeks per year), Black_i identifies black employees and Foreign Born_i is an indicator of being foreign born. Because of the small sample sizes, we focus on a very limited set of demographic variables in the county employee regressions.

Results from these regressions are presented in Table 10. Focusing on 1910 and 1926 (columns 1 and 3) we see that a ten percent increase in income was associated with a reduced levels of pollution exposure on the order of .34 standard deviations (1910) or .14 standard deviations (1926), results which are statistically significant at conventional levels. In 1910, point estimates for the relationship between pollution exposure and being black or foreign born are positive but statistically insignificant. There are no estimates on these variables for 1926 because, as discussed above, we did not match these individuals to census data. Turning to 1920 (column 2) we see a different pattern. The estimated income effect is essentially zero and being black is now associated with lower levels of pollution exposure. As we explore in more detail below, this result appears to be an artifact of a temporary reversal in pollution distribution that occurred around 1920 and temporarily moved Pittsburgh's largest black neighborhood from near the top of the pollution distribution to near the bottom. This issue aside, these results suggest that as early as 1910 the types of income-driven Environmental Justice (EJ) patterns that we see today were already established and could be identified even looking solely within the residential locations of individuals who all worked for the same employer.

2.4.2 Census Data

Turning to the matched census data, it becomes possible to consider a richer set of demographic characteristics and a broader range of years. However, it is now necessary to rely on Occupational Income Scores as proxy measures for income. We begin by focusing separately, in turn, on single women, single men and married couples. We next consider comparisons across marital status and then conclude analysis of the census data with an evaluation of how patterns of sorting evolved from 1910 to 1940.

We begin with an analysis of pollution exposure for single women. We expand on the model of equation 9 by incorporating controls for speaking English, home ownership, being in the labor force, and being widowed or divorced. Four sets of results (one each for 1910, 1920, 1930 and 1940) are presented visually in Panel A of Figure 12.[8] Focusing on the results for income, there is an apparent anomaly. In all four decades, on average ceteris paribus, single women with higher incomes are exposed to worse air pollution at their home's location than are their lower income counterparts. This apparent anomaly stems from the fact that over

[8]The regression results underlying Figures 12 through 14 are presented in Appendix Tables 40 through 43 .

these decades between 30 and 47 percent of single women are working as domestic live-in servants and that these women are at the very bottom of the income distribution for single women. They also experience relatively better air quality as they are living in the homes of relatively wealthy Pittsburghers.

To further explore the role of income for single women, in Panel B of Figure 12 we replicate the analysis of Panel A, dropping live-in domestic servants from the sample. Once these women are dropped from the sample, with the exception of the anomalous year (1920) the relationship between income and pollution exposure is negative and statistically significant for all years. A one standard deviation increase in income is associated with exposure to between .04 and .09 standard deviations more pollution. This relationship increases in strength between 1910 and 1940. Relative to income, the correlations of pollution with race and nativity Results for race are much stronger. Focusing on the 3 non-anamalous time periods, we see that single black women are exposed to between .23 and .93 standard deviations more pollution than are their white counterparts. In magnitude, this relationship dwarfs that of income. It also increases markedly in magnitude between 1910 and 1940. For foreign born single women the corresponding pollution penalties ranged between .34 and .59 standard deviations. Note that for this group the EJ relationship also holds in 1920, although more weakly. These results also show that foreign born single women who reported speaking English experienced a pollution penalty roughly half the magnitude of those that didn't speak English (there is no coefficient for 1940 because the Census didn't ask about English fluency during this wave of the Census). Finally, we also note that single women who owned their own homes generally experienced less pollution.

Figure 13 replicates the above analysis for single men. The results here largely mirror those for single women. Higher income is linked with reduced pollution exposure. With a one standard deviation increase in income being associated with roughly between a .05 and .1 standard deviation decrease in pollution exposure. As with Single women, race and nativity appear to be markedly more important than income for explaining pollution exposure. Ignoring 1920, single black men experience from .25 to .78 standard deviations more pollution than do their white counterparts. Again, we see this relationship growing over time. For foreign born single men, the penalty is relatively stable at roughly .4 standard deviations. As with single women, speaking English appears to offset much of this penalty. The results for single men show a similar, but slightly stronger relationship with home ownership. Finally, we see that men who are in the labor force (Worker) are exposed to more pollution than those who are not, experience a .14 to .30 standard deviation increase in pollution exposure. This result, that was also present for Women albeit in a weaker form, suggests that proximity to ones employer may be a contributing factor in determining pollution exposure.

2.4.2.1 Married Couples and Marital Status

In assessing married couples, we add to the estimating equation characteristics of both husbands and wives. The one exception is race where the census data includes essentially no reported interracial marriages in pre-war Pittsburgh. Thus, in the coefficients reported in Figure 14 there is only a single racial coefficient estimate. Patterns here largely echo those of single men and women. Race and nativity continue to dominate income as predictors of exposure, generally gaining in importance across the 30 year period that we study. We note two additional findings for the 1940 sample. First, the presence of children becomes a relatively important predictor of pollution exposure for the first time in this time period - with each additional child being associated with a .029 standard deviation increase in pollution. Second, this is also the only Census for which wife's income is a significant predictor of pollution exposure. The coefficient estimate here being roughly half that of the husband's. These two findings are perhaps the result of economic hardship experienced as a result of the Great Depression.

Connected to the results for married couples are the dynamics of pollution exposure and marital status. Figure 15 presents the results from regressing within period pollution exposure on marital status, including controls for race and nativity. All men and women, regardless of marital status, are are pooled for this analysis, with single men being the omitted category. The results show some clear patterns. Single women are exposed to less pollution than are their male counterparts. Upon marriage, women on average experience an increase in their pollution exposure, while men experience a decrease - with net effect being that married couples are on average exposed to less pollution than are single men. upon becoming widowed, both men and women on average are exposed to more pollution. When interpreting these results, it is important to keep in mind that in these regressions we have not controlled for other factors that also are that other factors are related to pollution exposure, such as income.

2.4.2.2 Cross-Decade Comparisons

Throughout our analysis, we have argued that, particularly for black individuals and their families, the 1920 pollution distribution is a relatively short-lived anomaly. To illustrate this point more directly, in Figure 16 we replicate our basic analysis for single men and women, holding demographics constant at their 1920 levels while using the pollution measures that we observe in our 4 distinct sample periods: 1910, 1920 1930 and 1940. For parsimony, we only report the coefficients on income, race and nativity. The 1920 coefficients are exactly the same as those reported above in Figures 12 and 13. However, for the other three periods, we are regressing a different period's pollution levels (for instance 1910) on 1920 demographics. The figure shows that for all periods, except 1920, pollution levels were elevated in the neighborhoods where black people were concentrated in 1920. In other words, the reversed relationship we see on race in 1920 are associated with a short-run change in the spatial distribution of pollution rather than a re-sorting of individuals across neighborhoods vis-a-vis pollution.

Of greater importance, We can also look across decades to shed light on the dynamics of pollution exposure. One key finding in our analysis so far has been the fact that, as the great migration increased the size of Pittsburgh's black population, the correlation between race and pollution grew substantially. In general, the spatial distribution of pollution sources, and hence pollution exposure, was constrained by the basic geography of the city and the heavy reliance of its industrial base on access to the rivers. Thus, this increased correlation was likely the result of the sorting of individuals into neighborhoods rather than the systematic location of pollution sources into black neighborhoods.[9]We now explore this sorting through

[9]It is important to note that this "sorting of individuals" was occurring in a highly discriminatory environment rife with systemic racism, particularly in housing markets, and thus shouldn't be interpreted as

several analytical lenses.

First, in Figure 17, fixing the spatial distribution of pollution at 1910 levels, we ask how did demographics adjust over the next 30 years relative to these "initial" conditions. The figure presents the relationship between 1910 sootfall levels (the initial conditions) and demographics in each of our 4 succeeding Census waves - presenting results for both single men and single women. The figure shows that between 1910 and 1940, as the city's black population grew, these individuals became increasingly concentrated in those areas that had been heavily polluted in 1910. This result reinforces our finding from the repeated cross-sections that the correlation between race and pollution increased over this time period and suggests that this increase was, at least in part, due to the sorting of individuals. While smaller in magnitude, for men, the relationship between income and pollution also strengthens over this period (recall that as a result of their prevalence as live-in servants, the relationship between income and pollution for single women is more difficult to interpret). The opposite is true for nativity where we see that over our 30 year period immigrants became less concentrated in those areas that were most polluted in 1910.

The analysis of Figure 17 is based on repeated cross sections. However, using both the 1940 Census (which reports data on where residents live 5 years prior) and the matched samples that are based on the Census Linking Project, it also possible to track individual's locations across Census waves. In the first 4 columns of Table 11 we regress pollution exposure in 1940 (expressed in standard deviations) on a full set of 1940 demographic variables[10] and interactions between race (black/white) and sorting. Because we only observe pollution levels within the city of Pittsburgh, in all models, every individual included in the analysis was living within the City of Pittsburgh in 1940. Sorting is captured by 3 exhaustive and mutually exclusive variables: 1) didn't change neighborhood over the relevant time period; 2) moved from one neighborhood within the City of Pittsburgh to another neighborhood within the city of Pittsburgh during the relevant time period; and, 3) moved into the City of Pittsburgh from outside of Allegheny County during the relevant time period. At the bottom of the table, we report the sample composition. Finally, 1940 is the only year in our

representing systemic differences in individual our household preferences over air quality.

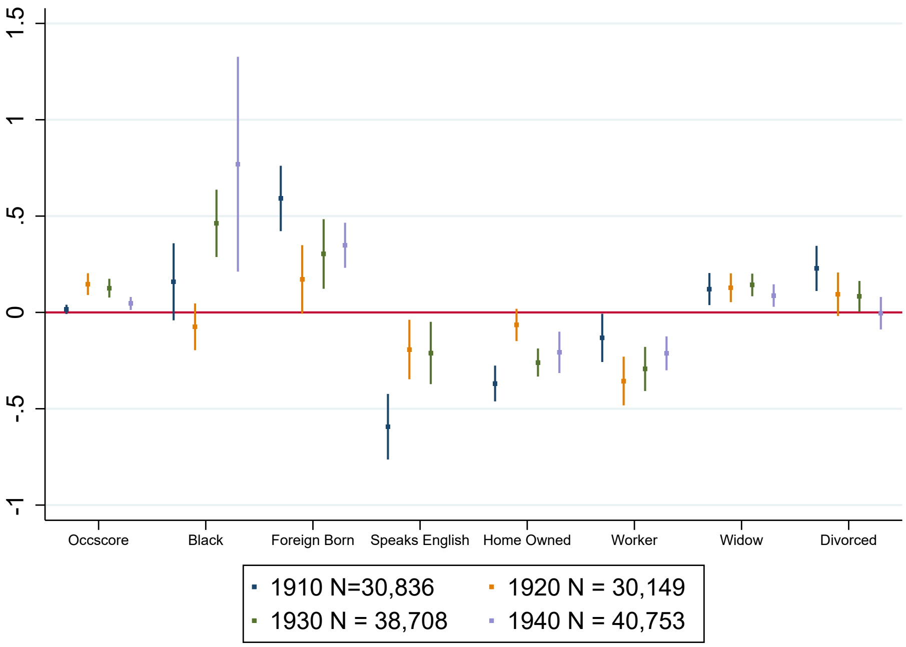
[10] See Appendix Table 45 for the full set of coefficient estimates.

data for which the Census Bureau included data on self-reported actual income. Thus, we include income (expressed in standard deviations) instead of occupational income scores in this particular analysis and report the coefficients on income in the Table.

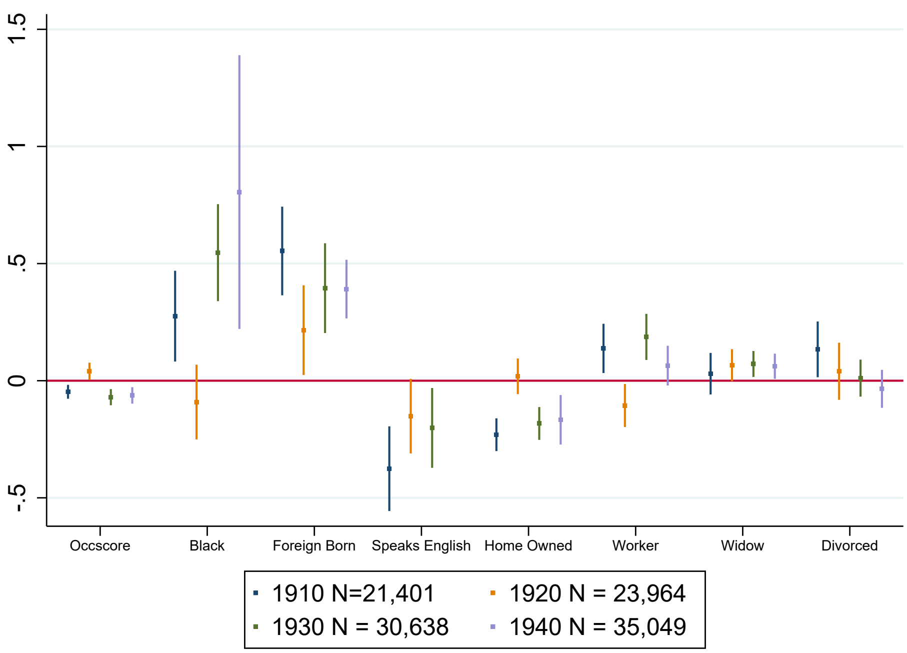
In columns 1 and 2 of Table 11, the sorting variables are based on the 1940 Census' question about where individuals lived 5 years ago. For these two columns, we have pooled single men, single women and all married individuals in the sample. In the first column we replicate our earlier analysis on this pooled sample. Results mirror those of the earlier tables. The relative importance of race and income reinforce results found in the earlier analysis. In column 2, we include our interactions between race and sorting - with white non-movers being the omitted category. Thus, the coefficient on black can be interpreted as the differential exposure (relative to non-moving whites) for blacks who didn't move in the last five years. We find that these individuals were, on average, exposed to .26 standard deviations more pollution in 1940 than were their non-moving white counterparts. The marked importance of neighborhood sorting is demonstrated by the coefficients on the interaction terms between race and changed neighborhood. Whites who reported moving over the previous 5 years were exposed to roughly a tenth of a standard deviation *less* pollution than non-moving whites, while blacks who reported moving in the last 5 years were exposed to .4 standard deviations *more* soot than were blacks who didn't report having moved - yielding a estimated movement-generated gap of .513 standard deviations. Turning to new migrants who came to Pittsburgh from outside the county over the previous 5 years, we find an even bigger gap. In-migrating whites locate in neighborhoods with .26 standard deviations less pollution than their non moving white counterparts who were already in Pittsburgh, while in-migrating blacks are exposed to .47 standard deviations more pollution than their non-moving counterparts - generating a gap of .725 standard deviations.

In columns 3 and 4, we turn to matched census samples (1930 - 1940 and 1910 - 1940). The requirements of the matching process leave us with a much smaller and all male sample. For within city moves, Looking back over a 10 year window with our matched sample, yields fairly similar results to those of column 2 (a 10-year movement-generated gap of .558 standard deviations compared to a 5-year gap of .513 standard deviations). However, results for moves into the city from outside of the County are quite different. Most striking is the composition of the overall sample (reported in the bottom of the table). The relative size of the out of county sample grows by a factor of 10 relative to the 5 year retrospective analysis based on the entire Census. It is possible that this difference reflects some selection process into the matched sample or perhaps it stems from higher inner-city mobility rates in the first half of the 1930s. However, given the magnitude of the difference, we believe it much more likely that the differences largely stem from noise in the matching process itself. The reason being as follows. In creating the cross-census matches, all possible individual matches across the entire U.S. are considered. And, because less than 1 percent of the total U.S. population lived in Pittsburgh in 1940, we would expect on the order of 99 percent of any false matches to show up in the data set as individuals who moved into Allegheny County over the relevant period. Thus, while we report coefficients for these individuals in the Table and they do suggest a modest further widening of the black-white gap, we don't put much weight on them. Finally column 4 looks back to 1910. Focusing on within city relocation over this 30 year period, the gap between black and white movers expands to .73 standard deviations. In other words black and white men who moved within Pittsburgh between 1910 and 1940 experienced differential soot exposures in 1940 that were .73 standard deviations higher than they would have been if both individuals had stayed in their initial locations.

While the first 4 models focus solely on 1940 pollution levels, by further restricting our sample to only those individuals who lived in Pittsburgh both at the beginning and end of the period, we can explore relative changes in exposure. Columns 5 and 6 of Table 11 present this analysis. Here, the dependent variable is the change in an individual's soot exposure percentile - i.e. soot exposure percentile in 1940 minus soot exposure percentile in 1930 (1910). For the 1930 to 1940 period white movers saw their soot exposure *reduced* by roughly 9 percentile points, while black movers experienced a roughly 10 percentile point *increase* in their soot exposure. Small sample sizes hinder precision in the analysis of 1910 to 1940 movers, however, the point estimates suggest a similar and slightly stronger relationship over this longer period. Collectively, the results of Figure 17 and Table 11 demonstrate that interactions with the city's real estate market markedly increased the black-white soot exposure gap in pre-WWII Pittsburgh.



(a) All Women



(b) Women with Domestics Removed

Figure 12: Single Women Coefficient Plots (Dep. Var. = Sootfall)

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

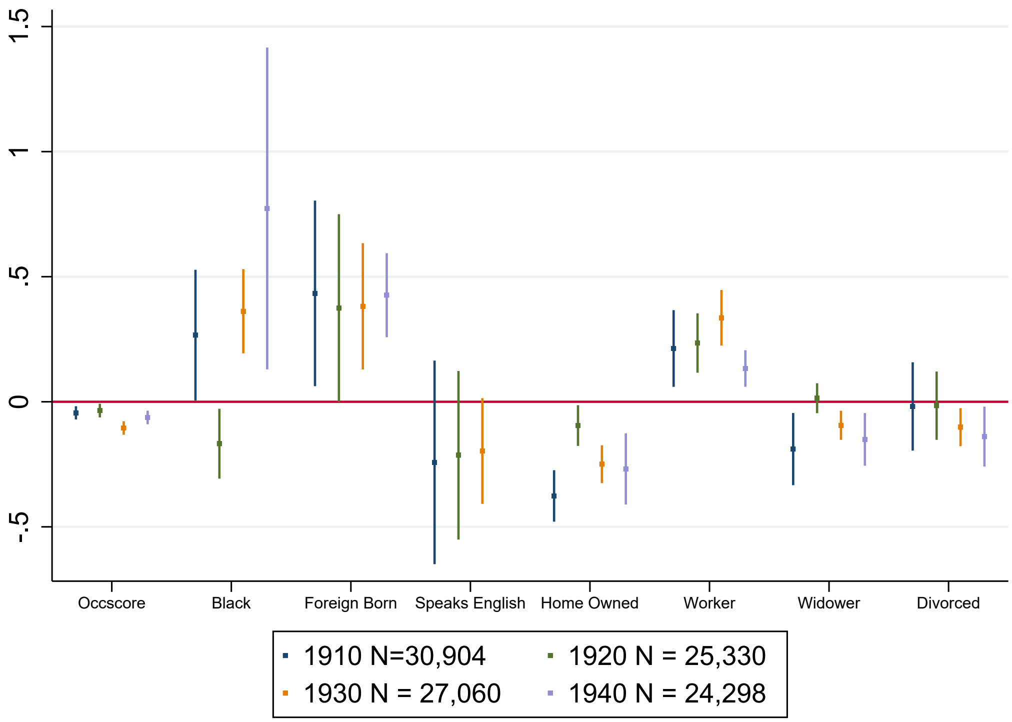


Figure 13: Single Men Coefficient Plots (Dep. Var. = Sootfall)

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

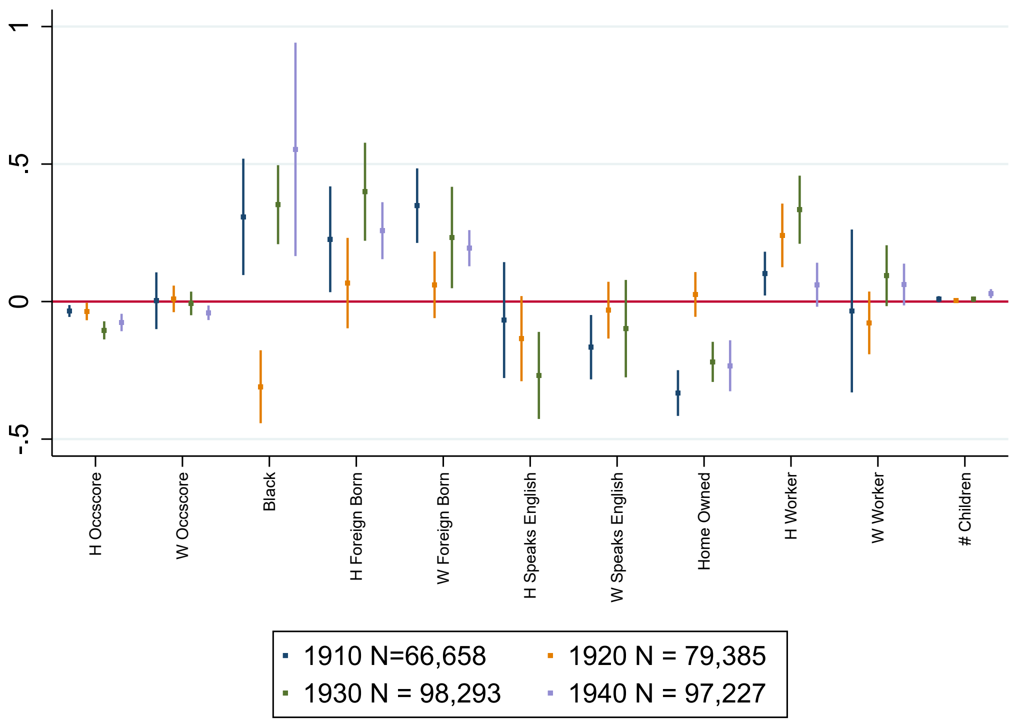


Figure 14: Married Couple Coefficient Plots (Dep. Var. = Sootfall)

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

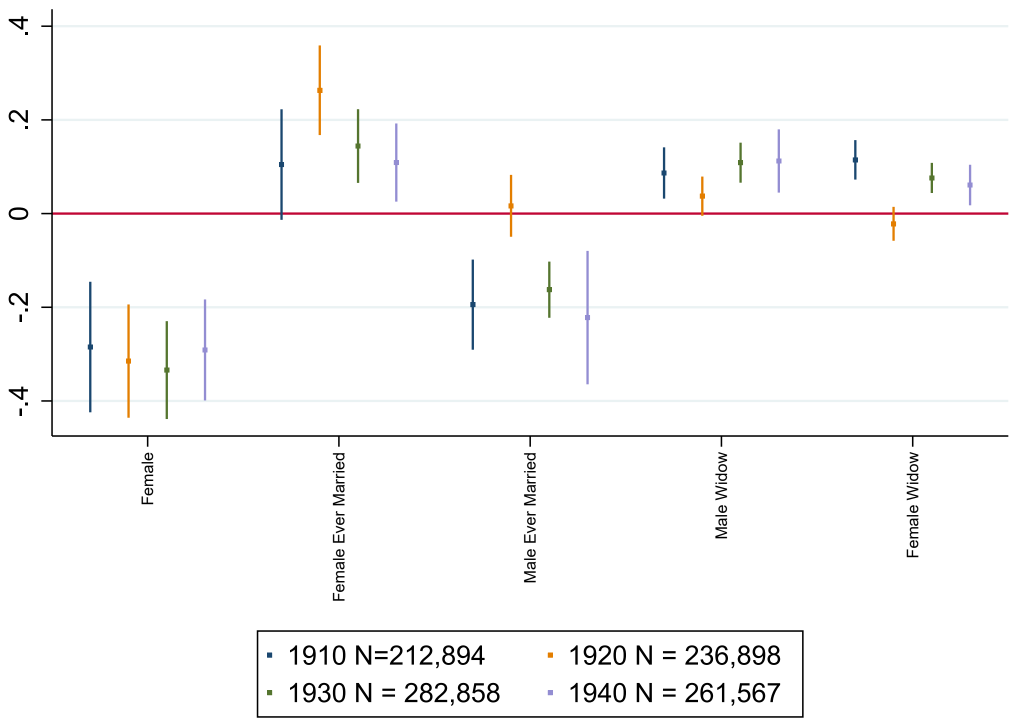
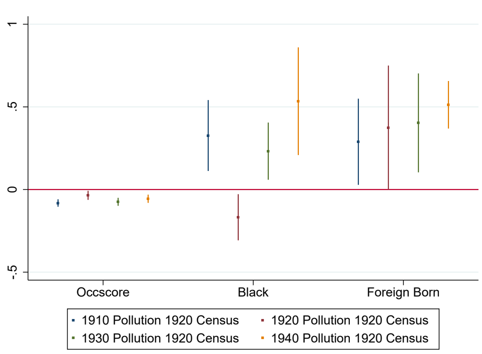
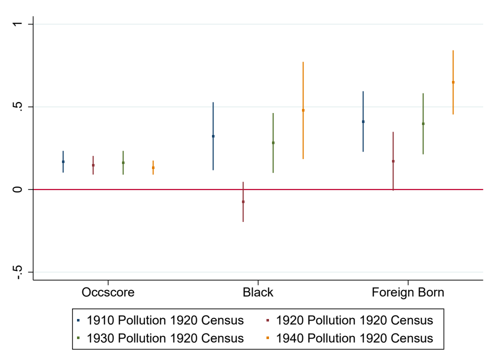


Figure 15: Pollution and Marital Status (Dep. Var. = Sootfall)

Note:Pollution levels are expressed in terms of within census standard deviations. Regressions include controls for race and foreign born status.



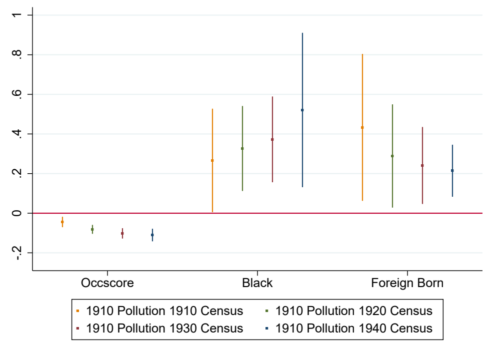
(a) Men



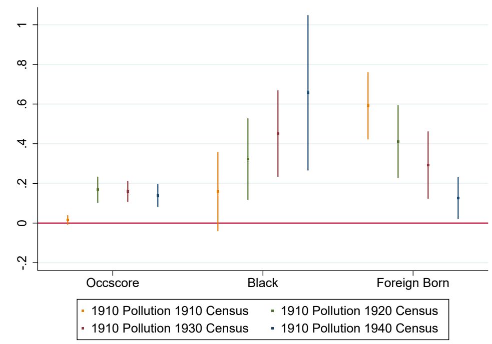
(b) Women

Figure 16: Exploring the 1920 Pollution Anomaly Single Men and Women

Note:Pollution levels are expressed in terms of within census standard deviations.



(a) Men



(b) Women

Figure 17: Dynamic Sorting of Single Men and Women (Dep. Var. = 1910 Sootfall)

Note:Pollution levels are expressed in terms of within census standard deviations.

Table 11: The Link Between Moving and Pollution Exposure

	1940 Full	1940 Full	1940 - 1930	1940 - 1910	1940 - 1930	1940 - 1910
Black	0.553**	0.272*	0.150	0.0537	-1.493	-3.689
	(0.217)	(0.141)	(0.128)	(0.185)	(3.743)	(4.905)
Change Nbrhd		-0.0987***	-0.197***	-0.361***	-9.337***	-18.20***
		(0.0300)	(0.0423)	(0.0677)	(2.613)	(2.746)
Black X Chg Nbrhd		0.416***	0.323***	0.436***	9.957***	20.06***
		(0.129)	(0.0851)	(0.113)	(3.303)	(5.237)
Annual Income	-0.0950***	-0.0909***	-0.0607***	-0.0851***	-0.408	-0.887
	(0.0157)	(0.0150)	(0.0117)	(0.0178)	(0.464)	(0.605)
Dep. Var.	1940 Soot	1940 Soot	1940 Soot	1940 Soot	Chg Soot Pctile	Chg Soot Pctile
N	415505	415505	44755	13232	44755	13232

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:Pollution levels and incomes are expressed in terms of within census standard deviations. All regressions include a complete set of 1940 controls (see Appendix Table 45 for a complete list of coefficient estimates). Columns 1 and 2 include all individuals in the 1940 census, with changes in neighborhood and/or county being based on the census' 5 year move move variable. Columns 3 and 4 match samples of men from the 1940 census to the 1930 and 1910 censuses respectively. Columns 5 and 6 use the matched samples as well, with the dependent variable being the change in pollution percentile from period 1 to period 2 - as a result, the sample is restricted to individuals who lived in Pittsburgh in both periods.

2.4.3 Hedonic Analysis

Table 12: Hedonic Analysis

	Ln Price 1930	Ln Rent 1930	Ln Price 1940	Ln Rent 1940
Tons/Sq Mile Soot	-0.0587***	-0.0547***	-0.0512***	-0.0487***
	(0.00688)	(0.0137)	(0.00641)	(0.00777)
Observations	12635	3773	11345	6296
R^2	0.661	0.434	0.605	0.549
Adjusted R^2	0.658	0.416	0.601	0.540

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Pollution levels are expressed in terms of within census standard deviations.

We conclude our empirical analysis with an assessment of the market salience of sootfall in Pittsburgh over this period. If pollution was an aspect of housing location that was relevant to individual location choices, it should have been capitalized into housing prices. We explore this issue here. The Census first asks about home values and rents in 1930. Thus, our systematic analysis of the pollution-price relationship is limited to 1930 and 1940. There is however anecdotal evidence on this link from the beginning of our study period. In parallel to their 1912 sootfall study, the Mellon Institute also undertook a study of the costs of smoke (O'Connor (1913)). As part of that study, in early 1913 John O'Connor Jr. surveyed real estate interests in Pittsburgh about the effect of soot on property values and rents. While a handful of responses argued that impacts were negligent or impossible to assess, the majority discussed extreme examples where property values/rents were discounted on the order of 25 to 50 percent. A typical response was that of real estate agent Edward Lang who stated "All the property in this section (that is residence property) has depreciated fully 50% by reason of the excessive smoke nuisance".[11]

For a more systemic analysis, we utilize the linked hedonic data set for 1930 and 1940 the construction of which we discuss above. We estimate the model presented in Equation

[11] For more on the broader activities of the Mellon Institute see Banzhaf and Walsh (2023). The specific letter quoted here is located in the University of Pittsburgh Archives, AIS.1983.07.Ser.1.ff8.

10 separately for owner occupied and rental units in each of 1930 and 1940,

$$ln[\text{Value/Rent}]_j = \alpha + \beta \cdot \text{Sootfall}_j + \Gamma' Z_j + \varepsilon_i \tag{10}$$

where Sootfall_j is normalized by its standard deviation and Z_j is a vector of housing characteristics that includes indicator variables for # of bedrooms, # of bathrooms and total rooms interacted with total living space. Z_j also includes age and age^2, an indicator for new build, lot area and a set of neighborhood indicators. We trim for outliers at the one percent level based on rent, price, lot size and square feet of living space. When modeling sales price, we also trim at the 95% for the ratio of 2022 assessed value to 1930/1940 reported value in an attempt to further tease out any potential inaccurate matches. Our results are not particularly sensitive to this trimming.

The results of this analysis are quite robust and are presented in the four columns of Table 12. On average, a one standard deviation increase in sootfall is associated with price and/or rent discounts roughly on the order of 5 to 6 percent.

2.5 Conclusion

We explore the relationship between air pollution exposure and demographic characteristics in Pittsburgh during the period of 1910 to 1940, which witnessed a rise in racial segregation in northern urban centers. Utilizing a unique and recently digitized historical panel data set on the spatial distribution of air pollution in Pittsburgh, perhaps the most polluted city in the pre-war United States, our findings reveal that race and nativity were much stronger predictors of exposure to pollution than income. Specifically, Black Pittsburgh residents were exposed to significantly higher levels of pollution than their White counterparts with similar demographic characteristics. This disparity grew to roughly three quarters of a standard deviation in pollution exposure by 1940.

Our analysis further reveals that within-city moves were a key driving force behind the increasing correlations between race and pollution exposure. Relative to White non-movers, White movers experienced lower levels of pollution. However, for Black residents, this relationship was reversed, with Black movers being exposed to higher pollution levels than non-moving Black residents. Taken together, these results suggest that the cumulative effect of moving on Black-White exposure gaps was between one half to three quarters of a standard deviation in contemporaneous pollution exposure.

Additionally, we find that the concentration of single women working as domestic servants created unexpected interactions between pollution, income, and labor force participation. For single men and couples, we consistently find that higher incomes were associated with lower levels of pollution exposure and that labor force participation was associated with higher levels of pollution exposure. For single women, these relationships are reversed. Further analysis shows that this divergence was driven by the large percentage of single women who worked for very low wages as live-in domestic servants. These low-wage members of the work force were exposed to low levels of pollution as a result of their high wage employers choosing to live in low pollution locations. removing live-in servants from the analysis revealed patterns for single women similar to those observed for single men.

We also shed light on the salience of air pollution in Pittsburgh's housing market, specifically the relationship between sootfall and housing prices in 1930 and 1940. Our analysis finds that a one standard deviation increase in sootfall was associated with both sales price and rental discounts of between 5 and 6 percent, providing perhaps the earliest systematic evidence to date of the capitalization of air pollution into housing prices.

These findings have important implications for the persistence of racial and economic inequalities in the United States. Taken together, they suggest that patterns of racial and economic inequality in Pittsburgh were likely reinforced by disparate exposure to air pollution. This concern is particularly significant when considering the growing evidence of the link between pollution exposure and a broad range of developmental, material, and health outcomes. While the pollution experienced in Pittsburgh were particularly acute, pollution levels were generally elevated in industrial cities across the U.S. during this time period. Given the broad prevalence of racialized housing markets across virtually all U.S. cities throughout this era, these results likely have implications that extend beyond just the City of Pittsburgh.

3.0 Women's Suffrage and Local Officials: Evidence from Ohio

3.1 Introduction

In 1920, decades of campaigning by women's suffrage organizations culminated in the nineteenth amendment, which outlawed the denial of voting rights on the basis of sex and allowed women in 33 states to finally cast ballots in all elections (Cascio and Shenhav, 2020). Women's entrance into the electorate noticeably impacted public policy in areas where women's preferences differed from men's, such as child welfare. A large literature documents increases in state and local spending focused on health and education (Lott and Kenny, 1999; Carruthers and Wanamaker, 2015; Miller, 2008) as well as improved outcomes in terms of infant mortality and completed years of education (Kose et al., 2021). Although scholars uncover a clear connection between women's preferences, voting rights, and policy outcomes, most studies remain agnostic as to extent and nature of women's political participation after gaining the right to vote.

Other work casts doubt on the idea that women's ability to vote straightforwardly led to policy outcomes they favored. Moehling and Thomasson (2012) posit that state participation in the 1922 Sheppard-Towner Act, which provided matching federal funds for maternal healthcare, was premised on politicians overestimating women's support for the issue. After politicians observed women's actual voting patterns, they allowed funding to lapse. Morgan-Collins (2021) finds that Congressional districts with higher shares of women voted out conservative, anti-suffrage politicians at higher rates, but the effect only appears in areas that hosted robust suffrage organizing prior to the nineteenth amendment. Thus, several factors beyond the basic ability to vote or the number of female voters potentially mediated women's impact on government policy in the immediate wake of their enfranchisement.

In this paper I will examine one such factor, the entry of women into political office. Focusing on the election and appointment of local officials between 1912 and 1940, I seek to answer three interrelated questions. First, as a matter of description, how many women held office in this period and how did they differ from male officeholders? Second, did places with markers of female political power, such as higher levels of support for suffrage or greater numbers of women, elect women at higher rates after the extension of suffrage in 1920? And third, was the presence of female officeholders associated with policy changes identified by previous studies, such as increased spending on public health.

I collect information on local officials in Ohio from rosters of county and municipal officers published by the Ohio Secretary of State. These rosters list the name, position, and party of officials serving in county, city and village government.[1] I identify female officials based on honorifics listed in the rosters (e.g., Miss or Mrs.) as well as the probability that their first name belongs to a woman.[2] To determine officeholder traits beyond their position, political party, and sex I match officeholders to the decennial census taken closest to their election year using their full name and the county in which they held office.

In the decade prior to suffrage, women made up a negligible share of city, village, and county officials and occupied roughly 5 percent of positions on city school boards, which they could vote for beginning in 1894, and among appointed city officials. Following the nineteenth amendment, the share of female officials increased in all categories. The share of women in city and county elected positions peaked in the 1920s at 12 percent for city school boards and just under 5 percent for all other positions. The share of women holding appointed positions increased steadily to 17 percent of such positions in 1940. Among elected positions, women primarily filtered into financial and administrative roles, serving as treasurers, auditors, and recorders of deeds. Women in appointed positions served almost exclusively on health and library boards. Thus, while women entered government in greater numbers following the nineteenth amendment, they were constrained to a limited set of roles. Comparing female to male officeholders reveals a number of familiar patterns. Consistent with the limited ability of married women to work outside the home (Goldin, 2006), female officeholders were far less likely to be married than their male counterparts and had fewer children. Female officials also earned less than male officials, and the gap remains when the sample is restricted to part-time officials with employment outside local government However, women in local

[1]Cities and villages are both types of incorporated places and differ in terms of population size. By definition, villages have fewer than 5,000 inhabitants and become cities when they exceed that threshold. Positions in village government in Ohio were far more standardized than city government.

[2]I calculate the shares of men and women with a given name based on individual count census data from 1910 to 1940.

government proved more likely to finish high school than male officials and entered college at similar rates.

I next examine whether several variables commonly associated with women's political power impact female office holding using a difference-in-differences identification strategy. Following previous work Carruthers and Wanamaker (2015); Morgan-Collins (2021), I source the female share of potential voters (citizens over 21 years of age) from the decennial census. Additionally, I collect county level returns from multiple referendums for women's suffrage and the statewide prohibition of alcohol as well as the vote share for the pro-suffrage Progressive Party in the 1912 presidential election. While all voters in these elections were men, suffrage and prohibition were the preeminent political issues for women before they gained the right to vote, and support for these causes could feasibly indicate a male voters' sympathy to women's issues or greater organizational and persuasive ability among local women. Finally, I collect financial data from the Ohio Women's Suffrage Organization (OWSA) to identify the number of donations from each municipality and county as well as the locations of affiliated local organizations.

The effects of these variables on the election of women are either entirely insignificant or vary based on the type of local government. The female share of potential of voters and the number of OWSA donations, and Progressive Party vote share show no effect on the election or appointment of women after 1920, and presence of a local OWSA affiliated suffrage organization is negatively associated with the election and appointment of women in city government. Support for suffrage and prohibition referendums are both positively and significantly related to the election of women at the county level and the appointment of women in cities, but negatively associated with with the election of women in cities. In short, the variables that could feasibly proxy for women's political power exert uneven and often contradictory effects on the the share of women in political office at the local level.

As a final step, I digitize county and city financial data[3] compiled by the State Auditor of Ohio to explore whether higher female office-holding is associated with higher taxes, higher spending, or lower mortality rates. In a cross-sectional model I regress the relevant per capita financial outcome in 1940 on the total share of female officeholders between 1920

[3]Financial statistics on villages were not collected.

and 1940, controlling for outcome's level prior to suffrage. I conduct this analysis for cities and counties separately and also regress city and county financial variables aggregated to the county level on the total female share of all officials in the county (including village officials). The aggregated measures of taxation and spending are positively and significantly correlated with the female share officeholders, but I find no such correlation for charity or health spending. Analyzing cities and counties in isolation, I find no correlation between women's office holding and the overall levels of taxation and spending or the level of charity spending. I do find a negative correlation between health spending at the city level and the female share of appointed city officials. Further, the negative correlation remains after I redefine the explanatory variable to be the female share of appointed city health officials. However, I find no correlation between the female share of health officials and infant or all ages mortality rates.

In relation to prior work, my findings make several contributions. First, I provide new information on women's political participation in the period encompassing the largest expansion of women's political rights in the history of the United States. Despite the clear impact of women's suffrage on the behavior of local and state governments (Lott and Kenny, 1999; Miller, 2008; Carruthers and Wanamaker, 2015; Kose et al., 2021), lack of data obscures potential changes in women's own political behavior. Given the lack of survey data on women's voting before 1940 (Cascio and Shenhav, 2020) and the rarity of women in federal office during the same period (Manning and Shogan, 2011), the presence of women in local office is one of the few meaningful markers of women's political activity that can be directly measured in the early twentieth century. Moreover, such data allows for comparison with contemporary studies of women in political office (Thomas and Wilcox, 2014; Ferreira and Gyourko, 2014; Hessami and da Fonseca, 2020) and complements qualitative studies of earlier female officeholders (Nicholas, 2018).

Second, my work adds to the literature on the characteristics of elected officials and how they differ from the general population. Most work on how closely politicians match those they represent occurs in modern contexts (Gulzar, 2021; Carnes and Lupu, 2023), and historical studies that take advantage of census matching have focused solely on federal legislators and bureaucrats (Thompson et al., 2019; Moreira and Pérez, 2021). Finally, my work adds to the literature on how newly enfranchised groups influence and enter government leadership. Morgan-Collins (2021), who also studies the effects of women's suffrage in the United States, constitutes the most direct comparison but focuses on turnover among members of Congress. Other papers have studied the impacts of black enfranchisement and political leadership in the Reconstruction era South Logan (2020) as well as the effects of lowering the voting age on youth political activity and the age of elected officials in modern contexts Belschner et al. (2023).

3.2 Historical Background

Women in Ohio were early and enthusiastic advocates for women's suffrage. Ohio's first statewide convention on women's rights was held in 1850, just two years after the country's first suffrage convention in Seneca Falls, New York. The 1850 convention, held in the town of Salem, provided the basis for the country's first statewide suffrage organization, the Ohio Women's Suffrage Association (OWSA), which formed in 1852 (Rozell, 2022).[4] Among other activities, women's rights activists managed to insert the question of women's suffrage into the Ohio Constitutional Conventions of 1850 and 1873 through submitting petitions. In 1850, constitutional delegates restricted the franchise to white men by a large margin, and an equal voting rights amendment again failed in 1873, albeit by a smaller margin (Shilling, 1916). Despite these setbacks, women managed to win the rights to vote and stand for office in local school board elections in 1894 (Stanton et al., 1902).

Ohio was also an early host to the other major women's issue of the period, temperance and prohibition. In 1873 and 1874 anti-liquor sentiments reached a fever pitch in the Temperance Crusade movement, a spontaneous backlash by women against alcoholism and the liquor industry. Close to 150,000 women joined in the movement across 29 states to engage in protests that included the public shaming of saloon keepers, the destruction of alcohol, and physically blocking entry to saloons by holding church services. Crusade activity concentrated in the Midwest and Ohio itself earned the nickname of the "Crusade State". In

[4]The organization formed as the Ohio Women's Rights Association but was renamed in 1885.

one show of force, a large group of Temperance crusaders marched on the state capital of Columbus in 1874 to oppose the repeal of the Adair Law, which made liquor sellers liable for damages resulting from customers' drunkenness. In the same year The first Women's Christian Temperance Union (WCTU), a women's group that institutionalized the fight for temperance and prohibition, formed in Cleveland. (Rozell, 2022; García-Jimeno et al., 2022).

Despite the strength the suffrage and temperance movements within Ohio and overlap between their memberships, the two groups found it difficult to cooperate towards common goals. The base of support for women's suffrage primarily came from the urban and northern parts of the state while temperance activity concentrated in rural and southern areas. Additionally, personal disagreements among the movements' leaders kept them from working in tandem. The first president of Ohio WCTU, Annie Wittenmyer, was a committed anti-suffragist and headed the group until 1879. After her exit, the Ohio WCTU dropped its hostile stance towards women's suffrage and even created a franchise department to support a state suffrage amendment. However, the leadership of the OWSA refused to reciprocate the Ohio WCTU's support for fear of alienating the anti-prohibitionist vote, and many conservative temperance supporters split from the Ohio WCTU in protest (Rozell, 2022).

Leadership of the OWSA continuously vacillated on the question of allying with the temperance movement. OWSA president Harriet Taylor Upton, who personally supported prohibition, allowed for an informal rapprochement between the two organizations in the early 1900s only to explicitly distance the OWSA from prohibition when both issues were put to referendums in the 1910s. In 1912 Ohio held its first constitutional convention since 1873. Strongly influenced by the Progressive movement, the convention delegates issued 42 proposed amendments for approval by voters. An equal voting rights amendment failed to receive majority support, but an amendment that enabled voter-led initiatives did pass. Suffrage and temperance supporters managed to put their issues on the ballot in 1914. Throughout the ballot initiative process Upton made statements to distance suffrage from prohibition despite cooperation between activists to collect signatures and persuade voters. Suffrage activists also received support from the Progressive Party who strongly endorsed a pro-suffrage platform in 1914. Regardless, Ohio men voted down both women's suffrage and prohibition (Rozell, 2022; Shilling, 1916; Pliley, 2008).

Following this defeat, Ohio suffragettes continued to pursue state-level recognition of women's voting rights. In 1917 they successfully pressured the Ohio legislature into passing the Reynolds Bill, which granted women presidential suffrage. However, anti-suffragists took advantage of the same ballot initiative system used by suffragists in 1914 to rally support against the bill. As a result, Ohio women lost their right to vote for President before they could exercise it. On the local level suffragists did find some success, earning the right to vote in municipal elections in the cities of East Cleveland, Lakewood, and Columbus (Dismore, 2020). After their second defeated referendum, the OWSA shifted focus to a national amendment, and Ohio became the fifth state to ratify the nineteenth amendment in 1919 (Rozell, 2022).

3.3 Data

3.3.1 Roster Data

My primary data source consists of rosters of local officials published every two years by the Ohio Secretary of State. Data on city and village officials come from *The Ohio Roster Township and Municipal Officers* while data on county officials are sourced from *The Ohio Official Roster of Federal, State and County Officers* (Ohio Secretary of State, 1912, 1914). City and village elections were held every other odd year (e.g., 1919 and 1921) and county elections every other even year (e.g., 1920 and 1922). I have digitized city officials for the election years of 1911, 1919, 1921, 1925, 1929, and 1939; village officials for 1917, 1919, 1921, and 1939; and county officials for 1912, 1916, 1918, 1920, 1924, 1930, and 1936.

Rosters provide information on the names, party affiliations, and positions of local officials. If a jurisdiction lists no party identifiers, I assign its officials the party affiliation of non-partisan. In addition to the provided information, I categorize officials by sex based on their first names and the presence of honorifics. I calculate the sex ratios of first names based on how many men and women report having that name in the 1910 through 1940 censuses (Ruggles et al., 2021). I classify an official as a woman if 99 percent of those with that name in the censuses are women or if their name includes an honorific, such as Miss or Mrs., because many married women are often listed by their husband's name in the roster (e.g., Mrs. John Smith). The total number of female-identified officials and the female share of officials are depicted in Figure 18 broken out by year and official type.

The types of positions held by county and village elected officials remain consistent through the study period, and are shown in the top two panels of Figure 19. Village officials consist of a mayor, a six member village council, a treasurer, a clerk, and a marshal. County officials consist of three county commissioners, legal officers (county prosecutor, probate judge, and sheriff), administrative officers (auditor, recorder of deeds, and treasurer), and a county surveyor (acts as an engineer). Cities employed a greater variety of officials, many individuals held dual positions, and city rosters record appointed officials in addition to elected officials. To simplify analysis of elected officials, I classify those listed as solicitors, city attorneys, and directors of law as law officers and those listed as auditors, treasurers, and directors of finance as financial officers. Other elected city officials include mayors, city council members, city commissioners, and city school board members. I treat city school members separately in my analysis because women could vote in school board elections for my entire study period.

Appointed city officials consist of health commissioners and boards of health (grouped as health officials), directors of public service and safety, library trustees, and sinking fund trustees. Directors of public safety oversaw police, firefighters, and other municipal employees, and directors of public service oversaw public facilities and public works. I define the positions jointly because both jobs were often assigned to a single individual. Trustees of the sinking fund managed the funds used to pay off city bonds and other debts.

3.3.2 Other Data

I collect a variety of data on potential proxies for women's political power. In the 1910s Ohio held three separate referendums on women's suffrage in 1912, 1914 and 1917 as well as three referendums on statewide prohibition in 1914, 1915, and 1917. I collect county level results in these referendums from annual reports published by the Ohio Secretary of

State (Graves, 1912, 1914; Fulton, 1918). For the purposes of analysis I construct an average of county support for each group of referendums weighted by turnout. I use figures from Clubb et al. (2006) on Progressive Party vote share in the 1912 presidential election, the only election the party seriously contested, to measure the local strength of the Progressive Movement. Although these variables gauge the disposition of an exclusively male electorate, there are multiple reasons to think they effectively measure women's political power. In the years leading to the implementation of nationwide prohibition and women's suffrage through constitutional amendments, women's organizations engaged in concerted efforts to persuade men of the causes' merits. Thus, support for those issues or the pro-suffrage Progressive Party likely corresponds to local women's ability to mobilize and persuade voters more generally. Further, men supportive of these issues are likely to be more sympathetic to women's political positions than men who opposed them. I additionally digitize financial data reported in the last OWSA yearbook, published in 1920, to directly identify suffrage supporters and suffrage organizations affiliated with the state association (OWSA, 1920). Individual donations are listed by county and city with the amount of the donation and the name of the donor organization or individual. In my analysis I use the number of donations from a jurisdiction as well as an indicator variable for the presence of a local suffrage organization that paid dues to the OWSA.

In addition, I source data on city and county finances from annual reports of comparative statistics published by the Ohio Auditor of State (O'Brien, 1940). Mortality statistics at the county level are drawn from Bailey et al. (2018). Finally, female electorate shares and census variables used for controls as well as census manuscripts used for matching are drawn from Ruggles et al. (2021). Table 13 reports summary statistics for the female share of various classes of officeholders (scaled from 0 to 100) as well as for explanatory and control variables.

Table 13: County Level Summary Statistics

	Count	Mean	SD	Min	Max
Share of Women Officeholders at the County Level					
County Elected Officials	615	1.768	4.327	0.000	25.000
Village Elected Officials	351	1.799	2.182	0.000	10.000
City Elected Officials	344	2.520	5.627	0.000	25.000
School Board	337	7.696	11.280	0.000	66.666
City Appointed Officials	340	10.713	10.692	0.000	68.75
Explanatory Variables					
Affirmative Vote Share in Suffrage Referendums	88	0.443	0.065	0.201	0.591
Affirmative Vote Share in Prohibition Referendums	88	0.552	0.082	0.195	0.798
Progressive Vote Share in 1912 Pres. Election	88	0.213	0.092	0.078	0.509
Female Share of the Electorate in 1920	88	0.495	0.012	0.423	0.521
OWSA Local Organization Present in 1919	88	0.307	0.464	0.000	1.000
Number of Donations to OWSA in 1919	88	4.398	8.106	0.000	35.000
Controls					
Log County Population	1046	10.696	0.839	9.239	14.012
County Urban Share	1046	0.402	0.239	0.000	0.973
County Black Share	1046	0.023	0.024	0.000	0.138
County Foreign Born Share	1046	0.052	0.059	0.000	0.333
County Household Farm Share	1046	0.313	0.153	0.006	0.650
County Occupation Income Score Mean	1046	17.078	2.114	0.000	23.626
County Manufacturing Employment Share	1046	0.054	0.038	0.000	0.226
County Female Labor Force Participation Rate	1046	0.174	0.043	0.000	0.316

3.4 Empirical Methods

3.4.1 Census Matching

To facilitate comparisons between female officials, male officials, and the general population of Ohio I match officials to decennial censuses based on their names and locations. Rosters of local officials contain two pieces of information that can be used to match them to the census; the official's name and the jurisdiction in which they served. I match officials to the census closest to their election year. So, if their election year fell between 1915 and 1924, I would match officials to the 1920 census. I restrict potential matches in the census to those between the ages of 15 and 75 who also lived in Ohio (as indicated in the census manuscript). I then match based on first name, middle initial, and last name. To successfully match, the first and last initials of the roster-listed official and the census entry must exactly match. However, I allow for fuzzy matches on names conditional on congruent initials. For example, an official with the last name Robins could match to a census entry with the last name Robinson. Each roster-listed official may match with multiple census entries. Many married women serving as officials are listed with their husband's name (e.g., Mrs. John Smith). In these cases, I match based on the husband's name using the normal criteria and only keep the matched census entries that are married household heads. As a final step, I then connect the wives of these married household heads to the original official.

I also conduct a second matching process that geographically restricts potential census entries to the county of the roster-listed official rather than the entire state. In my primary analysis I present two sets of results for officials that uniquely match to an individual within their home county and those that uniquely match to an individual within the state as a whole. Once officials are matched, I pool observations from the four censuses used for matching (1910 through 1940) and make comparisons by regressing a selected trait D_i for individual i on indicator variables for sex Fem_i, holding office $Office_i$, and their interaction $FemXOffice_i$,

$$D_i = \alpha_0 + \alpha_1 * Fem_i + \alpha_2 * Office_i + \alpha_3 * FemXOffice_i + \phi_i + \varepsilon_i \tag{11}$$

To ensure relevant comparisons I include a large set of fixed effects ϕ_i for every unique combination of values from a set of covariates. The covariates are census year, county, age, birthplace [5], farm status, and race. Estimated coefficients represent comparisons made between individuals of the same age, nativity, race, and farm status that live within the same county in the same census year.

3.4.2 Difference in Differences

Figures 18 and 19 show that, on the whole, women's office holding increased after women gained the right to vote in 1920. The goal of my identification strategy is to determine whether areas with greater pro-suffrage sentiment and greater sympathy towards women's issues also elected women to office at higher rates in the wake of suffrage. I employ a difference-in-differences identification strategy, using multiple potential proxies of voters' attitudes towards women's issues and women holding office. To identify how women's new-found political power influenced the election of female officials, treatment is defined as the interaction between one of these variables, D_{ct} , and an indicator variable $POST_t$ that takes on a value of one for years after 1920 and 0 otherwise. I estimate the effect of each proxy on the share of women holding office at a given level of local government using the equation:

$$FemElectedShare_{jct} = \beta_0 + \beta_1 POST_t * D_{ct} + \delta_c + \gamma_t + \beta X_{xt} + \varepsilon_{ct} \tag{12}$$

$FemElectedShare_{jct}$ is the female share of officials serving in local governments of type j within a county c in year t. The types of local government officials are county elected, village elected, city elected, city school board [6], and city appointed. I aggregate electoral outcomes to the county level because many of my measures of voters' attitudes are unavailable for individual municipalities. For example, the women's share of city elected officials in Richland County is the sum of elected female officials in the county's two cities, Shelby and Mansfield, divided by the total combined number of elected city officials in those two cities. I include a county fixed effect δ_c and a year fixed effect γ_t, and I cluster standard errors at the county

[5] Birthplace is coded by state of birth if an individual was born in the United States and country of birth if born outside the United States. Nativity is subsumed by the birthplace variable.

[6] City school boards were elected, but I treat them separately from other city elected officials because Ohio women gained the right to vote for school board in 1894 rather than 1920.

level throughout analysis. X_{ct} is a set of time-varying controls that includes log of population, share of county population in urban areas, black share, foreign born share, farm household share, average occupation income score (an estimate of wage income), the share of adults working in manufacturing, and female labor force participation rates.

3.5 Results

3.5.1 Descriptive Results

Figures 18 and 19 present time series of female office holding based on the frequency of officials having predominately female first names. In terms of absolute numbers women saw the most success as elected officials at the village level and as appointed city officials (see left panel of Figure 18. However, despite also making up a large share of appointed city officials, roughly 17 percent by 1940, they held less than 5 percent of village offices. Aside from appointed city officials, women were represented most highly on city boards of education, and the share of women serving on these boards reached its peak in the 1921 municipal elections. Since women in Ohio could vote for and serve on boards of education prior to the nineteenth amendment, this jump following 1920 suggests women's suffrage had an effect on female office-holding separate from the enfranchisement of women as voters. Enthusiasm in the immediate aftermath of the suffrage movement's victory could have mobilized feminist-minded voters or altered the composition of female candidates that chose to run for office.

Among other elected positions, women saw the highest representation in positions that focused on government finance and administration, such as treasurer, auditor, recorder of deeds, and other clerical roles. As can be seen in Figure 19, county recorder was a clear outlier among county elected positions, with the female share reaching a peak of 17 percent. Of elected village officials, women served almost exclusively in the roles of village treasurer and village clerk. Similarly, in city governments women were most commonly elected as financial officers (treasurers and auditors) and those offices actually had higher female representation (approximately 10 percent) than city boards of education by the late 1920s.

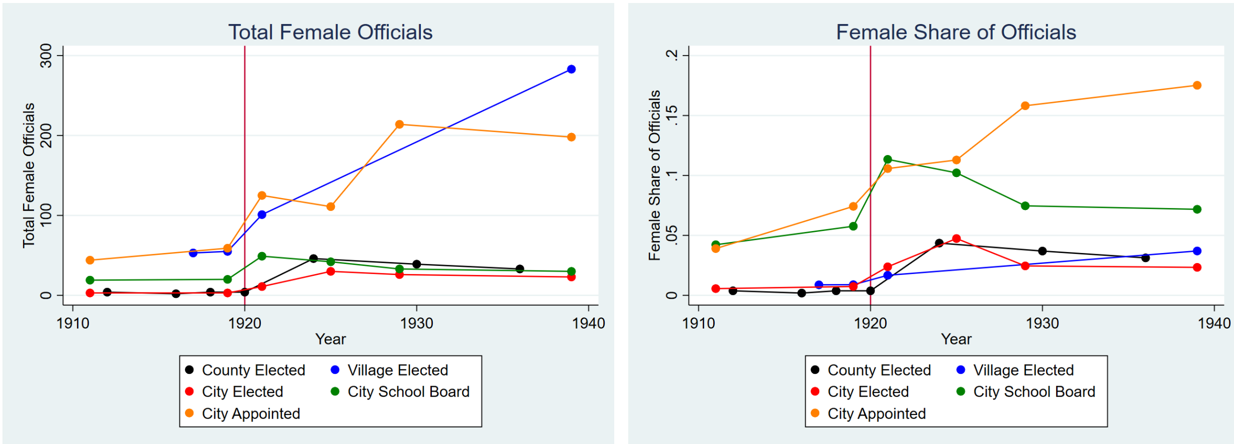


Figure 18: Number and Share of Female Officials over Time

Despite moderate success in entering a subset of elected positrons after the passage of women's suffrage, women remained effectively barred from other positions. In executive roles, such as county commissioner and village or city mayor, the female share of officeholders remained close to zero. Women gained a small number of city council seats in the mid-1920s only for the female share of councillors to once again fall to near zero. The share of female held positions on village councils stayed near zero for the entire period of study. A similar bifurcation of roles also occurs for appointed city officials. Practically no women serve as directors of public service or safety or as trustees of the city sinking funds. However, the filled 10 to 20 percent of spots on library boards prior to suffrage and took up over a third of those positions by 1940. Women constituted a negligible share of those serving as health commissioners or on boards of health prior to suffrage, but reached 12 percent of such positions after women gained the right to vote. Interestingly, the female share of appointments as library trustees and health officials both plateaued fairly quickly after an initial increase following 1920.

The differences in women's office holding from position to position appear to reflect women's opportunities in the labor market as a whole. During the early twentieth century women entered educational and clerical work in large numbers even though they faced barriers to advancement beyond entry-level positions (Goldin, 1994). Similarly, women could

Figure 19: Female Share by Position

Table 14: Male and Female Officials by Political Party

	Men		Women		Total
Nonpartisan	24762	(98.02)	500	(1.979)	25262
Republican	8053	(97.13)	238	(2.871)	8291
Democrat	5148	(97.48)	133	(2.518)	5281
Independent	795	(96.01)	33	(3.986)	828
Third Party	152	(96.20)	6	(3.797)	158
Total	38910	(97.71)	910	(2.285)	39820

enter into local government, but they were largely constrained to positions dealing with clerical work and education. Moreover, women proved completely absent from positions that would require them to supervise significant numbers of men, such as the role of director of public safety who oversaw police and fire departments. Women's disproportionate presence in clerical roles as opposed to more politicized positions in the 1920s and 30s also matches the experiences of contemporary women in local government who express greater hesitance to enter competitive races than male officials and who also place a greater emphasis on service rather than political ambition (Thomas and Wilcox, 2014).

Despite differences in the positions they held, Table 14 shows the partisan composition of female officials roughly mirrors that of male officials. Table 15 compares the marital status of male and female officeholders with the general population. Compared to men, women holding office were far less likely to be married and much more likely to have never been married. The gaps between male and female officeholders are overwhelmingly explained by the selection of unmarried women into local office as women in the general population were significantly more likely to be married than men. Although the differences in magnitude were smaller, female officials were also more likely than male officials to be widowed. Table 16 conducts a similar exercise, but focuses on household position and number of children. Women serving as officials essentially matched women in the general population in their likelihood of being household head or living with their parents. As a result, they were far less likely than male officials to head their household but lived with their parents at roughly equivalent rates. Women holding local office had significantly fewer children than their male

Table 15: Office Holding and Marital Status by Sex

	(1) Married	(2) Married	(3) Never Married	(4) Never Married	(5) Widowed	(6) Widowed
Female	0.0203***	0.0205***	-0.0751***	-0.0752***	0.0524***	0.0524***
	(0.000199)	(0.000199)	(0.000170)	(0.000170)	(0.000109)	(0.000109)
Officeholder	0.0839***	0.125***	-0.0608***	-0.0875***	-0.0297***	-0.0187***
	(0.00400)	(0.00294)	(0.00342)	(0.00251)	(0.00221)	(0.00162)
Female X Officeholder	-0.159***	-0.247***	0.131***	0.192***	0.0480***	0.0291***
	(0.0145)	(0.0111)	(0.0124)	(0.00948)	(0.00801)	(0.00612)
Constant	0.613***	0.613***	0.336***	0.336***	0.0397***	0.0398***
	(0.000136)	(0.000137)	(0.000117)	(0.000117)	(0.0000752)	(0.0000753)
Observations	17465646	17465646	17465646	17465646	17465646	17465646
# Matched Officials	11,753	21,892	11,753	21,892	11,753	21,892
# Matched Female Officials	891	1,533	891	1,533	891	1,533
Match Rate	27.2%	50.4%	27.2%	50.4%	27.2%	50.4%
Unique Match	In State	In County	In State	In County	In State	In County

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

counterparts or women in general, as would be expected given their low rates of marriage. Figure 20 depicts the age distributions of male and female officials under different matching strategies. Although the pattern is more visible when matching is restricted within counties, both histograms show women in local office tended to be younger than their male colleagues.

Taken together these results indicate that women serving in local office tended to be younger women who had not yet married. During this era married women faced severe restrictions, both formal and informal, on working outside the home (Goldin, 2006). Thus, women holding local office likely faced the same general pressures to exit the labor force after marriage, just as they were constrained to roles that matched their opportunities in the private sector. Similar issues also arise in modern contexts even as the labor force participation of married women has increased. Contemporary female politicians frequently cite family obligations as an obstacle to holding elected positions in government or advancing to higher office (Thomas and Wilcox, 2014).

Tables 17 and 18 report comparisons of income and education respectively. Columns (1)

Table 16: Office Holding and Household Position by Sex

	Relationship to Household Head				Own Children In Household	
	(1)	(2)	(3)	(4)	(5)	(6)
	Head	Head	Child	Child	# Children	# Children
Female	-0.513***	-0.513***	-0.0314***	-0.0314***	0.153***	0.153***
	(0.000173)	(0.000173)	(0.000148)	(0.000148)	(0.000679)	(0.000679)
Officeholder	0.114***	0.157***	-0.0282***	-0.0325***	0.0709***	0.0966***
	(0.00349)	(0.00256)	(0.00298)	(0.00219)	(0.0137)	(0.0101)
Female X Officeholder	-0.114***	-0.152***	0.0313***	0.0567***	-0.470***	-0.541***
	(0.0126)	(0.00966)	(0.0108)	(0.00826)	(0.0497)	(0.0380)
Constant	0.599***	0.598***	0.227***	0.227***	1.009***	1.009***
	(0.000119)	(0.000119)	(0.000102)	(0.000102)	(0.000467)	(0.000467)
Observations	17465646	17465646	17465646	17465646	17465646	17465646
# Matched Officials	11,753	21,892	11,753	21,892	11,753	21,892
# Matched Female Officials	891	1,533	891	1,533	891	1,533
Match Rate	27.2%	50.4%	27.2%	50.4%	27.2%	50.4%
Unique Match	In State	In County	In State	In County	In State	In County

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

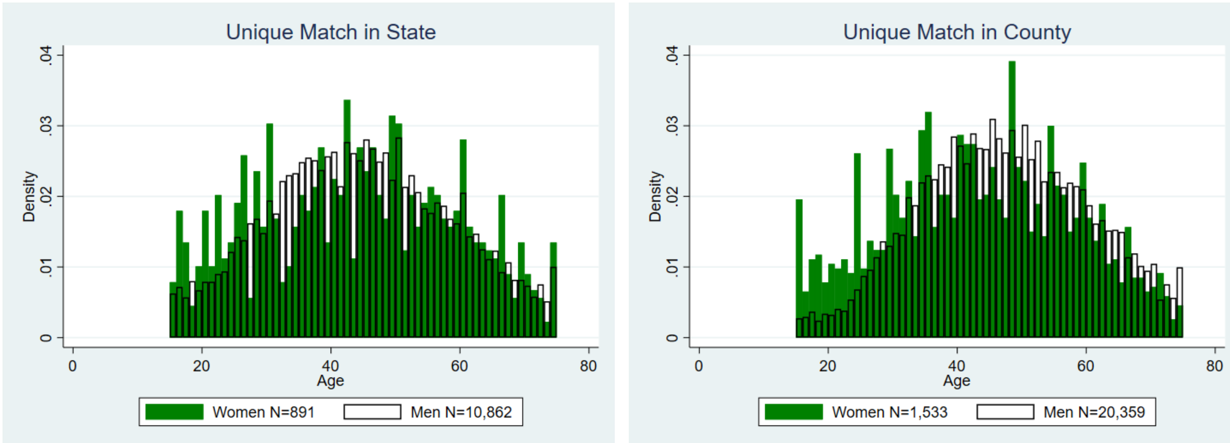


Figure 20: Matched Male and Female Officials by Age

and (2) of Table 17 show differences in occupation income score based on sex and office holding.[7] Similar to the population at large, female office holders earn less than their male peers. Columns (3) and (4) drop individuals that worked in public administration or whose sector of employment was unclassified in the census. After this modification, the occupation income scores of remaining officials represent either part-time work they held simultaneously with their public office or jobs they had directly before or after holding office. As with columns (1) and (2) female officeholders earn less than their male counterparts, but more than women in the general population. Because I drop those working in public administration, these gaps are not attributable to men holding more higher-paying senior posts in government. In columns (5) through (8) I substitute wage income for occupation income score and find similar results, although this change limits my sample to the 1940 census. Finally, Table 18 shows that while female officials were more likely than male officials to complete high school they were equally likely to have had at least one year of college education.[8] However, the education gaps between male and female officials are small in comparison to the gap between all officials and the population at large.

[7]The 1940 census was the first to report income from wages. As a result, it is common practice to use occupation income score to proxy for income. Occupation income score imputes income based on listed occupation and the distribution of wag between occupations in the 1950 census.

[8]Measures of education are also only available for the 1940 census.

Table 17: Office Holding and Income by Sex

	Occupation Income Score				Wage Income			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All	All	No Public	No Public	All	All	No Public	No Public
Female	-14.81***	-14.80***	-7.336***	-7.327***	-449.6***	-449.6***	-281.3***	-281.2***
	(0.00541)	(0.00541)	(0.00873)	(0.00873)	(1.261)	(1.261)	(1.625)	(1.625)
Officeholder	5.520***	7.487***	5.393***	7.904***	282.3***	165.3***	223.0***	157.6***
	(0.109)	(0.0800)	(0.118)	(0.0863)	(27.92)	(20.25)	(25.98)	(18.82)
Female X Officeholder	-3.216***	-4.602***	-3.712***	-5.871***	-17.95	-191.0**	-47.11	-215.7**
	(0.395)	(0.302)	(0.714)	(0.546)	(97.72)	(76.03)	(128.8)	(109.5)
Constant	18.72***	18.71***	23.68***	23.67***	1135.2***	1135.2***	1092.2***	1092.2***
	(0.00372)	(0.00372)	(0.00386)	(0.00386)	(0.880)	(0.880)	(0.804)	(0.805)
Observations	17465646	17465646	7976161	7976161	5161366	5161366	2821472	2821472
# Matched Officials	11,753	21,892	7,321	13,755	2,882	5,453	2,153	4,112
# Matched Female Officials	891	1,533	196	334	239	384	87	118
Match Rate	27.2%	50.4%	16.2%	30.3%	27.8%	51.2%	19.9%	37.7%
Unique Match	In State	In County	In State	In County	In State	In County	In State	In County

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

Table 18: Office Holding and Education by Sex

	(1)	(2)	(3)	(4)
	Finished High School	Finished High School	Any College	Any College
Female	0.0299***	0.0302***	-0.0146***	-0.0144***
	(0.000372)	(0.000372)	(0.000251)	(0.000251)
Officeholder	0.171***	0.206***	0.117***	0.141***
	(0.00826)	(0.00598)	(0.00556)	(0.00403)
Female X Officeholder	0.108***	0.0345	0.0347*	-0.0158
	(0.0294)	(0.0227)	(0.0198)	(0.0153)
Constant	0.270***	0.270***	0.0969***	0.0968***
	(0.000260)	(0.000260)	(0.000175)	(0.000175)
Observations	5087031	5087031	5087031	5087031
# Matched Officials	2,824	5,363	2,824	5,363
# Matched Female Officials	226	369	226	369
Match Rate	27.8%	51.2%	27.8%	51.2%
Unique Match	In State	In County	In State	In County

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

3.5.2 Local Determinants of Female Office Holding

Variation in women's office holding over time suggests that it increased as a result of women gaining equal voting rights in 1920. However, can differences in women's political power and the electorate's attitude towards women's issues explain variation in women's office holding between locations? Table 19 shows the results of three difference-in-difference models estimating the impacts of three measures that capture local variation in the electorate's support for women's issues. Panel A uses support for state-level women's suffrage averaged across three referendums conducted between 1912 and 1917, Panel B uses support for state-level prohibition averaged across three referendums conducted between 1914 and 1917, and Panel C uses the vote share received by the pro-suffrage Progressive Party in the 1912 presidential election. In all cases, the variable of interest is the interaction between the voter attitude measure and an indicator variable for post-1920 elections. The explanatory variables are standardized and centered on their means, and the dependent variable is the female share of officials scaled to between 0 and 100. The coefficient of the interaction term can thus be interpreted as the differential effect a one standard deviation increase in the voter attitude measure has on the share of women gaining office in post-1920 elections compared to pre-1920 elections. The unit of observation is the county, and each column reports results for different levels of local government.

For elected officials in county government a one standard deviation rise in support for state-level suffrage or prohibition both led to a 1.1 percentage point increase in the female share of officeholders after 1920. Both variables had an insignificant impact on the female share of elected officeholders at the city and village level. However, a one standard deviation increase in suffrage or prohibition support raised the female share of appointed city officials post-1920 by 2.5 and 3.6 percentage points respectively, although the estimates are only marginally significant. The estimated effects on the female share of city school boards in column (4) are not directly comparable to estimates presented in the other columns because Ohio women gained voting rights for school boards in 1894 rather than 1920. Consequently, women's political power with regards to school board elections would not shift nearly as dramatically as for other municipal and county offices. The implementation of suffrage rights in other elections could still feasibly impact women's representation on school boards. For example, the ability to vote for multiple municipal offices could alter women's incentives to cast ballots and change the composition of the female electorate. Likewise, the viability of holding other elected offices could also change the pool of female candidates running for school board. Support for suffrage and the Progressive party actually lowered women's representation on school boards in elections after 1920. In the case of suffrage support the share of women fell by 2.5 percentage points and in the case of Progressive presidential vote share support fell by a marginally significant 23.3 percentage points. This result suggests that the rise in female representation on boards of education shown in Figure 18 was driven by counties with low support for women's suffrage. Progressive support has no significant impact on any other types of officials.

3.5.3 Female Officials and Financial Outcomes

This section explores whether female office holding correlates with the policy changes commonly associated with women's suffrage; higher taxes, higher overall spending, and greater spending on health and welfare. I regress per capita measures of taxation and spending on the overall female share of officials elected or appointed between 1920 and 1940 controlling for population size in 1940 and a baseline measure of the relevant financial statistic. Data on taxes and spending are available for both city and county governments. In Column (1) of Tables 21 and 22 I aggregate the financial outcome variables and the female share of officeholders to the county level. Thus, per capita spending in Column (1) is the sum of county spending and the spending of all cities within that county divided by the total county population, and the female share of elected officials is aggregated from officials serving in all forms of local government within the county. Column (2) reports county per capita outcomes regressed on women's share of county officials, and Columns (3) and (4) regress per capita city outcomes on women's share of elected or appointed city officials.

Results from Table 21 show that when counties and cities are treated separately the share of female officials has no significant relationship with taxes per capita, spending per capita, or charity spending per capita. However, using the fully aggregated measures in

Table 19: Effect of Male Electorate Measures on the Election of Women

	(1) County Elected	(2) Village Elected	(3) City Elected	(4) City School Board	(5) City Appointed
Panel A: Suffrage Referendums					
Post 1920 X Suffrage Vote Share	1.107**	0.291	-0.813	-2.585**	2.516*
	(0.493)	(0.230)	(0.648)	(1.090)	(1.480)
Constant	32.79	-29.05	-27.24	-56.44	129.3
	(40.02)	(29.28)	(46.01)	(84.50)	(85.37)
Observations	615	351	344	337	340
Adjusted R^2	0.262	0.360	0.238	0.272	0.366
Panel B: Prohibition Referendums					
Post 1920 X Prohibition Vote Share	1.113**	0.254	-0.204	-1.316	3.688*
	(0.487)	(0.196)	(0.633)	(0.992)	(1.914)
Constant	18.42	-32.78	-22.95	-43.91	115.2
	(41.05)	(29.47)	(44.56)	(81.71)	(81.70)
Observations	615	351	344	337	340
Adjusted R^2	0.260	0.358	0.233	0.263	0.380
Panel C: 1912 Progressive Support					
Post 1920 X Progressive Vote Share	-4.465	6.575	2.347	-23.30*	18.41
	(6.837)	(4.194)	(5.202)	(13.26)	(14.07)
Constant	32.93	-22.67	-22.52	-47.50	118.0
	(38.93)	(27.39)	(44.85)	(82.23)	(88.34)
Observations	615	351	344	337	340
Adjusted R^2	0.246	0.357	0.236	0.263	0.356
Mean Female Share of Officials	1.8	1.8	2.4	7.8	10.3
Year FE	Yes	Yes	Yes	Yes	Yes
Jurisdiction FE	Yes	Yes	Yes	Yes	Yes

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

Table 20: Effect of Female Electorate Measures on the Election of Women

	(1)	(2)	(3)	(4)	(5)
	County Elected	Village Elected	City Elected	City School Board	City Appointed
Panel A: 1920 Female Electorate Share					
Post 1920 X Female Electorate Share	-0.679	-0.117	0.418	1.778	-1.682
	(0.450)	(0.271)	(0.591)	(1.427)	(1.319)
Constant	43.55	-28.50	-37.33	-105.6	178.0
	(39.32)	(30.32)	(50.51)	(88.65)	(110.6)
Observations	615	351	344	337	340
Adjusted R^2	0.251	0.355	0.234	0.266	0.358
Panel B: 1919 Local OWSA Presence					
Post 1920 X OWSA Suffrage Organization	-0.451	0.326	-3.849**	-4.400	-6.152**
	(1.050)	(0.458)	(1.473)	(2.794)	(2.808)
Constant	31.44	-26.04	-61.61	-87.96	50.88
	(44.08)	(29.69)	(49.98)	(87.79)	(90.57)
Observations	615	351	344	337	340
Adjusted R^2	0.245	0.356	0.260	0.269	0.372
Panel C: 1919 Number of OWSA Donations					
Post 1920 X OWSA Donations	-0.675	-0.0793	-0.267	0.0187	-0.795
	(0.510)	(0.219)	(0.554)	(1.893)	(1.262)
Constant	16.67	-31.91	-30.81	-43.09	90.49
	(45.08)	(30.59)	(47.61)	(90.14)	(100.1)
Observations	615	351	344	337	340
Adjusted R^2	0.249	0.354	0.233	0.260	0.354
Mean Female Share of Officials	1.8	1.8	2.4	7.8	10.3
Year FE	Yes	Yes	Yes	Yes	Yes
Jurisdiction FE	Yes	Yes	Yes	Yes	Yes

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

Column (1) produces statistically significant conditional correlations for taxation and overall spending, although the conditional correlation between women's office holding and charity spending remains statistically insignificant. Additionally, the measures of fit for regressions in Column (1) are substantially higher. The first row of Table 22 repeats the analysis of Table 21 with per capita health spending as the outcome. Health spending shows no statistically significant association with the female share of elected officeholders in Columns (1) through (3). However, health spending displays a significant and negative conditional correlation with the share of women appointed to city offices. Column (5) demonstrates that the negative relationship remains when the focus is narrowed to the female share of appointed health officials. This negative conditional correlation may result from mayors appointing women as health officials in cases when those positions were less prestigious and under-resourced. Table 22 also shows results from regressing county level infant mortality rates (infant deaths per 10,000 births) and all ages mortality rates (deaths per 10,000 population) on the female share of officials. I find a positive and statistically significant conditional correlation with all ages mortality in Column (1) and a negative and a marginally significant negative relationship with infant mortality in Column (3). Notably, the negative conditional correlation the female share of city appointed officials has with health spending is not matched by a negative correlation with mortality rates.

3.6 Discussion and Conclusion

After the passage of the nineteenth amendment in the United States women increased their political participation by not only casting ballots but also by serving in local government as elected and appointed officials. Moreover, unlike women's voting patterns, women's office holding is directly observable in the historical record, offering a window into how women's political participation changed in the wake of their enfranchisement. I find women's suffrage led to a substantial increase in female representation, but de facto restrictions existed on both the types of offices women could hold and the types of women who could hold office. The local government offices women could gain access to prior to 1940 largely corresponded to

Table 21: Share of Female Officials and Local Government Finances

	(1)	(2)	(3)	(4)
	Aggregated County	County Elected	City Elected	City Appointed
Panel A: Taxation				
Share Officials Women 1920-1940	0.773**	10.82	-4.263	25.94
	(0.323)	(10.24)	(49.43)	(23.79)
Taxes 1916	0.616***	0.277***	1.527***	1.509***
	(0.122)	(0.0737)	(0.394)	(0.389)
Constant	-100.7***	32.75***	-26.32	-33.88*
	(10.48)	(5.699)	(18.06)	(19.03)
Mean 1940 Taxes Per Capita	37.15	22.49	44.64	44.64
Observations	88	88	79	79
Adjusted R^2	0.741	0.284	0.224	0.236
Panel B: Total Spending				
Share Officials Women 1920-1940	0.641*	4.721	-0.789	22.92
	(0.374)	(11.26)	(56.77)	(27.82)
Expenditures 1916	0.410***	0.204***	0.103	0.0801
	(0.120)	(0.0748)	(0.202)	(0.203)
Constant	-94.51***	40.25***	-16.36	-22.92
	(12.24)	(6.140)	(20.51)	(21.72)
Mean 1940 Expenditures Per Capita	37.01	22.37	43.54	43.54
Observations	88	88	80	80
Adjusted R^2	0.657	0.255	0.069	0.077
Panel C: Charity Spending				
Share Officials Women 1920-1940	0.0972	-1.023	3.237	7.601
	(0.0891)	(4.225)	(10.84)	(5.213)
Charity Expenditures 1916	0.923**	0.573*	2.579**	2.545**
	(0.383)	(0.296)	(1.056)	(1.042)
Constant	-16.14***	6.422***	-11.22**	-13.38***
	(2.863)	(2.107)	(4.599)	(4.777)
Mean 1940 Charity Expenditures Per Capita	7.79	6.31	3.77	3.77
Observations	88	88	79	79
Adjusted R^2	0.476	0.012	0.296	0.314

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

Table 22: Share of Female Officials and Health Outcomes

	(1) Aggregated County	(2) County Elected	(3) City Elected	(4) City Appointed	(5) Health Officials
Panel A: Health Spending					
Share Officials Women 1920-1940	0.0166	2.412	0.0812	-1.117**	-0.615**
	(0.0241)	(1.600)	(0.948)	(0.450)	(0.291)
Health Expenditures 1916	0.0131*	0.0133	0.391	0.371	0.262
	(0.00772)	(0.0106)	(0.240)	(0.231)	(0.241)
Constant	-4.034***	-3.396***	-0.0784	0.257	0.104
	(0.787)	(0.873)	(0.342)	(0.352)	(0.340)
Mean 1940 Health Expenditures Per Capita	0.79	0.60	0.56	0.56	0.56
Observations	88	88	79	79	79
Adjusted R^2	0.362	0.177	0.051	0.123	0.104
Panel B: Infant Mortality					
Share Officials Women 1920-1940	4.315	251.0	-496.4*	-19.27	147.6
	(5.132)	(345.4)	(248.3)	(135.8)	(88.74)
Infant Mortality 1920	0.222**	0.224***	0.149*	0.166**	0.164**
	(0.0857)	(0.0816)	(0.0780)	(0.0820)	(0.0816)
Constant	650.9***	610.7***	604.0***	577.4***	526.4***
	(164.0)	(151.0)	(100.4)	(109.3)	(111.9)
Mean 1940 Infant Deaths per 10,000 Births	443.3	443.3	440.2	440.2	440.2
Observations	88	88	80	80	80
Adjusted R^2	0.066	0.064	0.089	0.057	0.088
Panel C: All Ages Mortality					
Share Officials Women 1920-1940	1.253**	-40.92	32.05	-1.269	14.19
	(0.603)	(35.51)	(58.62)	(20.37)	(12.83)
All Ages Mortality 1920	0.462***	0.557***	0.617***	0.594***	0.579***
	(0.108)	(0.158)	(0.179)	(0.179)	(0.157)
Constant	82.49***	80.01***	73.75***	78.55***	75.62***
	(20.64)	(20.24)	(24.69)	(25.38)	(24.32)
Mean 1940 Deaths per 10,000 Population	116.1	116.1	118.4	118.4	118.4
Observations	88	88	80	80	80
Adjusted R^2	0.260	0.231	0.262	0.256	0.269

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

the opportunities available to them in the private sector. Female officials disproportionately held positions related to clerical work, such as city auditor or treasurer, as well as education. Starting from a baseline of negligible representation, the female share of city treasurers and auditors rose to 10 percent, the share of village treasurers rose to 18 percent, and the female share of county recorders reached 16 percent. Female representation in government roles related to education, the only positions that supported women's office holding prior to the nineteenth amendment, also increased following suffrage. The share of women on library boards rose from 20 percent to 34 percent, and the share of women on boards of education doubled in the first election after suffrage from 6 to 12 percent. However, despite gains in these areas female representation among mayors, municipal legislators, and legal officers remained close to zero.

Women elected or appointed to office differed from male officeholders and the general population in several ways. Female officials were far less likely to have ever been married than their male peers or women in the general population, and widows were also over-represented among female officials. Female officials also had significantly fewer children than male officials or women not holding office and were more likely to have completed high school. In short, women holding office tended to be educated, younger women who had not yet married, and, similar to women workers in the private sector, they most likely exited their positions upon marriage.

I also explore whether more women were elected in places where women had greater political power. Difference-in-differences estimations suggest that women's political had a weak and sometimes counterproductive influence on women holding office. Male support of suffrage and prohibition, as measured by vote shares in referendums, are the only two proxies of women's political power that positively impacted female office holding, and the effect was limited to county elected officials and city appointed officials. The female share of the electorate and the quantity of donations to the state suffrage movement both had insignificant effects on the election of women, and the presence of a local suffrage organisation affiliated with the broader state movement actually reduced female representation among city officials. In short, the election of women to office does not seem to have been a consistent preference among female voters or male voters sympathetic to women's issues. Voters supportive of women's issues may not have prioritized the election of women given the limited number of roles feasibly available to them within local government. In turn, women may have been limited in their choice of local offices because of the general expectation they would give up their political careers upon marriage.

I do find that increased female office holding is associated with greater taxing and spending. However, the relationship if not robust, and I am unable to identify whether the correlation results from the influence of women in office, the preferences of voters that elected women, or unobserved confounders. I also find a negative correlation between women serving on boards of health and health spending at the city level. This negative correlation could result from negative selection in which women disproportionately gained appointments when boards of health were already under-resourced. Alternatively, the presence of women on boards of health could indicate greater volunteer resources and, consequently, less spending.

Several questions remain regarding the determinants and effects of women's office holding in the years following the extension of women's suffrage. Expanding the scope of the investigation to include elections and unsuccessful candidates would provide insights into the selection process for female officeholders. For example, to what extent are the differences between male and female officeholders attributable differences between candidates and to what extent are they determined by the voters' selection among candidates. Additionally, while measures of women's political power had largely null effects on the election of female officials, that does not mean they had no impact on female candidacy. Finally, data on election results could also help causally identify the effects of female officials by using close elections in a regression discontinuity framework.

Appendix A Alternative Land Availability Measure

In my primary analysis I rely on measures of developable land that do not scale based on the cities' geographic footprints. Applying a one-size-fits-all approach may introduce measurement error and bias by falling short of the urban boundary for large cities or needlessly including irrelevant rural land for smaller settlements. In this appendix I detail the construction of an alternative measure that uses historical development data to more accurately envelope the urban fringe, and I show my results are robust to using the scaled measure as an instrument. I utilize the Historical Settlement Data Compilation for the United States (HISDAC-US) created by Leyk and Uhl (2018). Based on property records collected by Zillow, this data-set contains the year of first settlement as well as the total floor space for every cell in a 250m by 250m grid overlaying the Continental United States from 1810 to 2015 with a 5 year frequency

To construct the scaled measure, I combine information on built-up areas in 1920 (depicted in red and blue in Figure 21) reported by HISDAC-US with modern (2021) city boundaries (shown in gray in 21). I classify a grid cell as developed if HISDAC-US reports it containing any structures. I treat the modern city boundary as the outer bound for city limits in 1920, and identify the largest contiguous patch of developed grid cells (shown in blue) within the modern boundary. I treat this patch as a city's core developed area. I then draw the minimum bounding circle for each city's core developed area (the dotted line). The innermost circle of measurement, analogous to the 0 to 4 kilometer range in my primary analysis, consists of the minimum bounding circle plus 2 kilometers. As in my primary analysis, I also measure developable land share in larger circles, expanding the radius by 4 kilometers for each subsequent circle of measurement. Compared to my original measure the scaled version differs not only in size but in location. In Figure 21 the black dot marks the center of Cincinnati according to coordinates provided by Ruggles et al. (2021) while the scaled measure shifts the center southeast

Despite its expansiveness over space and time, the HISDAC-US suffers from two notable limitations. First, the data-set's origin in modern records means it measures surviving development from a given year rather than all development that existed contemporaneously. For example, a neighborhood entirely demolished by a natural disaster or urban renewal in 1952 would appear empty in 1950. I therefore adopt a conservative cut-off, defining grid cells as built up if they contain any development to minimize false negatives [1]. Second, records are wholly unavailable for some counties, especially in rural areas. Due to these gaps, I am unable to construct the scaled measure for 457 municipalities, or 18% of my primary sample

Table 23 compares summary statistics between dropped cities and those remaining in the sample. Dropped cities significantly differ from the remaining sample along nearly every measured variable with the exceptions of elevation, ruggedness, and the distance to nearest river or state line. Dropped municipalities are less likely to have zoned by 1936 and are drawn disproportionately from the Midwest and Northeast. Demographically, they contain more foreign born and fewer black residents on average. They tend to be smaller, less urbanized, and less industrialized with fewer manufacturing workers per capita and lower incomes as measured by occupation income score. In short, HISDAC-US disproportionately omits isolated, rural communities in the Northeast and Midwest.

Table 24 presents the my primary result using the scaled measure as the instrument in comparison with the unscaled measure used in the primary analysis (Table 2). Column (1) and Column (3) contain, respectively, the initial OLS and IV results, and Column (2) and Column (4) simply restrict the sample to cities for which the scaled instrument can be constructed. Finally, Column (5) presents the coefficient of an IV regression using the scaled measure at a range of core area plus 2 km as the instrument. Restricting the sample does not significantly alter the effect size, nor does using the scaled measure. However, using the scaled measure does lead to a much stronger first stage with an effective F-stat roughly 1.5 times that of the size of the unscaled measure. Figure 22 compares scatter-plots of the first stage for the original and scaled measures of the developable land share instrument. As the F-stat in Column (4) shows, this increase is not driven by selection. Table 25 recreates Table 4 using scaled developable land share as the instrument. Results remain similar, although

[1] Given the construction of the data-set, I assume false positives, i.e., grid cells assigned development when they were empty, are negligible compared to potential false negatives. False negatives could arise demolished buildings, incomplete records, or missing records while a false positive would require an otherwise valid record with an incorrect date.

the drop in magnitude and statistical significance when using out of state land is more pronounced when using the scaled measure

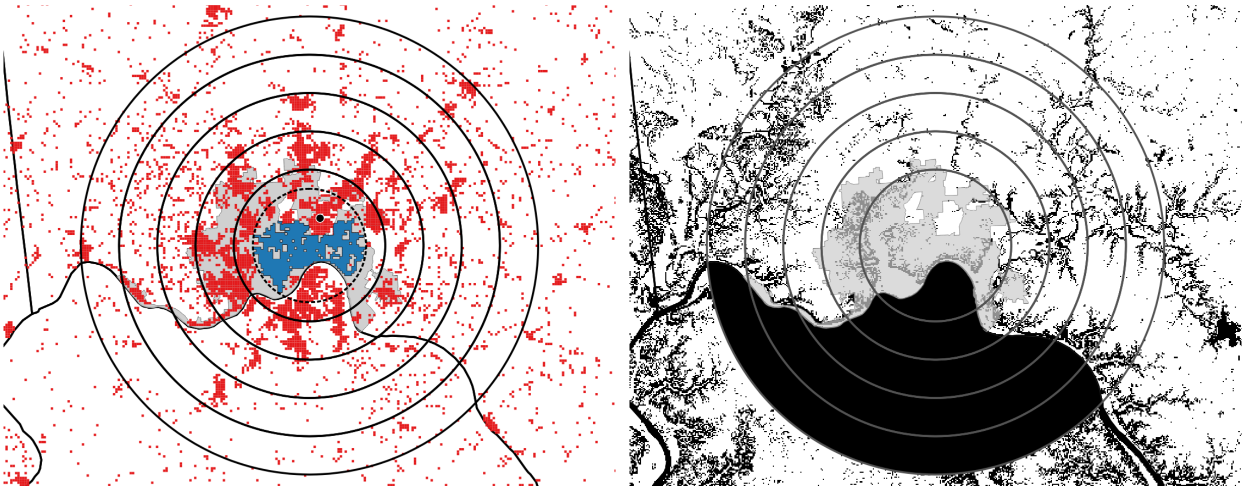


Figure 21: Scaled Developable Land Measure Construction

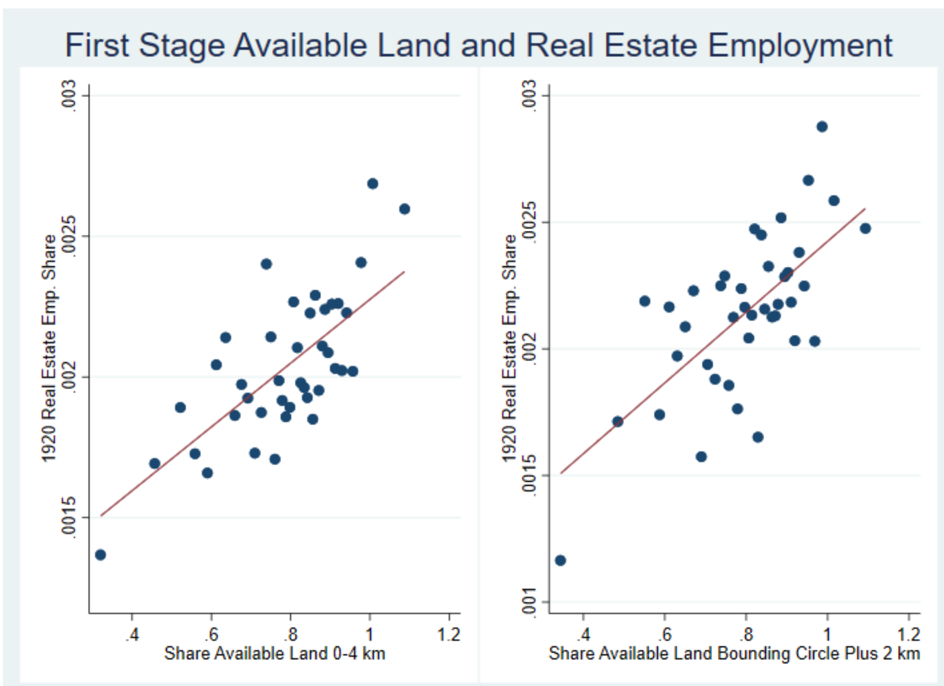


Figure 22: First Stage of Alternative Instrument

Table 23: Balance Table

	Mean of Sample	Mean of Dropped	Difference	p-value
Zoned by 1936	0.307	0.175	0.132	0.000
Northeast	0.335	0.420	-0.085	0.001
Midwest	0.310	0.414	-0.103	0.000
South	0.252	0.127	0.125	0.000
West	0.103	0.039	0.063	0.000
Log 1920 Population	8.886	8.638	0.248	0.000
1920 County Urban Share	0.483	0.433	0.050	0.000
1920 Black Share	0.074	0.054	0.019	0.003
1920 Foreign Born Share	0.117	0.135	-0.018	0.001
1920 Manufacturing Workers Per Capita	0.076	0.064	0.012	0.000
1920 Mean Occupation Income Score	17.811	17.428	0.383	0.004
1920 Home Ownership Rate	0.497	0.528	-0.030	0.000
1920 Real Estate Employment Share	0.002	0.002	0.001	0.000
1912 County Progressive Pres. Vote Share	0.244	0.287	-0.044	0.000
Distance to Coast (km)	251.677	204.902	46.776	0.000
Distance to Rivers (km)	2.508	2.281	0.228	0.430
Distance to State Line (km)	44.933	43.006	1.927	0.403
Elevation (meters)	248.801	238.287	10.514	0.486
Elevation Standard Deviation (within 20 km)	135.978	163.656	-27.677	0.335
Municipalities with 25 km	16.348	10.958	5.389	0.000
Observations	2111	457		

Table 24: Main Results

	(1)	(2)	(3)	(4)	(5)
	Zoned by 1936	Zoned by 1936	Zoned by 1936	Zoned by 1936	Zoned by 1936
Real Estate Emp. Share 1920	0.154***	0.147***	0.754***	0.788***	0.758***
	(0.0243)	(0.0264)	(0.194)	(0.219)	(0.181)
Observations	2568	2111	2568	2111	2111
Adjusted R^2	0.369	0.376	0.205	0.187	0.205
Estimator	OLS	OLS	IV	IV	IV
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Outcome Mean	0.283	0.307	0.283	0.307	0.307
F-Statistic			29.802	23.060	46.739
Anderson-Rubin p-val.			0.000	0.000	0.000
KP underident p-val.			0.000	0.000	0.000

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 25: Vary Distance and Inclusion of Out-of-State Land

	(1)	(2)	(3)	(4)	(5)
	Core Plus 2 km	Core Plus 6 km	Core Plus 10 km	Core Plus 14 km	Core Plus 18 km
Panel A: Out of State Land Excluded					
Real Estate Emp. Share 1920	0.758***	0.605***	0.487***	0.443***	0.405***
	(0.181)	(0.156)	(0.144)	(0.141)	(0.141)
Estimator	IV	IV	IV	IV	IV
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Outcome Mean	0.307	0.307	0.307	0.307	0.307
F-Statistic	46.739	55.682	61.714	62.828	60.091
Anderson-Rubin p-val.	0.000	0.000	0.001	0.002	0.004
KP underident p-val.	0.000	0.000	0.000	0.000	0.000
Panel B: Out of State Land Included					
Real Estate Emp. Share 1920	0.668***	0.457***	0.331**	0.282*	0.237
	(0.184)	(0.153)	(0.148)	(0.153)	(0.160)
Observations	2111	2111	2111	2111	2111
Estimator	IV	IV	IV	IV	IV
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Baseline Controls	Yes	Yes	Yes	Yes	Yes
Outcome Mean	0.307	0.307	0.307	0.307	0.307
F-Statistic	40.997	52.019	55.452	51.767	46.967
Anderson-Rubin p-val.	0.000	0.003	0.028	0.070	0.145
KP underident p-val.	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix B Additional Robustness Checks for Available Land Instrument

Table 26: Correlations between Land Availability Instrument and Geographic Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
Elevation	0.00937**					
	(0.00431)					
Distance to Coast		0.0488***				
		(0.00415)				
Distance to River			-0.00802***			
			(0.00294)			
Ruggedness				-0.0440***		
				(0.00338)		
Distance to State Border					0.0619***	
					(0.00364)	
# Nearby Municipalities						-0.00956***
						(0.00263)
Constant	0.778***	0.743***	0.790***	0.798***	0.722***	0.796***
	(0.00511)	(0.00521)	(0.00427)	(0.00390)	(0.00524)	(0.00490)
Observations	2568	2568	2568	2568	2568	2568

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 27: Robustness to Geographic Outliers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Real Estate Emp. Share 1920	0.795***	0.813***	0.955***	1.063***	0.615***	0.562***	1.040***
	(0.174)	(0.218)	(0.300)	(0.360)	(0.215)	(0.176)	(0.299)
Observations	2311	2312	2311	2312	2311	2304	2199
Excluded Cities	Bottom 10%	Bottom 10%	Top 10%	Top 10%	Bottom 10% State	Top 10%	Bottom 10%
	Coastal Distance	River Distance	Elevation	Ruggedness	Border Distance	Nearby Muni	Nearby Muni
Cutoff	11.7 km	0.2 km	427 m	131 m	1.5 km	35	2
F-Statistic	54.946	23.957	15.389	10.995	19.367	32.842	16.377
Anderson-Rubin p-val.	0.000	0.000	0.000	0.000	0.004	0.001	0.000
KP underident p-val.	0.000	0.000	0.000	0.001	0.000	0.000	0.000

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix C Construction of Shift Share Instrument

C.1 Instrument Construction

This appendix further details the construction of the shift share instrumental variable (SSIV) and provides robustness checks for results in Section 5.2. My SSIV identification strategy borrows heavily from methods developed by Bazzi et al. (2023) as well as earlier work by Boustan (2010) and Derenoncourt (2022). These methods differ from the standard migration-based SSIV strategy in two ways. First, because the census did not record migration rates or include questions on prior residence [1] between 1900 and 1920, I rely on linked census records created by Abramitzky et al. (2020b) to estimate migration flows between Southern counties and non-Southern cities. Second, rather than using the census-linked migration flows directly, I use the variation in migration flows predicted by origin county push factors to construct my SSIV. I calculate out migration, as opposed to net migration used in Boustan (2010) and Derenoncourt (2022), from Southern counties for each decade $t = \{1910, 1920\}$,

$$Black\, mig_{ot} = \sum_{i=1}^{I} \frac{\#\ black\ men\ in\ o\ in\ t-10\ linked\ to\ i\ at\ t}{\#\ black\ men\ in\ o\ in\ t-10\ linked\ to\ Census\ t} \times Total\, black\, pop_{o,t-10} \tag{13}$$

where o represents Southern origin county, i represents non-Southern destination city. The numerator is all black men present in non-Southern city i linked to Southern county o ten years prior. The denominator is the number of black men living at any location in year t that can be linked to Southern county o ten years prior. $Total\ black\ pop_{o,t-10}$ is the total black population in origin county o in year $t-10$ derived from the full-count Census.

After estimating out migration, I regress the census-linked estimates on a set of county level push factors in the zeroeth stage regression:

[1] With the exception of birth state.

$$South\,black\,mig_{o,t} = \alpha + \eta \mathbf{push}_{o,t-10} + \phi population_{o,t-10} + \varepsilon_{o,t} \quad (14)$$

Table 28 reports summary statistics of the push factors. Table 29 shows coefficients from the zeroth stage regressions. Urbanized population share, black population share, mining employment, and log of mean farmland value are all positively associated with out migration in 1910 and 1920. Tobacco and cotton cultivation as well as the spread of the boll weevil which devastated Southern cotton crops have significant but inconsistent relationships with black emigration

Table 28: Summary Statistics of Predictors of Southern Out-Migration from 1900-1910

			(1)		
	count	mean	sd	min	max
% Urban Population	2473	9.03	18.79	0.00	129.87
% Black Population	2473	28.24	25.12	0.00	124.28
Manufacturing Employees per 100 Population	2473	0.68	1.32	0.00	13.29
Miners per 100 Population	2473	0.33	1.34	0.00	24.36
% Land in Farms	2438	69.82	28.49	0.00	444.06
% of Farms that are Tenant Farms	2438	41.62	21.50	0.00	163.41
% of Farms that are Black Farms	2438	23.47	25.31	0.00	120.18
% of Farms with 1,000+ Acres	2438	4.49	14.84	0.00	150.83
Log of Mean Land Value	2438	2.28	0.95	-2.66	9.39
% of Farm Ares in Tobacco	2514	0.34	1.02	0.00	7.58
% of Farm Acres in Coton	2514	7.76	10.19	0.00	61.96
Boll Weevil County	2514	0.39	0.49	0.00	1.00
Boll Weevil County X % Cotton	2514	4.68	8.45	0.00	48.32

Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 29: Predict Southern Out-Migration to Non-Southern Counties Using Sending County Characteristics

	(1)	(2)
	Black Out-Migrants 1900 to 1910	No. Black Out-Migrants 1910 to 1920
% Urban Population	9.511***	20.89***
	(0.711)	(1.646)
% Black Population	2.844*	10.42***
	(1.609)	(4.004)
Manf. Emp. per 100 Population	6.501	4.196
	(10.40)	(19.68)
Miners per 100 Population	24.62**	69.34***
	(11.33)	(16.51)
% Land in Farms	0.725*	2.617**
	(0.427)	(1.122)
% of Farms that are Tenant Farms	0.104	0.537
	(1.061)	(2.348)
% of Farms that are Black Farms	3.260*	6.460
	(1.742)	(4.243)
% of Farms with 1,000+ Acres	2.152	3.697
	(1.772)	(2.487)
Log of Mean Land Value	105.2***	235.3***
	(16.68)	(41.18)
% of Farm Ares in Tobacco	43.84***	-58.52**
	(11.40)	(28.28)
% of Farm Acres in Coton	-12.44***	9.483
	(2.464)	(6.361)
Boll Weevil County	-134.6***	200.0**
	(39.71)	(79.01)
Boll Weevil County X % Cotton	5.955**	-29.14***
	(2.701)	(6.882)
Constant	-215.1***	-1064.7***
	(52.05)	(135.7)
Observations	1114	1219
Adjusted R^2	0.375	0.350
Decade	1900-1910	1910-1920
Outcome Mean	208.4	480.5

Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

C.2 Robustness Checks

Table 30 shows 2SLS estimates using spatially adjusted standard errors from Conley (1999). Estimates lose precision, but remain at least marginally significant in all but one specification. Table 31 shows the effect of white southern migrants on zoning in non-Southern cities. While the estimated effect is negative, i.e., cities with more white migrants zoned at lower rates, the estimate suffers from a weak first stage. The weak first stage implies that chain migration was stronger for black southerners than white southerners between 1900 and 1920. The Anderson-Rubin p-value of 0.123 means that 2SLS cannot detect a significant effect using weak-instrument robust inference

Figures 23 and 24 illustrate the impact of dropping individual destination states and origin states on results from section 5.2. The left panels show estimates with total black population share as the endogenous variable, and the right panel show estimates using southern-born black population share as the endogenous variable. Dropping the destination states of Kansas or Missouri noticeably attenuates the estimated effect of black migration, but the coefficients remain positive. Results remain robust to dropping any single origin state

Table 30: Shift-Share Instrument Results with Conley Standard Errors

	(1)	(2)	(3)	(4)
	Zoned by 1936	Zoned by 1936	Zoned by 1936	Zoned by 1936
Panel A				
Black Share 1920	0.244*	0.244	0.244**	0.244*
	(0.128)	(0.150)	(0.122)	(0.133)
Observations	1795	1795	1795	1795
State Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Outcome Mean	0.327	0.327	0.327	0.327
F-Statistic	26.723	26.723	26.723	26.723
Range of Spatial SEs	50 km	250 km	50 km	250 km
Bartlett	No	No	Yes	Yes
Panel B				
Southern-born Black Share 1920	0.434*	0.434*	0.434**	0.434*
	(0.223)	(0.257)	(0.213)	(0.228)
Observations	1795	1795	1795	1795
State Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Outcome Mean	0.327	0.327	0.327	0.327
F-Statistic	35.358	35.358	35.358	35.358
Range of Spatial SEs	50 km	250 km	50 km	250 km
Bartlett	No	No	Yes	Yes

Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 31: Comparison between Southern Black and Southern White Migration

	(1) Zoned by 1936	(2) Zoned by 1936	(3) Zoned by 1936	(4) Zoned by 1936
Southern-born Black Share 1920	0.0674		0.420**	
	(0.0515)		(0.195)	
Southern-born White Share 1920		-0.0727		-0.317**
		(0.0746)		(0.161)
Observations	1982	1982	1982	1982
Adjusted R^2	0.359	0.359	0.282	0.291
Estimator	OLS	OLS	2SLS	2SLS
State Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Outcome Mean	0.326	0.327	0.326	0.327
F-Statistic			35.029	7.934
Anderson-Rubin p-val.			0.013	0.123
KP underident p-val.			0.000	0.000

Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 32: Two Endogenous Variables and Two Instruments

	(1) 4 km Range	(2) 8 km Range	(3) 12 km Range	(4) 16 km Range	(5) 20 km Range
Black Share 1920	0.354**	0.328**	0.303**	0.296**	0.293**
	(0.159)	(0.148)	(0.137)	(0.136)	(0.135)
Real Estate Emp. Share 1920	1.167***	0.952***	0.741***	0.687***	0.661***
	(0.373)	(0.275)	(0.205)	(0.197)	(0.198)
Observations	1979	1979	1979	1979	1979
Estimator	IV	IV	IV	IV	IV
State Fixed Effects	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Outcome Mean	0.327	0.327	0.327	0.327	0.327
F-Statistic	9.98	14.79	21.92	23.40	23.14
Anderson-Rubin p-val.	0.000	0.000	0.000	0.000	0.001
KP underident p-val.	0.000	0.000	0.000	0.000	0.000

Significance levels denoted by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 23: Drop Destination States

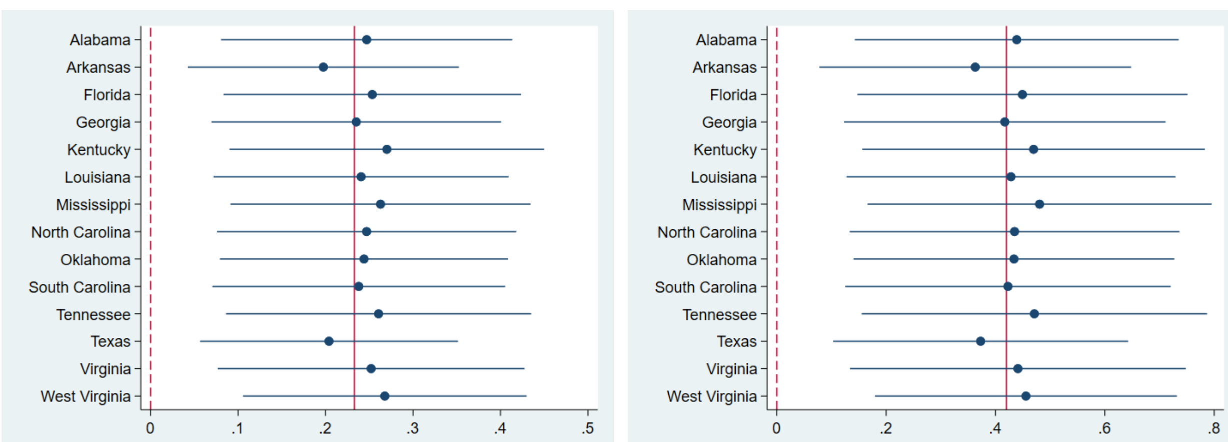


Figure 24: Drop Origin States

Appendix D New Jersey Aerial Photography

I combine aerial photography, land use surveys supplemented with manual classification, and guided machine-learning tools from the Orfeo Toolbox to determine the extent of speculative, low density development in New Jersey during the 1930s at the municipality level (Kunz, 2012; New Jersey State Planning Board, 1938, 1941; Grizonnet et al., 2017). The goal of classifying land use at a granular level is to verify the claim, which underpins this paper's primary identification strategy, that increased local real estate employment accompanied the 1920s shift towards low-density development on the urban fringe. In this appendix I will explain the sources and methods used to classify land uses, validate my classification strategy using external sources, and analyze the relationship between speculative, low-density urban land uses (primarily empty subdivisions) and local real estate employment. I will argue that taking into account some factors specific to the state of New Jersey, the analysis confirms the observations of historical sources (Bodfish, 1929; Simpson, 1933; Weiss, 1987) that during the 1920s real estate boom changes in development patterns and real estate employment went hand in hand.

The New Jersey State Planning Board purchased a detailed air map of the entire state completed by an unnamed private firm in 1932 (New Jersey State Planning Board, 1936). The second annual report of the organization states

> Probably by far the most valuable and useful item of maps and surveys now in possession of the State Planning Board ... is an air map of the entire State, at a scale of 1 inch equals 1000 feet. This map is comprised of 260 atlas sheets, 29 inches by 38 inches in size. It is made up of 5000 individual photographs, taken at an elevation of about fifteen thousand feet, and skillfully pieced together. On this map may be seen every house and every factory, streets, railroads, airports, streams, farms, forests, and marshlands. (New Jersey State Planning Board, 1936, p. 66)

I acquired scans of the 260 atlas sheets digitized by Kunz (2012) and available online from the New Jersey State Library. I combined the digitized atlas sheets into a single raster image using the QGIS geographical information system application. Snippets of the map are shown in Figures 25 and 26

The New Jersey State Planning Board also published two reports, partially informed by the air map, on the extent of premature and speculative subdivision in the state. The first, *Land Subdivision in New Jersey: Its Extent, Quality and Regulation*, they published in 1938, and the follow-up, *Premature Land Subdivision, a Luxury: A problem of Local Government in New Jersey*, released in 1941. Occasioned by a glut of tax-delinquent vacant properties, both reports attempt to diagnose the extent of excess subdivision in New Jersey and propose remedies to the problem. During the boom times of the 1920s, subdividers created enough vacant lots to absorb a century of projected population growth. In terms of layout, location, and infrastructure, the empty subdivisions proved very shoddy on the whole. Many owners abandoned their investments and stopped paying property taxes. The lack of tax income paired with the extension of municipal services over greater areas strained finances at the state and local levels of government (New Jersey State Planning Board, 1938, 1941)

Beyond textual descriptions and summary statistics aggregated to the county and regional levels, the two reports each contain a highly detailed map of empty subdivisions based on information collected in 1936. The map from the 1938 report depicts several towns in North Middlesex County and distinguishes between occupied platted area (more than 5 houses per block), semi-occupied platted area (1 to 5 houses per block), unoccupied platted area (divided into lots but no housing built), and unplatted areas (uninhabited or rural areas). The 1941 report contains a similar map for East Bergen County, which classifies land according to the same criteria. Figures 25 and 26 show the maps alongside aerial photographs of the corresponding areas

Using the categorized maps from the reports as training data, I train a machine learning algorithm to identify occupied, semi-occupied, and unoccupied land in the aerial photographs. Because the maps use different projections, I georeference them in QGIS to align them with the aerial photography. As a next step I overlay a 100mX100m square grid over the categorized maps and manually assign grid squares the following categories

a. Occupied

b. Semi-Occupied

c. Unoccupied

d. Unoccupied or Semi-occupied in Wooded Area

e. Transitional

f. Agriculture
g. Light Forest
h. Heavy Forest
i. Swamp
j. Water
k. Beach
l. Null (Off-map)

The first three categories are drawn directly from the maps. The fourth "unoccupied or semi-occupied in wooded area" refers to empty subdivisions with visible street grids and forested areas between the streets (in the absence of this category the algorithm would mistake the trees for houses and assume the grid square was fully occupied). The "transitional" category covers rural roads not arranged in a grid pattern indicative of subdivision. In addition to the two mapped locations, I also manually categorize land uses in eight other locations throughout the state. Table 35 lists all locations used for training. I categorize 100X100m grid squares as opposed to individual pixels because the land use of interest, gridded or patterned streets without housing, cannot be identified on a pixel by pixel basis

After categorizing surveyed grid squares by land use, I assign a vector of characteristics derived from the pixels of the aerial photographs to every square in a 100m X 100m grid covering all of New Jersey. The aerial photographs consist of a single raster layer with each pixel having a gray scale value between 0 and 255 inclusive. The vector includes summary statistics of the pixel values beneath a grid square (sum, mean, median, minimum, maximum, range, minority, majority, and variety of gray scale values). Due to the lack of additional raster layers, I also texture the image by assigning each pixel additional values based on surrounding pixels. I use the inverse distance moment (IDM), or homogeneity, which measures the similarity of pixels in a line (in my case, 5 pixels on either side). I assign IDM values to pixels based on lines drawn vertically (0 degrees), horizontally (90 degrees), and diagonally (45 and 135 degrees). Measuring homogeneity in straight lines adds useful information since streets contrast starkly with other land uses in the photographs. Including the summary statistics of the generated IDM pixel values increases the vector length from 9 to 45

As a next step, I apply a random forest classification algorithm from Orefeo Toolbox, an open source collection of remote sensing tools available in QGIS (Grizonnet et al., 2017). Specifically, I create a model using the "TrainVectorClassifier" tool with 200 trees, a depth of 30, and a random seed of 42. The algorithm classifies all grid squares throughout the state. For the purposes of analysis, I group the semi-occupied, unoccupied, and unoccupied or semi-occupied in a wooded area under the label of "speculative land uses". Figure 27 and Table 34 show correlations between my measure of speculative land use in each county and county level statistics on the acreage of unoccupied land and miles of streets laid out in unoccupied areas from the State Planning Board Report (New Jersey State Planning Board, 1938, p. 19). Although noisy, there is a significant positive correlation between my machine generated measure and data collected directly by the New Jersey Stat Planning Board at the county level

Table 33 contains city level summary statistics on the share of land dedicated to speculative land uses and the share dedicated to fully urban land uses (category 1). I construct measures for the shares at various distances using the method outlined in in Appendix A. Figures 28 and 29 show coefficients from regressing 1930 real estate employment [1] share on speculative land uses and fully urban land uses respectively; each distance represents a separate regression. I run regressions without controls and with basic controls for population and county level urbanization [2]

The relationship between fully urban land uses and real estate employment is significant, small in magnitude, and unchanging with the area measured. On the other hand, the correlation between real estate employment and speculative land uses is negative at first before becoming significantly positive as the area measured expands. At the farthest distance measured, urban core plus 18 kilometers, the coefficient for speculative land uses is twice as large as that of fully urban land uses. The estimates for speculative land uses also have much larger standard errors than the estimates for fully urbanized land uses

The larger standard errors likely indicate that the classification of speculative land uses

[1] Although 1920 real estate employment is used in the paper's primary analysis, I use the 1930 measure because it is closest in time to when the aerial photography was produced.

[2] I also include an indicator variable for whether a municipality is located on one of the barrier islands of the Jersey Shore. These municipalities face unique geographic constraints, and the quality of the aerial photography in these areas suffers from the reflected light of sandy beaches.

is nosier and more error prone than the classification of fully urban uses. Fully urbanized uses appear more distinctly in the aerial photography, and some speculative land uses may have no markers visible from the air, for example, if an area was subdivided but still lacked roads. The upward drift of the coefficients as the area of measurement expands is consistent with the regional allocation of speculative development within New Jersey. Both state planning reports note that speculative development occurred disproportionately in northeastern counties close to New York City. In these areas, municipalities tend to be small, numerous (126 of 340 municipalities in the sample come from the six counties closest to New York City), and packed together. Thus, for the smallest areas of measurement speculative development would only be evident in edge municipalities despite being connected to real estate employment throughout northeastern New Jersey. Accounting for the interconnected nature of the state's largest real estate market by expanding the area measured reveals the positive correlation between real estate employment and speculative land share.

During the 1930s in New Jersey real estate employment positively correlated with land uses identified as speculative development in aerial photographs. The classification strategy used to categorize land uses produces results consistent with direct measurements at the county level. In sum, the results of this appendix offer more evidence that real estate employment share acts as an effective proxy for speculative, low density development on the urban fringe.

Figure 25: North Middlesex

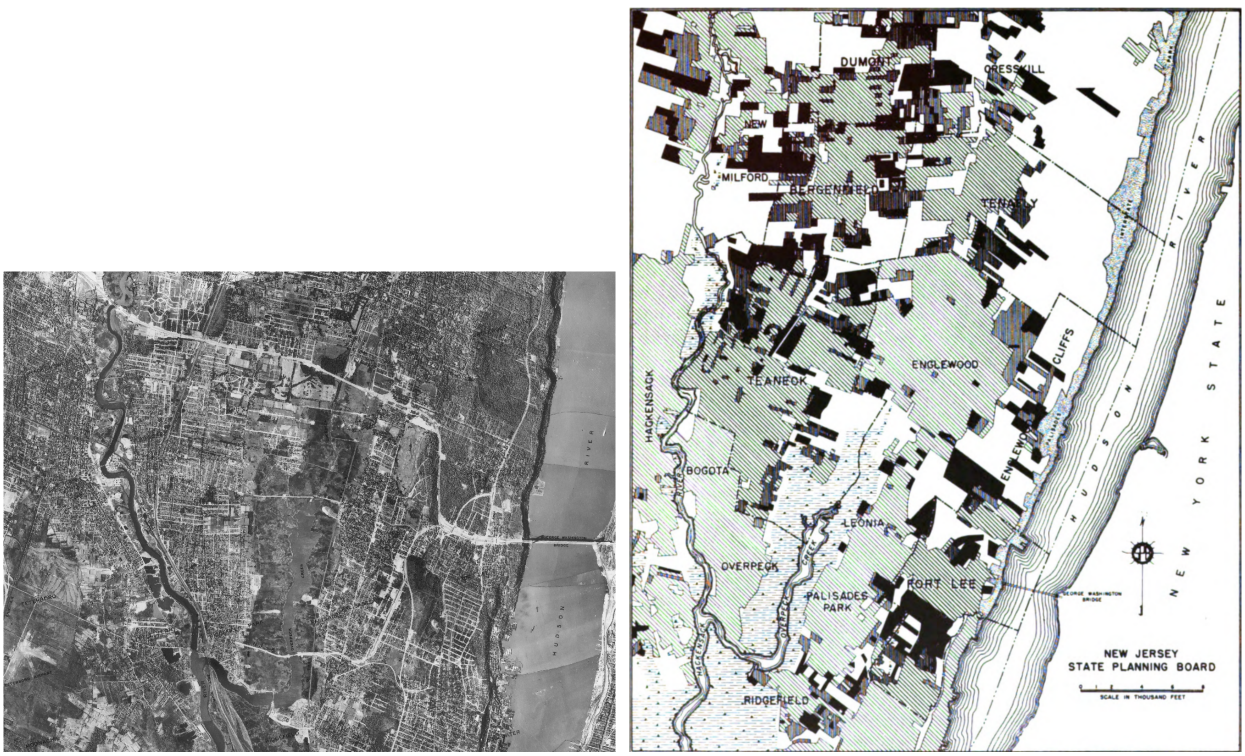


Figure 26: East Bergen

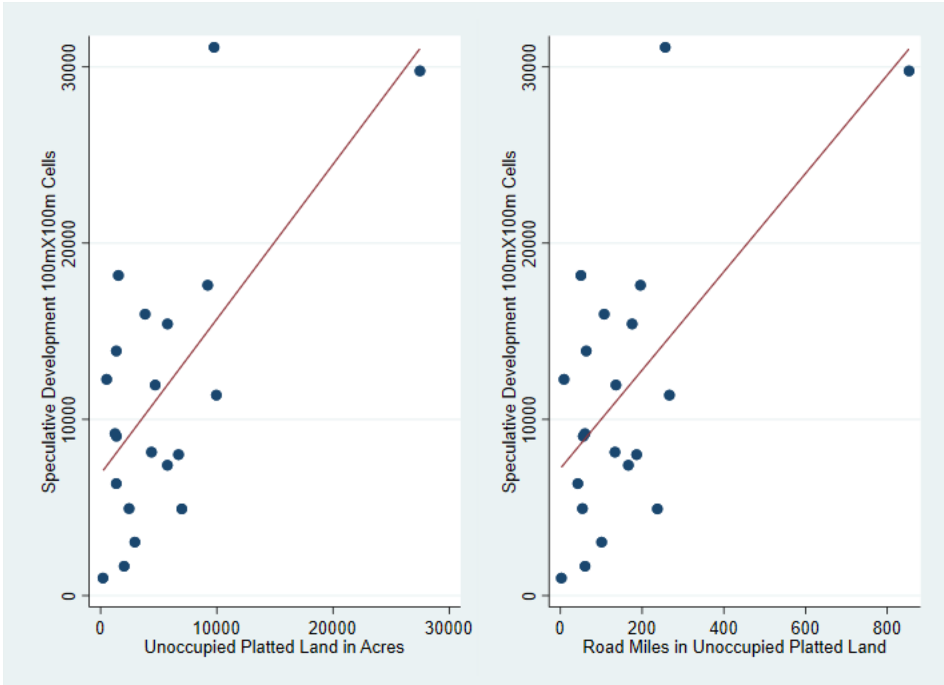


Figure 27: Correlations between County Aggregates and Predicted Speculative Land Share

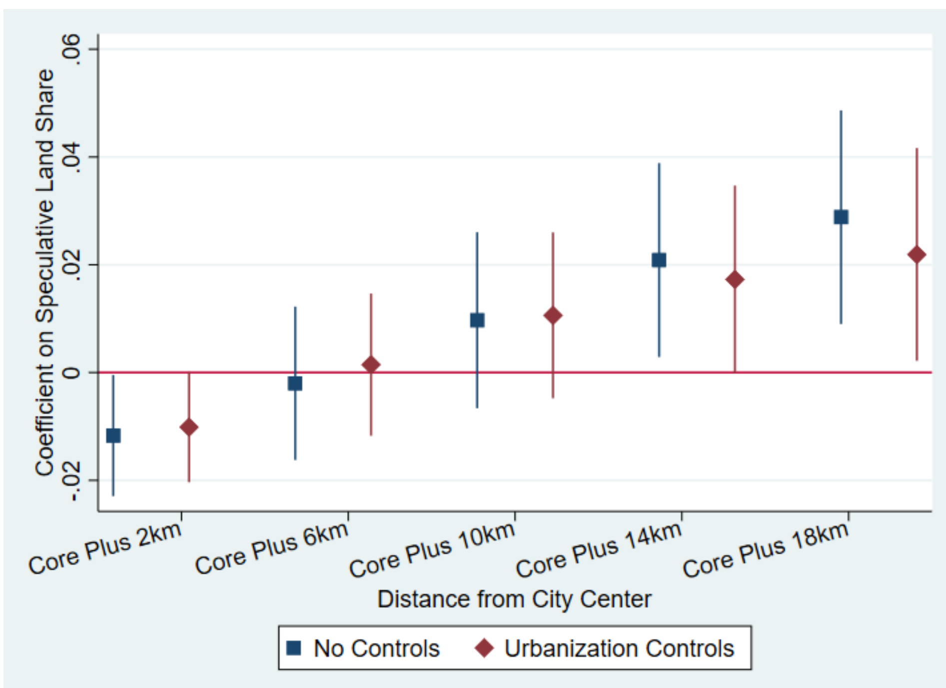


Figure 28: Real Estate Employment Regressed on Speculative Land Share at Different Distances

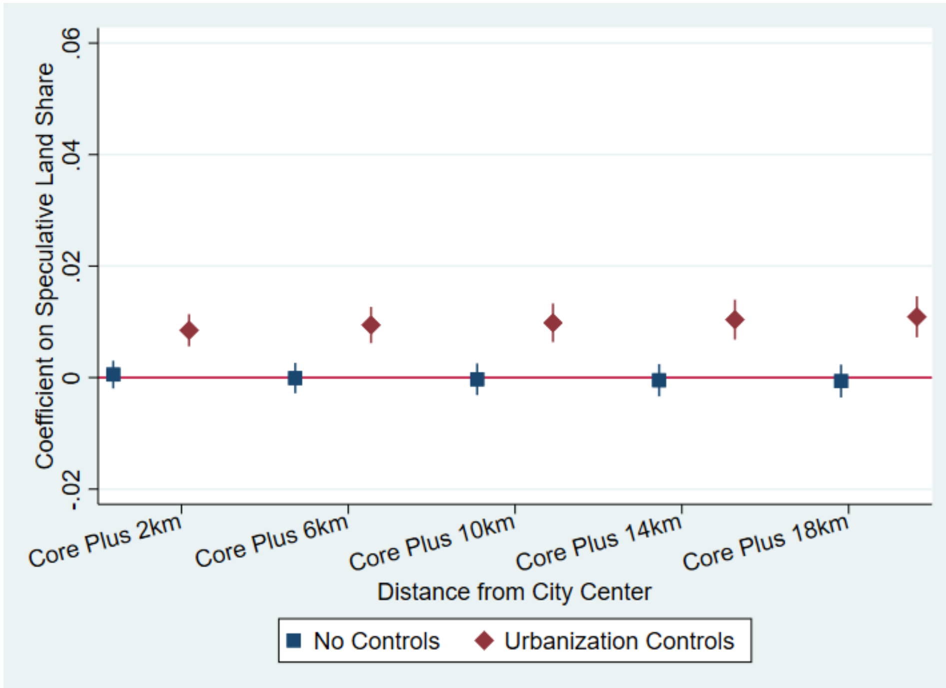


Figure 29: Real Estate Employment Regressed on Urban Land Share at Different Distances

Table 33: Summary Statistics

	count	mean	sd	min	max
Speculative Development Land Share, Bounding Circle Plus 2km	348	0.112	0.055	0.005	0.308
Speculative Development Land Share, Bounding Circle Plus 6km	348	0.111	0.044	0.021	0.214
Speculative Development Land Share, Bounding Circle Plus 10km	348	0.111	0.038	0.041	0.198
Speculative Development Land Share, Bounding Circle Plus 14km	348	0.111	0.034	0.052	0.196
Speculative Development Land Share, Bounding Circle Plus 18km	348	0.111	0.031	0.053	0.184
Urban Development Land Share, Bounding Circle Plus 2km	348	0.412	0.249	0.012	0.966
Urban Development Land Share, Bounding Circle Plus 6km	348	0.371	0.228	0.011	0.834
Urban Development Land Share, Bounding Circle Plus 10km	348	0.360	0.218	0.023	0.742
Urban Development Land Share, Bounding Circle Plus 14km	348	0.353	0.214	0.033	0.696
Urban Development Land Share, Bounding Circle Plus 18km	348	0.345	0.210	0.042	0.690
Zoned by 1936	347	0.409	0.492	0.000	1.000
Log 1930 Population	340	7.847	1.553	1.609	12.999
1930 County Urban Share	348	0.638	0.278	0.000	1.000

Table 34: Comparison with County Aggregates

	(1)	(2)	(3)	(4)
Unoccupied Platted Land in Acres	0.878***	1.036**		
	(0.234)	(0.466)		
Road Miles in Unoccupied Platted Land			27.90***	35.17*
			(8.034)	(18.50)
Constant	6904.7***	6319.7**	7219.1***	6423.0**
	(1830.2)	(2386.6)	(1866.0)	(2631.9)
Observations	21	20	21	20

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

Table 35: Locations of Training Data

Number	Description	Latitude	Longitude
1	Teaneck, Englewood, and Surroundings : East Bergen County	40.55476	-74.37566
2	Perth Amboy, Plainfield, and Surroundings : North Middlesex County	40.90576	-73.97837
3	Belmar and Shark River: East Monmouth County	40.18222	-74.05203
4	Lakewood and Surroundings: North Ocean County	40.08734	-74.18196
5	Pleasantville and Inland Surroundings: East Atlantic County	39.39636	-74.53753
6	Landisville Buena and Northern Surroundings: West Atlantic County	39.53835	-74.92436
7	Pitman and Glassboro: Central Gloucester County	39.71778	-75.10473
8	Mount Ephraim and Other Suburbs South of Camden: North Camden County	39.87953	-75.08171
9	Pennington and Surroundings: Northwest Mercer County	40.33171	-74.80037
10	Stanhope and Hopatcong: South Sussex County	40.91036	-74.67392

Appendix E Additional Pittsburgh Pollution Results

Table 36: Summary Statistics for Single Women

	Census 1910	Census 1920	Census 1930	Census 1940
Sootfall	80.41	110.5	82.80	86.58
	(21.09)	(27.61)	(20.19)	(50.10)
Occ. Income Score	8.153	7.031	7.522	7.465
	(11.67)	(10.24)	(10.30)	(10.62)
Black	0.0674	0.0649	0.0945	0.0984
	(0.251)	(0.246)	(0.292)	(0.298)
F.Born	0.378	0.291	0.237	0.199
	(0.485)	(0.454)	(0.425)	(0.399)
F.Born, Spk.English	0.319	0.271	0.224	
	(0.466)	(0.444)	(0.417)	
Age	40.01	44.80	45.39	50.08
	(17.09)	(16.20)	(16.88)	(16.94)
Owns Home	0.392	0.370	0.479	0.418
	(0.488)	(0.483)	(0.500)	(0.493)
Live-In Servant	0.280	0.187	0.195	0.137
	(0.449)	(0.390)	(0.397)	(0.344)
In Labor Force	0.596	0.553	0.551	0.450
	(0.491)	(0.497)	(0.497)	(0.497)
Observations	33690	33027	41300	41604

Table 37: Summary Statistics for Single Men

	Census 1910	Census 1920	Census 1930	Census 1940
Sootfall	86.67	114.6	87.43	100.6
	(22.24)	(26.79)	(21.33)	(57.52)
Occ. Income Score	18.89	18.79	18.91	18.78
	(12.82)	(13.24)	(13.34)	(13.25)
Black	0.0809	0.118	0.146	0.152
	(0.273)	(0.322)	(0.354)	(0.359)
F.Born	0.519	0.379	0.270	0.237
	(0.500)	(0.485)	(0.444)	(0.425)
F.Born, Spk.English	0.265	0.330	0.257	
	(0.442)	(0.470)	(0.437)	
Age	33.58	38.67	41.69	47.97
	(13.74)	(14.44)	(15.45)	(16.18)
Owns Home	0.199	0.243	0.391	0.337
	(0.399)	(0.429)	(0.488)	(0.473)
Live-In Servant	0.00797	0.00527	0.00614	0.00725
	(0.0889)	(0.0724)	(0.0781)	(0.0849)
In Labor Force	0.939	0.934	0.900	0.765
	(0.239)	(0.249)	(0.300)	(0.424)
Observations	37137	30904	31620	24950

Table 38: Summary Statistics for Couples

	Census 1910	Census 1920	Census 1930	Census 1940
Sootfall	81.02	116.0	83.58	88.75
	(20.75)	(28.24)	(22.20)	(52.08)
Occ. Inc. Score Husband	21.10	20.87	21.86	25.19
	(14.61)	(14.65)	(14.12)	(11.85)
Occ. Inc. Score Wife	0.509	0.498	0.750	1.396
	(3.571)	(3.514)	(4.130)	(5.668)
Husband Black	0.0512	0.0616	0.0815	0.0744
	(0.220)	(0.240)	(0.274)	(0.262)
Wife Black	0.0505	0.0607	0.0815	0.0743
	(0.219)	(0.239)	(0.274)	(0.262)
F.Born Husband	0.439	0.379	0.315	0.245
	(0.496)	(0.485)	(0.464)	(0.430)
F.Born Wife	0.403	0.342	0.272	0.199
	(0.491)	(0.474)	(0.445)	(0.399)
F.Born, Spk.English Husband	0.357	0.349	0.307	0
	(0.479)	(0.477)	(0.461)	(0)
F.Born, Spk.English Wife	0.285	0.289	0.250	0
	(0.451)	(0.453)	(0.433)	(0)
Age Husband	41.12	41.92	43.15	44.75
	(11.93)	(12.22)	(12.30)	(13.16)
Age Wife	37.35	38.07	39.36	40.95
	(11.49)	(11.96)	(12.11)	(12.94)
Couple Owns Home	0.268	0.274	0.398	0.312
	(0.443)	(0.446)	(0.489)	(0.463)
Husband In Labor Force	0.970	0.970	0.960	0.901
	(0.170)	(0.170)	(0.196)	(0.299)
Wife In Labor Force	0.0558	0.0397	0.0543	0.0798
	(0.230)	(0.195)	(0.227)	(0.271)
Observations	85609	102338	119095	99320

Table 39: Matching Statistics for Hedonic Data

	1930	1940
Census Data		
Single Head Households	154,803	173,035
Useable Addresses	74,400	75,962
Assessor's Data		
Single Family (pre 1930.1940)	66,260	83,617
Usable Addresses	65,566	82,688
Merged Data		
Strict Address Matches	19,844	22,664
Assessor's Lat/Long in E.D./Tract	19,013	20,453
Clean Hedonic Variables	16,408	17,641

Table 40: Pollution Exposure for Single Women

	Census 1910	Census 1920	Census 1930	Census 1940
Occscore	0.0158	0.147***	0.126***	0.0465***
	(0.0122)	(0.0287)	(0.0248)	(0.0171)
Age	-0.000455	0.00115	0.00263***	-0.00326***
	(0.00131)	(0.000884)	(0.000984)	(0.000975)
Black	0.159	-0.0747	0.462***	0.769***
	(0.102)	(0.0617)	(0.0889)	(0.283)
Foreign Born	0.591***	0.171*	0.303***	0.348***
	(0.0863)	(0.0905)	(0.0919)	(0.0593)
Speaks English	-0.593***	-0.192**	-0.211**	
	(0.0866)	(0.0785)	(0.0823)	
Home Owned	-0.369***	-0.0651	-0.260***	-0.207***
	(0.0472)	(0.0427)	(0.0370)	(0.0544)
Widow	0.121***	0.128***	0.143***	0.0875***
	(0.0423)	(0.0381)	(0.0299)	(0.0296)
Divorced	0.228***	0.0941	0.0831**	-0.00408
	(0.0595)	(0.0575)	(0.0408)	(0.0427)
Worker	-0.132**	-0.356***	-0.294***	-0.212***
	(0.0637)	(0.0643)	(0.0583)	(0.0446)
Constant	3.934***	3.967***	4.002***	1.844***
	(0.131)	(0.0649)	(0.0798)	(0.104)
Observations	30836	30149	38708	40753
R^2	0.068	0.031	0.061	0.090
Adjusted R^2	0.068	0.031	0.061	0.090

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

Table 41: Pollution Exposure for Single Women, Domestic Servants Removed

	Census 1910	Census 1920	Census 1930	Census 1940
Occscore	-0.0474***	0.0400**	-0.0704***	-0.0628***
	(0.0151)	(0.0187)	(0.0175)	(0.0178)
Age	-0.00256	-0.000379	0.000472	-0.00460***
	(0.00164)	(0.00101)	(0.000857)	(0.000982)
Black	0.276***	-0.0911	0.547***	0.805***
	(0.0985)	(0.0811)	(0.105)	(0.296)
Foreign Born	0.554***	0.216**	0.395***	0.391***
	(0.0962)	(0.0973)	(0.0975)	(0.0634)
Speaks English	-0.375***	-0.151*	-0.202**	
	(0.0919)	(0.0810)	(0.0867)	
Home Owned	-0.231***	0.0187	-0.182***	-0.167***
	(0.0356)	(0.0387)	(0.0356)	(0.0535)
Widow	0.0299	0.0662*	0.0715**	0.0618**
	(0.0451)	(0.0348)	(0.0282)	(0.0272)
Divorced	0.134**	0.0403	0.0111	-0.0347
	(0.0605)	(0.0620)	(0.0402)	(0.0411)
Worker	0.138**	-0.106**	0.187***	0.0643
	(0.0535)	(0.0467)	(0.0501)	(0.0430)
Constant	4.022***	4.036***	4.096***	1.912***
	(0.144)	(0.0625)	(0.0695)	(0.109)
Observations	21401	23964	30638	35049
R^2	0.048	0.004	0.036	0.086
Adjusted R^2	0.048	0.004	0.035	0.086

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

Table 42: Pollution Exposure for Single Men

	Census 1910	Census 1920	Census 1930	Census 1940
Occscore	-0.0443***	-0.0352**	-0.105***	-0.0626***
	(0.0134)	(0.0139)	(0.0138)	(0.0138)
Age	0.00626**	0.000326	0.00285***	0.000446
	(0.00293)	(0.000951)	(0.000820)	(0.00107)
Black	0.266**	-0.168**	0.362***	0.773**
	(0.133)	(0.0710)	(0.0857)	(0.326)
Foreign Born	0.433**	0.374*	0.382***	0.426***
	(0.189)	(0.191)	(0.128)	(0.0851)
Speaks English	-0.242	-0.214	-0.197*	
	(0.207)	(0.171)	(0.108)	
Home Owned	-0.376***	-0.0951**	-0.250***	-0.269***
	(0.0523)	(0.0414)	(0.0385)	(0.0722)
Widower	-0.189**	0.0143	-0.0941***	-0.150***
	(0.0734)	(0.0305)	(0.0296)	(0.0533)
Divorced	-0.0187	-0.0157	-0.102***	-0.139**
	(0.0898)	(0.0695)	(0.0387)	(0.0607)
Worker	0.213***	0.235***	0.336***	0.133***
	(0.0780)	(0.0604)	(0.0565)	(0.0370)
Constant	3.513***	4.130***	3.960***	1.676***
	(0.120)	(0.0781)	(0.0669)	(0.0947)
Observations	30904	25330	27060	24298
R^2	0.076	0.021	0.059	0.128
Adjusted R^2	0.075	0.021	0.059	0.128

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

Table 43: Pollution Exposure for Married Couples

	Census 1910	Census 1920	Census 1930	Census 1940
H Occscore	-0.00343***	-0.00370**	-0.0107***	-0.00819***
	(0.00110)	(0.00166)	(0.00172)	(0.00173)
W Occscore	0.000250	0.000807	-0.000645	-0.00442***
	(0.00427)	(0.00204)	(0.00210)	(0.00146)
H Age	-0.00123	-0.00314***	0.00118	0.00101
	(0.00179)	(0.000780)	(0.000902)	(0.00109)
W Age	0.00277	0.00120*	-0.000560	-0.00523***
	(0.00199)	(0.000705)	(0.000861)	(0.00126)
Black	0.308***	-0.310***	0.352***	0.553***
	(0.108)	(0.0675)	(0.0731)	(0.197)
H Foreign Born	0.227**	0.0672	0.399***	0.258***
	(0.0978)	(0.0836)	(0.0907)	(0.0525)
W Foreign Born	0.349***	0.0609	0.233**	0.194***
	(0.0689)	(0.0616)	(0.0938)	(0.0333)
H Speaks English	-0.0673	-0.135*	-0.269***	
	(0.107)	(0.0788)	(0.0805)	
W Speaks English	-0.166***	-0.0312	-0.0984	
	(0.0595)	(0.0525)	(0.0901)	
Home Owned	-0.333***	0.0259	-0.219***	-0.233***
	(0.0423)	(0.0414)	(0.0371)	(0.0470)
H Worker	0.102**	0.241***	0.334***	0.0612
	(0.0405)	(0.0589)	(0.0630)	(0.0406)
W Worker	-0.0341	-0.0776	0.0941*	0.0620
	(0.151)	(0.0580)	(0.0563)	(0.0385)
Children	0.00864	0.00361	0.00861*	0.0289***
	(0.00570)	(0.00429)	(0.00511)	(0.00831)
Constant	3.756***	4.101***	3.650***	1.910***
	(0.0732)	(0.0627)	(0.0660)	(0.114)
Observations	66658	79385	98293	97227
R^2	0.070	0.009	0.052	0.072
Adjusted R^2	0.070	0.009	0.052	0.072

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

Table 44: Pollution and Marital Status

	Census 1910	Census 1920	Census 1930	Census 1940
Female	-0.285***	-0.315***	-0.334***	-0.291***
	(0.0709)	(0.0615)	(0.0532)	(0.0547)
Female Ever Married	0.105*	0.263***	0.144***	0.109**
	(0.0600)	(0.0487)	(0.0400)	(0.0423)
Male Ever Married	-0.194***	0.0165	-0.162***	-0.222***
	(0.0489)	(0.0336)	(0.0305)	(0.0722)
Female Widow	0.115***	-0.0219	0.0760***	0.0609***
	(0.0214)	(0.0184)	(0.0164)	(0.0220)
Male Widow	0.0866***	0.0371*	0.109***	0.112***
	(0.0278)	(0.0213)	(0.0217)	(0.0342)
Female Divorce	0.242***	-0.101	0.0184	-0.0559
	(0.0780)	(0.0660)	(0.0400)	(0.0505)
Male Divorce	0.271***	0.0224	0.0923**	0.0782
	(0.0785)	(0.0724)	(0.0411)	(0.0597)
black_female	0.158***	-0.300***	0.442***	0.664***
	(0.0557)	(0.0586)	(0.0770)	(0.225)
black_male	0.204***	-0.306***	0.479***	0.731***
	(0.0645)	(0.0591)	(0.0769)	(0.254)
for_male	0.563***	0.288**	0.622***	0.406***
	(0.162)	(0.119)	(0.139)	(0.0708)
for_female	0.586***	0.196**	0.453***	0.366***
	(0.0858)	(0.0931)	(0.114)	(0.0631)
for_eng_male	-0.279*	-0.178*	-0.387***	
	(0.166)	(0.0962)	(0.115)	
for_eng_female	-0.399***	-0.114	-0.263***	
	(0.0771)	(0.0717)	(0.0985)	
age_male	-0.00114	-0.00260***	-0.00165***	-0.00422***
	(0.00101)	(0.000697)	(0.000570)	(0.000826)
age_female	-0.00135**	-0.00106	-0.000847	-0.00477***
	(0.000616)	(0.000716)	(0.000659)	(0.000961)
Constant	3.928***	4.874***	3.939***	1.950***
	(0.0703)	(0.0653)	(0.0572)	(0.114)
Observations	212894	236898	282858	261567
R^2	0.050	0.016	0.030	0.060
Adjusted R^2	0.050	0.016	0.030	0.060

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note:Pollution levels and Occupation Scores are expressed in terms of within census standard deviations.

Table 45: Link Between Moving and Pollution Exposure (Full Results)

	1940 Full	1940 Full	1940 - 1930	1940 - 1910	1940 - 1930	1940 - 1910
Black	0.542***	0.259*	0.155	0.0572	-1.493	12.50
	(0.208)	(0.134)	(0.125)	(0.166)	(3.743)	(7.941)
Changed Neighborhood		-0.104***	-0.210***	-0.327***	-9.337***	-15.00***
		(0.0310)	(0.0380)	(0.0612)	(2.613)	(4.419)
Black X Chg. Nbrhd.		0.409***	0.348***	0.403***	9.957***	9.976
		(0.128)	(0.0876)	(0.102)	(3.303)	(8.068)
Changed County		-0.259***	0.153***	0.140***		
		(0.0690)	(0.0266)	(0.0297)		
Black X Chg. County		0.466***	0.193	0.299*		
		(0.142)	(0.139)	(0.157)		
Annual Income	-0.0440***	-0.0422***	-0.0688***	-0.102***	-0.408	-2.522***
	(0.0152)	(0.0145)	(0.0128)	(0.0176)	(0.464)	(0.723)
Age	-0.00308***	-0.00342***	-0.00302***	-0.00281***	-0.0964**	-0.217***
	(0.000974)	(0.00101)	(0.00109)	(0.000973)	(0.0375)	(0.0638)
Foreign Born	0.373***	0.357***	0.305***	0.292***	4.110***	6.027**
	(0.0627)	(0.0601)	(0.0551)	(0.0600)	(1.517)	(2.333)
Never Married	0.0949***	0.0747***	0.121***	0.154***	0.468	3.100**
	(0.0246)	(0.0248)	(0.0291)	(0.0439)	(0.875)	(1.508)
Divorced	-0.00943	-0.00222	0.0835	-0.0152	2.400	3.292
	(0.0358)	(0.0334)	(0.0635)	(0.0548)	(2.147)	(5.629)
Widower	0.0513***	0.0505***	0.0494**	0.0322	-1.026	1.836
	(0.0126)	(0.0122)	(0.0223)	(0.0276)	(1.121)	(1.902)
Working	-0.0229*	-0.0173	0.00731	-0.00943	0.225	-1.376
	(0.0124)	(0.0115)	(0.00998)	(0.0265)	(0.527)	(1.681)
Homeowner	-0.211***	-0.239***	-0.231***	-0.221***	-3.673**	-7.915***
	(0.0457)	(0.0420)	(0.0423)	(0.0445)	(1.514)	(1.581)
female	-0.0439***	-0.0405***				
	(0.00995)	(0.00913)				
Constant	1.792***	1.816***	1.925***	2.154***	10.04**	20.74***
	(0.106)	(0.114)	(0.115)	(0.134)	(4.153)	(7.609)
Model of Pctile. Change					X	X
N	541929	541929	66772	30865	44755	6778

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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