# Zoning and the Dynamics of Urban Redevelopment

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**Abstract**

Cities increasingly grow through redevelopment—demolishing old buildings to make way for new ones. This paper studies this process and how it is influenced by zoning, which regulates the size and uses of new buildings, using New York City as a case study. I build the first parcel-level panel of a city's buildings, zoning, and floorspace prices. This data allows me to estimate a new dynamic spatial equilibrium model of floorspace supply and demand. I validate the model using quasi-experimental variation from recent zoning reforms and apply it to evaluate the effects of relaxing regulation on construction and affordability. While zoning strongly constrains city growth, the effects of relaxing regulation take decades to materialize and are limited in inexpensive or densely built areas. This is due to the large fixed costs of redevelopment, which rise sharply with the size of existing buildings. These costs generate considerable persistence in city structure and substantially lower the expected gains from relaxing zoning. Furthermore, due to migration, the affordability benefits of zoning reform largely accrue to households outside the rezoned neighborhoods.

**JEL Classifications**: R31, R52, R14
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# 1 Introduction

Urban neighborhoods constantly evolve to accommodate growing populations and new economic activities. This continuous transformation is essential for a city's success, yet in many places, it appears to be faltering. In particular, the world's largest cities face acute housing shortages and soaring rents. Insufficient construction there is holding back aggregate economic growth, as these cities are the most productive and innovative parts of the modern economy.

Zoning regulations, which limit the size and permitted uses of buildings, are widely seen as a major contributor to these issues. In response, many cities have begun to relax these rules or are considering deregulation to spur construction and improve affordability. However, whether these reforms will achieve their aims remains unclear. Indeed, regulation is not the only constraint preventing large cities from growing. In city cores, vacant land is scarce and most new construction comes through redevelopment—demolishing existing buildings to replace them with new ones. While this process has recently become the dominant mode of urban expansion (Frolking et al., 2024), it is much costlier than building on undeveloped land.

Using New York City as a case study, this paper examines how zoning and the existing building stock influence a city's evolution and evaluates the effects of relaxing zoning on construction and equilibrium prices. Such an analysis has long been hindered by two challenges. First, it requires data about developers' behavior: which buildings they demolish and when, what they build in their place, and the zoning constraints they face. This information is not readily available and must be assembled from numerous sources. Second, modeling the evolution of a large city is technically challenging: developers make dynamic, durable investment choices on hundreds of thousands of land parcels, each with distinct buildings depreciating slowly over time and facing diverse zoning constraints. These development decisions depend on local floorspace prices now and far into the future, which in turn depend on development decisions across the entire city. Indeed, construction in one neighborhood influences other areas via migration and commuting spillovers.

To overcome these challenges, I build the first parcel-level panel dataset tracking a city's buildings, zoning, and floorspace prices. Using this data, I first provide new facts about redevelopment and evaluate the impact of recent zoning reforms. I then estimate a new model of urban evolution that integrates a dynamic model of developers' redevelopment decisions into a spatial equilibrium model of households and firms. Finally, I leverage this framework to evaluate the effect of relaxing zoning on construction, prices, and the city's structure.

The data enabling my analysis is presented in Section 2. To track land uses in NYC, I first link cadastral maps issued in different years using a custom algorithm and manual reconciliation. This allows me to partition the city into about 833,000 parcels and follow the buildings on each parcel for each year between 2004 and 2022. I extract building characteristics from property tax records (obtained through FOIA requests and agency portals) and from scraped online listings. Over the study period, about 22,000 parcels were redeveloped (i.e., a new building was constructed there). For these parcels, I track the redevelopment process using building permits and certificates of occupancy, hundreds of thousands of which had to be digitized. I match this data with the universe of real estate transactions in NYC since 2003, rent data from scraped building-level tax notices, and zoning maps for each year. This panel allows me to measure individual development decisions and the constraints developers face: zoning and the demolition of existing buildings.

In Section 3, I provide new stylized facts about redevelopment and reduced-form evidence on the effects of relaxing zoning. Tracking individual parcels over time, I show that redevelopment is associated with densification: 96% of demolished buildings are replaced with larger ones, with new structures on average 3.4 times larger than the ones they replace. Conversely, redevelopment seldom happens when it cannot increase the amount of floorspace on a parcel, such as when the parcel is already at the maximum density allowed by zoning. By substantially increasing the amount of floorspace on a parcel, developers can overcome the fixed costs associated with demolishing an old building. I show that, in addition to increasing the aggregate supply of floorspace in a city, redevelopment enables adjustments in the ratio of residential to commercial floorspace within each neighborhood. Developers tend to build the most valuable type of floorspace, reallocating land to its most profitable use.

I leverage the quasi-exogenous timing of recent zoning changes to evaluate the effect of relaxing regulatory constraints (upzoning) in a difference-in-differences design at the parcel level. While upzoning does increase construction, its effects materialize slowly over time: ten years after the policy change, only 9% of the newly allowed floorspace has been built. The effects of upzoning are concentrated on parcels where redevelopment is the most profitable—those with high floorspace prices and low levels of existing development.

To extrapolate beyond observed rezonings (i.e., to evaluate more ambitious policies, apply them to neighborhoods not recently targeted by planners, and assess their long-term effects) and to measure their impact on local and distant prices, I develop a dynamic spatial equilibrium model of floorspace supply and demand, described in Section 4. To model floorspace supply, I consider that each parcel is associated with a potential developer who periodically decides whether to redevelop it or not. When redeveloping a parcel, developers choose what to build subject to zoning limits on use and size. Redevelopment is costly. Some costs are variable and increase with the size of the new building. Others, such as those associated with permitting, eviction, and demolition, are fixed and vary from one structure to the next. For instance, demolition will be costlier for tall buildings in dense neighborhoods.

I integrate this model of developers' behavior into a spatial equilibrium model of workers and firms. Workers choose where to live and work in the city, consume residential floorspace, vary in their productivity, and have non-homothetic preferences. Firms consume commercial floorspace. Over time, redevelopment changes the supply of floorspace in each neighborhood, leading to changes in local amenities and productivity levels due to agglomeration spillovers both within and across residential and commercial land uses. Buildings deteriorate over time, reducing their value and increasing the profitability of redevelopment. Each period, floorspace rents adjust so that markets clear. Developers, aware of these dynamics, make forward-looking decisions with rational expectations.

Section 5 describes how I estimate the model. For the supply side, which models the behavior of developers, I rely on methods developed in the empirical industrial organization literature and their application to urban economics (Rust, 1987; Murphy, 2018; Almagro and Domínguez-Iino, 2025; Hsiao, 2024). Specifically, I proceed in three steps. First, I use real estate sales data to estimate the value of buildings as a function of their characteristics. This allows me to estimate the value of properties in NYC and assess how redevelopment could increase their worth. Then, I estimate variable construction costs using a revealed-preferences approach. When redevelopment takes place, I observe the choices made by developers as well as the floorspace prices and zoning regulations they faced. This provides information on the cost schedule developers face. Finally, I estimate fixed costs through a nested fixed-point algorithm, extending Rust (1987) to a spatial equilibrium setting. Specifically, fixed costs are chosen so that the model best reproduces the relationship between developers' choices and the expected value of those choices. This requires repeatedly solving the full dynamic equilibrium for different candidate values of the fixed cost parameters. Indeed, the option value of future redevelopment depends on the entire future path of prices. This path is an equilibrium outcome determined by the collective actions of all developers, which, in turn, depend on the very fixed costs being estimated. I find that fixed costs are higher in denser neighborhoods and increase sharply with the size of the building to be demolished.

To estimate the parameters of the demand model, I first infer workers' preferences and firms' production functions through observed rents, commuting flows, and floorspace consumption. Accounting for worker heterogeneity and non-homothetic preferences proves essential to rationalize the patterns of floorspace demand in the data. To estimate agglomeration forces, I leverage the construction of large new buildings. Comparing areas that received construction earlier vs. later in a staggered difference-in-differences design, I estimate local elasticities of rents to floorspace supply. I find that new construction lowers the rents of nearby preexisting buildings of the same type. This effect combines a supply effect and an agglomeration effect, as new buildings change local amenities and productivity. I estimate agglomeration externalities so that the model reproduces the demand elasticities estimated in the reduced form. I find strong positive spillovers within land uses (i.e., of residential construction on residents, or commercial construction on firms), while spillovers across land uses are limited.

My model is estimated independently of my difference-in-differences estimates of the effects of upzoning. Therefore, to validate my model, I reestimate it on the subsample of parcels that were not upzoned and then predict the effects of upzoning on parcels that were. The model's predicted effects closely match my quasi-experimental estimates across a wide range of horizons and in different contexts, indicating that it can reliably predict the effects of zoning changes.

The estimated model allows me to simulate the city's evolution over the coming decades under different policy scenarios. I compute counterfactuals by finding a fixed point in the paths of floorspace supplies and prices, where floorspace supplies are consistent with developers' optimal behavior given prices and zoning, and prices each period are given by spatial equilibrium. In Section 6, I compare NYC's trajectory under current regulations with scenarios in which zoning constraints are relaxed to measure how much relaxing zoning would boost construction and increase affordability.

I first quantify the aggregate effects of deregulation. The model projects that an ambitious but realistic upzoning of NYC could increase the city's floorspace supply by 15 pp over 40 years. However, the take-up of upzoning remains limited in the medium run: at a 40-year horizon, only 18% of the newly allowed floorspace is built. Furthermore, the effects of upzoning unfold slowly: ten years after upzoning, only 23% of the reform's long-term impact on construction has materialized. Fully removing zoning regulations yields larger increases in floorspace (+58 pp), but even in this extreme scenario, residential rents in NYC decrease only moderately (-17 pp). This is because new construction triggers migration to the city, dampening local rent reductions while contributing to diffuse rent declines in other cities. Yet, removing zoning would still yield sizable welfare gains for New Yorkers (+13 pp by 2060), with lower-income workers benefiting the most. Furthermore, upzoning substantially outperforms two alternative policies aimed at increasing construction and affordability: reducing construction costs and granting property tax breaks on new buildings. Tax breaks are particularly costly because they tend to subsidize inframarginal projects. Finally, I find that use and density zoning limits interact: the effect of relaxing both limits together is substantially larger than the sum of the effects of relaxing each one separately.

Because the fixed costs associated with redevelopment are large and increase sharply with the amount of floorspace to be demolished, the effects of relaxing zoning are highly heterogeneous over space. Relaxing zoning has very limited effects in neighborhoods where floorspace is inexpensive. There, redevelopment is usually unprofitable and therefore rare, and new buildings tend to be small. Upzoning parcels that are already densely built is also largely ineffective. Even without zoning limits, developers rarely redevelop these parcels because fixed costs typically exceed the additional rents redevelopment would yield. The neighborhoods whose growth is most distorted by zoning are those with limited density and high floorspace prices. A simpler model that ignores the large adjustment costs associated with redevelopment would not only overstate the effects of relaxing zoning, predicting nearly twice as much floorspace growth as my dynamic model would, but also suggest that removing zoning would completely reshape the city's structure. In reality, high redevelopment costs create considerable path dependence and tightly constrain urban growth.

An alternative way to assess zoning's impact on urban growth is to quantify its effect on floorspace supply elasticities. Under current zoning regulations, NYC's floorspace supply is largely unresponsive to price increases, with an aggregate floorspace supply elasticity reaching only 0.13 at a 40-year horizon. Supply elasticities vary widely across neighborhoods and are essentially determined by how much of the maximum allowed density has already been built. Removing zoning would more than quintuple the city's overall floorspace supply elasticity and make local elasticities depend more on density, with denser areas remaining less elastic.

The large welfare losses resulting from zoning raise the question of why city planners implemented such costly regulations. In the final section of the paper, I argue that NYC's zoning resolution may have been socially beneficial when adopted in 1961: demand for floorspace had plateaued, so zoning imposed relatively low costs while helping to curb negative externalities from industrial activity. Today, those externalities have largely faded, while floorspace prices often exceed marginal construction costs by a factor of two or three, making growth restrictions much more costly. The zoning code has, however, failed to adapt to changing economic conditions and has been much more persistent than its creators intended.

**Contribution to the literature.** Understanding the allocation of land uses in cities has long been a core goal of urban economics. Successive literatures have described how economic fundamentals and agglomeration shape urban density and land use, from the early studies of Burgess (1925) and Hoyt (1939) to monocentric city models (Alonso, 1964; Mills, 1967; Muth, 1969; Ogawa and Fujita, 1980; Lucas and Rossi-Hansberg, 2002) and modern quantitative approaches (Allen and Arkolakis, 2014; Ahlfeldt et al., 2015; Allen, Arkolakis and Li, 2015; Heblich, Redding and Sturm, 2020). These frameworks typically analyze long-run steady states and assume a frictionless adjustment of land uses. However, cities change slowly, and their evolution is severely constrained by redevelopment costs and regulation. Hence, this paper focuses on the slow evolution of cities and how zoning affects their transition dynamics. This perspective is more policy-relevant than static approaches. It also allows me to quantify the adjustment costs associated with new construction, which I find are central to understanding the effects of zoning. Finally, it enables an analysis of historical persistence, which I show plays a key role in shaping city structure.

Studying these urban dynamics requires detailed data on the evolution of cities and a granular model of urban change. To that end, I build the first parcel-level panel of land use and zoning for a city, and use it to estimate a new model of redevelopment. My model builds on three modeling approaches in the literature. A first set of studies uses data from individual development projects to model the dynamic behavior of developers (Murphy, 2018; Soltas, 2024). I extend these analyses by measuring how zoning and demolition costs constrain developers. A second set of articles, originating with Ahlfeldt et al. (2015), builds granular spatial equilibrium models that account for the complex interactions between urban neighborhoods. I extend these studies by building a model with rich heterogeneity in worker productivity and non-homothetic preferences, and by providing measures of agglomeration externalities, including novel measures of spillovers across land uses. Finally, I build on dynamic urban models that describe the progressive evolution of a city (Hsiao, 2024; Gechter and Tsivanidis, 2023; Greaney et al., 2025; Henderson et al., 2021; Peng, 2023). For tractability and due to data limitations, these studies model (re)development as an increase in the aggregate capital stock of different neighborhoods. While these models account for the slow evolution of urban areas, they cannot precisely identify the effect of zoning and demolition costs on construction, as both constraints vary widely from one parcel to the next within a neighborhood.

By evaluating how NYC would evolve in the coming decades if zoning were relaxed, I contribute to an active literature assessing the impact of land use regulations. A first set of studies, at the micro level, leverages recent zoning changes to show that relaxing land use regulation leads to additional construction (Anagol, Ferreira and Rexer, 2024; Büchler and Lutz, 2021; Liao, 2022; Peng, 2023). Observed rezonings, however, are typically limited in scope and enacted in areas where planners believe they will be effective. The model developed in this paper can extrapolate beyond these case studies and predict the impact of various zoning reforms over extended time periods. A second set of studies, at the macro level, shows that zoning reduces the aggregate housing supply, raises prices, and causes a costly spatial misallocation of land uses (Glaeser, Gyourko and Saks, 2005; Gyourko and Molloy, 2015; Ganong and Shoag, 2017; Glaeser and Gyourko, 2018; Hsieh and Moretti, 2019; Ospital, 2022). This paper microfounds the aggregate supply and demand for floorspace and shows that existing spatial equilibrium models can substantially overstate the effects of relaxing zoning if they do not account for the large fixed costs of redevelopment. Both sets of studies have overwhelmingly focused on housing and density restrictions. I extend my analysis to commercial real estate and use regulations (which restrict where commercial and residential buildings can be constructed). This wider scope is valuable because commercial buildings represent a large share of the floorspace stock (35% in NYC) and their location is a key determinant of job access and commuting times.[1]

I also contribute to the literature measuring housing supply elasticities. Saiz (2010) highlights the importance of geography in determining these elasticities across metropolitan areas, and Baum-Snow and Han (2024) find more variation in supply elasticities within metropolitan areas than between them, with lower elasticities near central business districts. Like Murphy (2018), I use a dynamic model of developers' behavior to measure supply elasticities. This allows me to provide granular elasticity estimates across different time horizons. I find wide variation in supply elasticities across neighborhoods, with zoning as their primary determinant, rather than existing construction.

[1] This broader focus relates my work to Kulka, Sood and Chiumenti (2024), who also investigate the multifaceted nature of zoning by studying the interaction between different types of regulations that limit housing density. I also find such interactions, namely between density and use restrictions.

Finally, a large body of research has emphasized the role of adjustment costs in explaining investment in fixed assets and labor (Lucas, 1967; Dixit, 1989; Nickell, 1986; Caballero, Engel and Haltiwanger, 1997). These costs have both fixed and variable components. They may reflect technological constraints (e.g., installation or training costs) or stem from regulation (such as environmental or employment protection laws). Disentangling these frictions is essential to quantify misallocation in the economy (Asker, Collard-Wexler and De Loecker, 2014; David and Venkateswaran, 2019). This paper contributes to this literature by carrying out such a decomposition for investment in a specific but important form of capital: buildings.

## 2 Data and Context

With over eight million inhabitants, NYC is the largest city in the United States. The total value of its real estate exceeds three trillion dollars, and while real home prices in NYC have almost doubled between 2000 and 2025, the city's growth over this period has been slow. NYC's neighborhoods vary widely in density and income levels, providing a rich setting for analyzing urban change across a range of contexts. I assembled data from a wide range of sources to measure the behavior of developers as well as the prices and regulations they face. This section describes the key datasets I rely on, with Appendix A providing additional details.

**A parcel-level panel of NYC buildings.** I track the evolution of land use in NYC at the parcel level. This granular data is essential for studying redevelopment, as developers make decisions at the parcel level and the technological and regulatory constraints they face vary widely from one parcel to the next. However, parcel-level panels of land use are not readily available. The closest existing datasets consist of repeated cross-sections of all buildings in a city. Over time, redevelopment causes some buildings to disappear from the cross-section and others to appear. To construct a panel dataset of land use, one must link new buildings with the old ones demolished to make way for them.

To do so, I rely on cadastral maps. These maps divide all of NYC into lots, each associated with a tax identifier. I overlay maps published in different years and link them using a custom polygon conflation algorithm.[2] This allows me to divide NYC into about 833,000 parcels and find the property tax identifiers of the buildings located on them between 2004 and 2022.

I then associate these buildings with a wide range of characteristics. My primary source is property tax data gathered from publicly available assessor rolls, FOIA requests, and scraping individual property tax statements. I complemented this data with information from StreetEasy (Zillow's NYC subsidiary), for which I scraped data covering 1.6 million units.

[2]This procedure (described in Appendix A.1) allows me to track parcel boundary changes (such as splits and mergers) that sometimes accompany redevelopment. To ensure a perfect tracking of all of NYC's parcels, I manually coded 5,700 boundary changes that were not detected by the algorithm.

Over my period of study, about 22,000 parcels were redeveloped.[3] To understand when redevelopment started, I match my panel with a dataset of building permits. To measure when it ended, I rely on certificates of occupancy (documents issued by the city certifying that a new building is fit for use).[4] Construction projects are usually completed quickly, with certificates of occupancy typically granted two years after the corresponding building permit (see Appendix Figure C.2).

**Real estate prices and rents.** To measure floorspace prices throughout the city and over time, I rely on the NYC Department of Finance's Property Sales Files, which document the universe of real estate transactions that took place in the city between 2003 and 2022.

For a subset of buildings, I can further recover yearly rent estimates from the Notices of Property Values (NOPVs) sent annually to property owners to inform them of their property taxes. These documents are used in Li (2022) to build building-level rent measures covering 2003–2013. By scraping over 600,000 NOPVs issued in recent years, I extend Li's dataset up to 2021.

**Zoning constraints.** I extract from NYC's zoning resolution the regulatory constraints imposed on different parcels. The zoning map, of which an extract is presented in Appendix Figure B.1, associates each parcel with a zoning district, indicating allowed land uses and the maximum allowed size of new buildings. Density in NYC is mainly regulated through Floor Area Ratio (FAR) limits. The FAR of a parcel is defined as the total floorspace of its buildings divided by its land area (see Appendix Figure B.2 for an illustration).

NYC's current zoning resolution was adopted in 1961 and largely reflects the city's organization in the early 1960s. Commercial zoning districts are concentrated in the high-density neighborhoods of the lower half of Manhattan and Downtown Brooklyn, while more peripheral neighborhoods are almost exclusively zoned for residential purposes, with strictly limited densities (see Figure 1 and Appendix Figures B.3 and B.4).

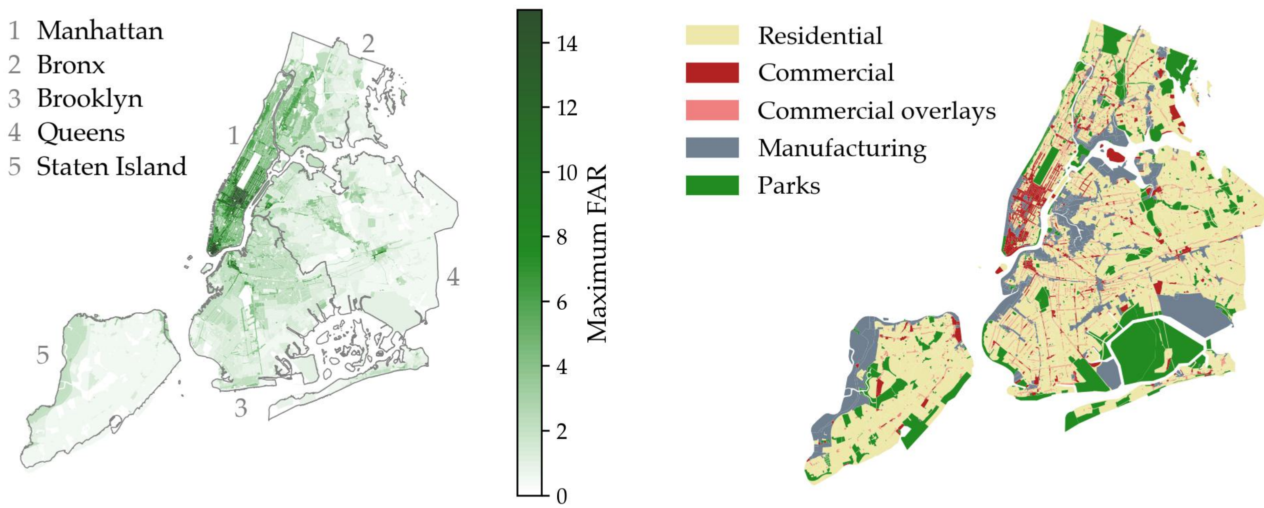
The average parcel in NYC has a built FAR of 1.1 and a maximum allowed FAR of 1.4 (see Appendix Figure C.3). A third of parcels exceed their maximum allowed FAR, often because they were built before 1961 and have been grandfathered in. Another quarter are within 0.25 FAR points of the limit, making density restrictions binding or nearly binding for most parcels in the city.

[3] I consider that a parcel has been redeveloped when a new building is constructed. I also tracked conversions (usually of commercial buildings to residential ones), which account for a small share of total redevelopment activity (see Appendix Figure C.1) and are therefore ignored in the quantitative analysis below. Renovations and building extensions are also excluded from the scope of this study, as the amount of floorspace added to the city through them is an order of magnitude lower than that added through new construction.

[4] Certificates of occupancy issued after July 2012 are available in a public database. To cover earlier redevelopment events, I scraped and digitized 250,000 certificates from the NYC Buildings Information System.

**Figure 1:** NYC's zoning map

**(a)** Density (FAR) limits **(b)** Use limits




*Notes*: This figure illustrates NYC's zoning map. Panel (a) shows the maximum allowed densities (FARs) on parcels across the five boroughs of the city. Panel (b) shows land use districts in NYC's zoning map. Residential districts only allow residential uses, commercial districts allow both residential and commercial uses, and manufacturing districts only allow commercial uses. Commercial overlays correspond to zones in residential areas that allow some commercial uses (e.g., stores on the first floor of buildings).

**Additional data sources.** For some analyses, I further leverage smartphone data from Advan, commuting flows data from the LEHD-LODES database, commuting times from Google Maps, historical building permits from the Office for Metropolitan History, and historical sales data from the Real Estate Board of New York.

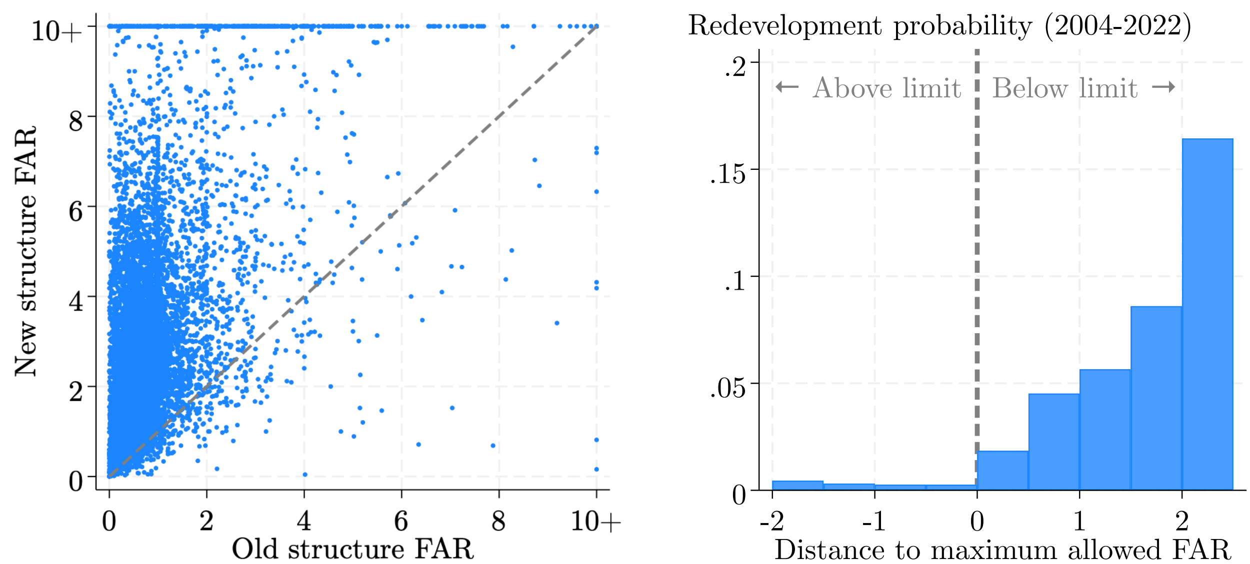
# 3 Motivating Facts

The granular datasets I have collected allow me to describe developers' behavior at the micro level. In this section, I present new facts describing how redevelopment progressively changes land uses and reduced-form evidence of zoning's effects on development. I report additional descriptive statistics in Appendix C.

**Redevelopment is associated with densification.** Redevelopment entails high fixed costs. Indeed, to construct a new building, existing structures must be demolished (and their future stream of rents forgone), building permits must be obtained, existing tenants must be relocated, etc. Hence, redevelopment is financially viable only when new structures are significantly more valuable than the ones they replace. A developer can increase a parcel's value by increasing the quality of the building on it. Indeed, older structures are much more likely to be redeveloped than newer ones. However, new buildings are more valuable than old ones primarily because they are larger: Figure 2(a) compares the FAR of new structures with the FAR of those they replaced. 96% of redevelopment events increased the amount of floorspace on the redeveloped parcel, and on average, new buildings had FARs 3.4 times higher than those they replaced.[5]

**Figure 2:** Redevelopment happens when it can substantially increase a parcel's floorspace

**(a)** FAR of new vs. old buildings **(b)** Redevelopment and zoning limits




*Notes*: Panel (a) compares, for redeveloped parcels, the FAR of new structures with the FAR of the structures they replaced. The dashed line corresponds to the 45-degree line. Panel (b) shows the probability of observing a redevelopment event in the panel for different bins of the distance (in FAR points) between the FAR of the initially existing structure and the maximum FAR allowed by zoning.

In line with this, redevelopment only takes place when zoning allows the replacement of an existing structure with a larger one. Figure 2(b) shows that parcels at or above the maximum allowed FAR are very rarely redeveloped. Indeed, it is unlikely that redevelopment would increase the value of these parcels enough to cover the fixed costs of redevelopment. On the other hand, buildings well below the maximum allowed FAR are much more likely to be redeveloped.

**Relaxing zoning leads to progressive density increases in some areas.** The extent to which zoning affects redevelopment can be directly evaluated by analyzing recently rezoned parcels. Although zoning rules tend to be persistent, several neighborhoods of NYC have been upzoned in the past decades, meaning that FAR restrictions have been substantially relaxed. These areas offer valuable case studies to investigate the effects of zoning reform.

Rezonings are politically fraught, require approval from many stakeholders, and can take decades to pass. Therefore, when the Department of City Planning initiates a neighborhood rezoning, there is considerable uncertainty about which parcels will be affected, how their FAR

[5]This finding echoes that of Henderson et al. (2021), who, using LiDAR data, show that newly built structures in Nairobi are roughly three times larger than the buildings they replaced.

and use limits will change, and when those changes will take effect.[6] While upzoned parcels are typically ripe for redevelopment and represent a selected sample, the exact timing of rezonings can reasonably be considered exogenous.

To estimate the effect of upzoning on redevelopment, I focus on parcels within areas rezoned between 2004 and 2022, whose maximum allowed FARs increased by more than 0.25.[7] I then compare parcels that were upzoned earlier vs. later using the staggered difference-in-differences procedure of de Chaisemartin and d'Haultfœuille (2020).

Figure 3(b) reports event study estimates of the effects of upzoning on built FAR. While relaxing zoning constraints stimulates development, increases in floorspace supply only materialize slowly over time. Even a decade after the policy change, take-up remains limited. On average, upzonings raise the maximum allowed FAR by one, but result in only a 0.09 increase in built FAR over ten years.

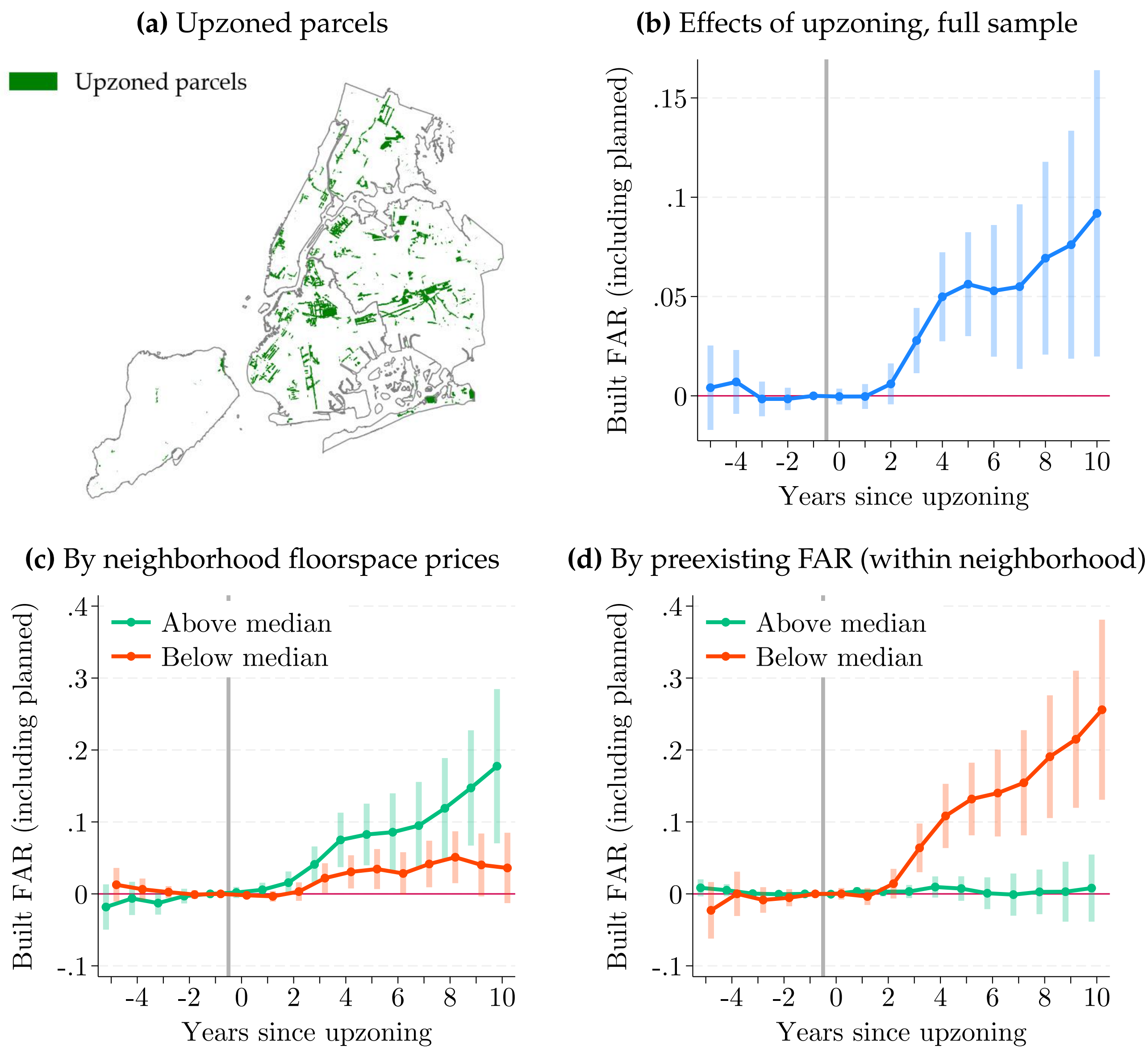
These results are striking in light of the wide gap between the price of floorspace and its marginal construction cost in NYC. In 2019, reported construction costs there ranged between \$160 and \$600 per sq. ft of floorspace (see, e.g., RSMeans, 2020; New York Building Congress, 2019). At the same time, the price of floorspace averaged around \$700 per sq. ft, reaching much higher levels in some parts of Manhattan. This large wedge, noted by Glaeser, Gyourko and Saks (2005), would be arbitraged by developers if they could easily increase the city's floorspace supply. However, even when zoning is relaxed to permit additional construction, technological constraints limit the extent to which developers can expand the supply of floorspace.

Consistent with the presence of large fixed costs of redevelopment, the effects of upzoning are highly heterogeneous. Figure 3(c) shows the impact of upzonings separately for neighborhoods with high vs. low floorspace prices, revealing that the effects of upzoning on construction are almost entirely driven by upzonings in expensive neighborhoods. Upzoning parcels in areas where floorspace prices are low yields little new construction; there, the reward for increasing floorspace supply is usually too low to cover redevelopment costs. Figure 3(d) further shows that the effects of upzoning are fully concentrated on parcels with relatively low FARs before upzoning. Upzoning parcels that already have large buildings typically does not result in additional construction, as redeveloping these structures involves forgoing a large stream of future rents and paying higher demolition costs.

[6]For instance, discussions to rezone the Gowanus Canal area began in the mid-2000s during the Bloomberg administration. Local community groups opposed rezoning proposals, fearing the changes would lead to gentrification and worsen the canal's flooding and contamination. The rezoning was finally approved in late 2021, after nearly twenty years of negotiation.

[7]In the analysis sample for the event study, I exclude parcels that were upzoned as part of small rezonings, defined as rezonings affecting fewer than 30 parcels. These small rezonings are often requested by developers and may be processed more quickly than larger ones, making their occurrence endogenous. Large rezonings, conversely, tend to be initiated by city planners and follow a longer approval process. Approximately 10% of the redevelopment events occur on parcels upzoned as part of a large rezoning, and 1% on parcels upzoned as part of a small rezoning. Parcels in my estimation sample are mapped in Figure 3(a).

**Figure 3:** Effects of upzoning on built FAR

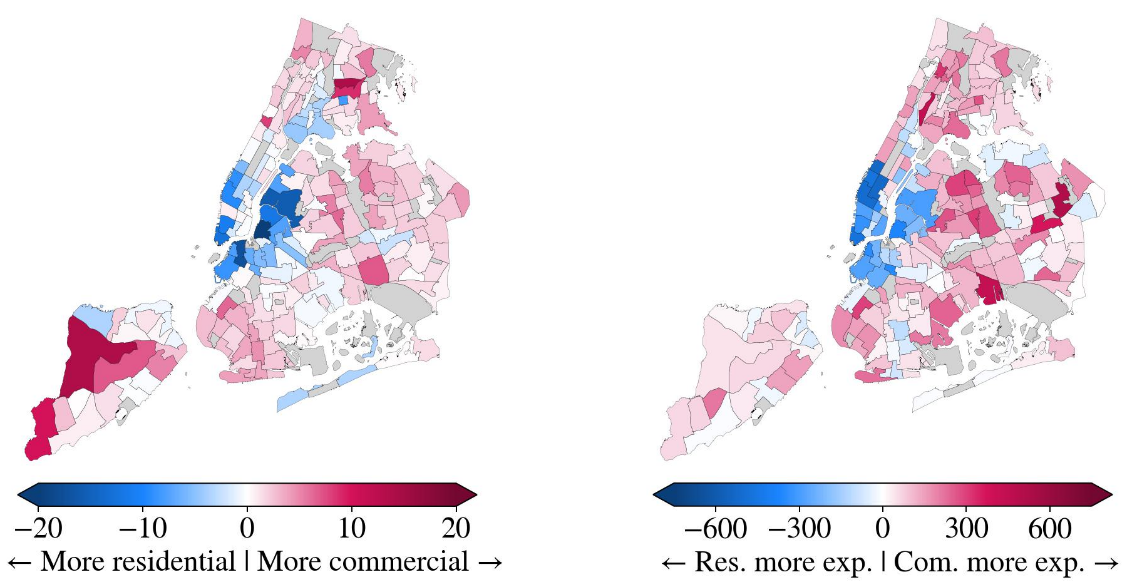



*Notes*: This figure presents estimates of the effects of upzoning on built FAR. Panel (a) shows parcels that were upzoned (i.e., that saw their maximum allowed FAR increase by more than 0.25) between 2004 and 2022, excluding upzonings that were part of rezonings affecting fewer than 30 parcels. Panel (b) shows the effect of upzoning on built FAR (including the planned floorspace of buildings under construction) for the full sample. In Panel (c), I split the estimation sample between neighborhoods with floorspace prices above/below the median. In Panel (d), I split the sample between parcels whose built FAR in 2004 was above/below their neighborhood's median. Treatment effects are computed using the procedure of de Chaisemartin and d'Haultfœuille (2020), comparing parcels upzoned earlier vs. later. Observations are weighted by parcel size, and standard errors are clustered at the city block level. On average, upzonings increased the maximum allowed FAR by one. Before rezoning, upzoned parcels had an average built FAR of 1.3.

**Redevelopment reallocates land to its most profitable use.** Land uses in NYC are becoming increasingly mixed. Figure 4(a) shows that, over the past decades, the city's (mostly commercial) central neighborhoods have shifted to become more residential, while its (mostly residential) peripheral neighborhoods have become more commercial.

**Figure 4:** Redevelopment reallocates land to its most profitable use

**(a)** Change in commercial share (%) between 2004 and 2022 **(b)** Commercial-residential price differential (in $/sq. ft)




*Notes*: Panel (a) shows the change in the share of commercial floorspace in total floorspace between 2004 and 2022. Panel (b) shows the price difference between a sq. ft of commercial floorspace (office or retail) and a sq. ft of residential floorspace. Data is aggregated at the Neighborhood Tabulation Area level.

These city-level trends align with the financial incentives developers face. In NYC's central neighborhoods, residential floorspace is on average 30% more expensive than commercial floorspace. In contrast, in peripheral neighborhoods, commercial floorspace commands a 30% premium over residential floorspace; see Figure 4(b). The similarities between the two panels show that redevelopment tends to reallocate land to its most profitable use.

These patterns reflect NYC's broader transformation from a manufacturing hub to a service-oriented metropolis. Since 1961, the share of manufacturing in employment in New York has fallen by a factor of 10, and the central areas of the city have become quieter, less polluted, and generally more attractive for residents. Between 1950 and 2019, rents in the city center grew 2.5 times faster than in more residential neighborhoods (see Appendix Figures B.5 and B.6). Meanwhile, businesses have been gradually relocating away from the central business district.

Smartphone location data, analyzed in Appendix Figure B.7, suggests that this trend will accelerate with the rise of working from home. In the aftermath of the 2020 pandemic, visits to commercial locations in the center of NYC decreased relative to those in peripheral locations, consistent with workers spending more time in residential neighborhoods.

Regulation, however, slows this reallocation of land uses. Indeed, zoning favors the construction of commercial buildings in the city's core and usually disallows such construction in peripheral areas (see Appendix Figure B.8). The extent to which zoning rules limiting parcels' residential or commercial use bind can be directly tested using event studies analogous to those of Figure 3. In Appendix Figure G.1, I show that rezonings that newly allow a parcel to have a residential (or commercial) use spur the construction of floorspace for that use.

**Remaining questions.** The evidence presented in this section highlights two benefits of relaxing zoning regulations: densification and the reallocation of land to more profitable uses. However, it is insufficient to answer several key policy questions. Indeed, the upzonings we observe are in neighborhoods that were selected by planners, are often limited in scope, and can only be evaluated over short time horizons. Since the effects of upzoning vary widely and unfold over several decades, the effects of broader, more ambitious upzonings are uncertain, especially in the longer run. Moreover, the effects of upzoning on affordability remain unclear. Here, measurement is complicated by general equilibrium effects, as building more in one area affects not only local prices but also prices in other neighborhoods.

# 4 A Model of Urban Evolution

To better understand the city's slow evolution through redevelopment and evaluate the extent to which zoning distorts this process, I build a dynamic spatial equilibrium model of the city. In the model, new floorspace is supplied by forward-looking developers whose decisions depend on prices, zoning regulations, and the characteristics of existing buildings. Workers consume residential floorspace, while firms use commercial floorspace in production.

## 4.1 Supply

The model's supply side is designed to capture three key aspects of the redevelopment process. First, replacing old buildings with new ones entails large fixed costs, which can vary with the characteristics of the building to be demolished. Second, what developers build is restricted by zoning and influenced by market prices. Third, as with other forms of investment, development decisions are made dynamically. Buildings deteriorate slowly over time, and the price of floorspace evolves from year to year as a function of expected future rents, leading developers to optimize when they tear down a structure to replace it with a new one.[8]

**Setup.** The city comprises a fixed set of parcels, each associated with a potential developer. Each year, developers decide whether to redevelop their parcel or not, taking an action $a$ in $\mathcal{A}_{it}^{\text{allowed}} \subset \{\emptyset, R, C\}$. $\emptyset$ corresponds to not redeveloping the parcel, and $R$ (resp., $C$) corresponds to building a new residential (resp., commercial) structure on it. If a developer decides to build, they choose $h^{\text{new}}$, the FAR of the new structure.

[8] Many studies, including Titman (1985), Quigg (1993), and Murphy (2018), provide evidence of developers' forward-looking behavior.

The set of available actions $\mathcal{A}_{it}^{\text{allowed}}$ is restricted in two ways. First, to redevelop a parcel, a developer must first buy it. Redevelopment, therefore, can happen only after a parcel is transacted on the real estate market, which happens with probability $p_i^{\text{transaction}}$ each year.[9] Second, new construction must comply with zoning. If a parcel is zoned for residential uses only, a developer cannot decide to build a new commercial building on it.

Developers make decisions so as to maximize the profits they can extract from a parcel,

$$V_{it} = \max_{a \in \mathcal{A}_{it}^{\text{allowed}}} \mathbb{E}_t \left[ (\pi_{ait} + \epsilon_{ait}) \cdot K_i + \frac{V_{i,t+1}(a)}{1+r} \right], \tag{1}$$

where $\pi_{ait}$ corresponds to the payoff of taking action $a$ on parcel $i$ in year $t$, and $\epsilon_{ait}$ is a parcel-period-action-specific profit shock. To facilitate interpretation, these payoffs and shocks are measured per sq. ft of land. Hence, the total flow payoff of choosing $a_{it}$ is $(\pi_{ait} + \epsilon_{ait}) \cdot K_i$, where $K_i$ is the land area of parcel $i$. Flow payoffs are all measured relative to the status quo (choosing not to redevelop), and are given by

$$\pi_{\emptyset it} = 0, \qquad \pi_{\theta it} = \max_{h^{\text{new}} \leq \bar{h}_{\theta it}} \Bigg[ \underbrace{\mathcal{P}_{it}(h^{\text{new}}, \mathbf{x}_{it}^{\text{new}}) - \mathcal{P}_{it}(h_i^{\text{old}}, \mathbf{x}_{it}^{\text{old}})}_{\text{Change in parcel value}} - \underbrace{[VC_{\theta it}(h^{\text{new}}) + FC_{it}]}_{\text{Cost of redevelopment}} \Bigg], \tag{2}$$

where $\theta \in \{R, C\}$. When redevelopment occurs, developers choose the FAR of the new building $h^{\text{new}}$ so as to maximize redevelopment profits subject to the zoning limit $\bar{h}_{\theta it}$. The developer's profit corresponds to the increase in the parcel's value brought by redevelopment minus redevelopment costs, which can be fixed or variable. The vector $\mathbf{x}_{it}^{\text{new}}$ (resp., $\mathbf{x}_i^{\text{old}}$) corresponds to the characteristics of the new (resp., old) building, including, for instance, its age, type, and condition. $\mathcal{P}(h, \mathbf{x})$ corresponds to the discounted sum of future rents derived from a building. As time passes, buildings age, and the old buildings' value $\mathcal{P}_{it}(h_i^{\text{old}}, \mathbf{x}_{it}^{\text{old}})$ decreases, making redevelopment increasingly profitable. Buildings that are shorter and have less valuable characteristics are more profitable to redevelop and hence are more likely to be demolished.

Variable costs $VC$ correspond to construction costs, which increase with the size of the new building $h^{\text{new}}$. Fixed costs $FC$ are those associated with demolition, vacating existing tenants, and permitting. I allow them to vary from one parcel to the next.

I assume that developers are perfectly foresighted and price-taking: they know the path of future costs and prices, and do not condition their choices on other developers' actions. This is justified by the very large number of parcels in the city, as well as the competitive nature of the

[9] Buildings in NYC are usually not directly redeveloped by their owners. Rather, the redevelopment process tends to begin with a developer purchasing a building and applying for a building permit. Appendix Figure C.4 shows that the sale probability of a parcel rises sharply in the years preceding redevelopment, reaching nearly 40% in the year before permit issuance, compared to a baseline annual sale probability of just 5.6%. Overall, 73% of redeveloped parcels are sold in the year redevelopment begins or in one of the two years prior.

real estate development industry in NYC, which encompasses thousands of firms and has a low degree of concentration (see Glaeser et al., 2005).

**Parametrization.** To estimate the model, I parametrize price and cost functions. For prices, I assume that the expected value of a parcel (per sq. ft of land) is a function of its geographic location and the characteristics of the building occupying it, with

$$\mathcal{P}_{it}(h_{it}, \mathbf{x}_{it}) = \underbrace{P_{\theta nt}}_{\text{Baseline price per sq. ft}} \times \underbrace{Q(\mathbf{x}_{it})}_{\text{Building quality}} \times \underbrace{h_{it}}_{\text{Building FAR}} . \tag{3}$$

Here, $P_{\theta nt}$ measures the price of a sq. ft of floorspace of type $\theta$ (residential or commercial) and of average quality in neighborhood $n$ and time $t$. It is the discounted sum of future rents $R_{\theta nt}$:

$$P_{\theta nt} = \sum_{k=0}^{\infty} \frac{R_{\theta n,t+k}}{(1+r)^k}. \tag{4}$$

This price is inflated or deflated by $Q(\mathbf{x}_{it})$, which reflects the building's quality as a function of its characteristics (including its FAR $h_{it}$). Finally, the quality-adjusted price per sq. ft is multiplied by the number of sq. ft of floorspace per sq. ft of land, $h_{it}$.

Studies estimating the production function for housing have found it is well approximated by a Cobb-Douglas aggregation of land and capital, for both small and tall structures (Epple, Gordon and Sieg, 2010; Combes, Duranton and Gobillon, 2021; Ahlfeldt and McMillen, 2018). Hence, I assume that investing $k$ units of capital on a sq. ft of land allows the developer to build a structure of FAR $h = k^{\zeta}$, where $\zeta$ is the capital cost share in construction. The cost of a unit of capital is given by $\alpha_{\theta it} e^{\eta_{it}}$, where $\eta_{it}$ is a construction cost shock. Hence, the variable cost function is given by

$$VC_{\theta it}(h_{it}^{\text{new}}) = \alpha_{\theta it} (h_{it}^{\text{new}})^{1/\zeta} e^{\eta_{it}}. \tag{5}$$

Finally, while some fixed costs of redevelopment are independent of the height of the old building, others increase with the amount of floorspace to demolish. Furthermore, demolition costs are likely higher for protected parcels (either as landmarks or because they are in historic districts) and in denser neighborhoods. Hence, I parametrize fixed costs as

$$FC_{it} = (\delta^0 + \delta^{\text{demolition}} h_{it}^{\text{old}} + \delta^{\text{density}} \bar{h}_{n(i)t})(1 + \delta^{\text{protected}} \mathbb{1}_{it}^{\text{protected}}), \tag{6}$$

where $\delta^0$ reflects the fixed cost (per sq. ft of land) associated with starting the construction of a building on vacant land that is unprotected (i.e., not landmarked or in a historic district). The parameter $\delta^{\text{demolition}}$ measures how fixed costs grow with the FAR of the structure to demolish, $\delta^{\text{density}}$ how they grow with the average FAR of parcels in the same neighborhood $\bar{h}_{n(i)t}$, and $\delta^{\text{protected}}$ quantifies the extent to which protected parcels (with $\mathbb{1}_{it}^{\text{protected}} = 1$) are harder to redevelop.

**Additional assumptions.** To facilitate estimation, I make three additional assumptions. First, I assume that redevelopment is a terminal decision, i.e., that once a building has been redeveloped, it will not be redeveloped again. This assumption simplifies estimation by turning the developer's dynamic decision process into an optimal stopping problem. It is also unlikely to substantially affect my results, as the median age of redeveloped buildings is 85 years, and I only focus on the city's evolution in the next 40 years in counterfactuals.

Second, I assume that the profit shocks $\epsilon_{ait}$ are distributed i.i.d. according to a Type I Extreme Value distribution with a mean of zero and a scale parameter $\sigma_{it} = \sigma_\epsilon^0 + \sigma_\epsilon^{\text{demolition}} h_{it}^{\text{old}} + \sigma_\epsilon^{\text{density}} \bar{h}_{n(i)t}$. $\sigma_\epsilon^{\text{demolition}}$ and $\sigma_\epsilon^{\text{density}}$ are both expected to be positive, capturing the fact that the shocks facilitating or hindering redevelopment are more variable for parcels with larger buildings or in dense neighborhoods.

Finally, I make some timing assumptions. Each period, developers choose an action in $\mathcal{A}^{\text{allowed}}$ after observing profit shocks $\epsilon_{ait}$, but they observe the cost shock $\eta_{it}$ only if they decide to redevelop. After observing $\eta_{it}$, the developer chooses the amount of floorspace they want to provide. This allows me to estimate the model in steps, as described in Section 5.1.

## 4.2 Demand

To understand the effect of redevelopment on prices and welfare, I develop a model of the demand for floorspace, building on the quantitative spatial models of Ahlfeldt et al. (2015) and Tsivanidis (2019). These workhorse models rely on data on commuting times and floorspace prices (or land prices) but not on floorspace quantities, which are treated as structural residuals. Accordingly, these models are typically used to evaluate the effects of changing commuting times but not to predict the effects of increasing the amount of floorspace in a neighborhood. In contrast, the model developed in this section directly incorporates data on quantities of floorspace, which I can vary in counterfactuals. Matching the observed data on the amount of floorspace consumed in each neighborhood requires modeling two important features of reality: the high heterogeneity in workers' earnings capacity and the fact that housing is a necessity good, making preferences non-homothetic. A model without these features would fail to rationalize, for instance, that the typical resident of the Upper East Side spends more than five times as much on housing as the typical resident of the Bronx.[10]

[10]In Appendix E.1, I calibrate a simple quantitative spatial model with homogeneous agents and homothetic preferences and describe why it fails to adequately predict floorspace consumption.

**Workers.** I partition the city into a finite set of neighborhoods populated by $\mathcal{L}$ workers as well as firms that produce a single final good, the numéraire.[11] Workers consume the final good and housing, and choose where to live and where to work. They are perfectly mobile within the city.

Each worker has a type $\theta$ and a skill level $s(\theta)$, corresponding to the number of efficiency-adjusted units of labor they can provide. The distribution of worker types is given by $L$, with $\mathcal{L} = \int_\theta L(\theta)\,\mathrm{d}\theta$. A worker $o$ living in neighborhood $n$ and working in neighborhood $m$ has the following Stone-Geary utility function:

$$U_{nmo} = \frac{B_n z_{no}^H z_{mo}^W}{d_{nm}} C_{nmo}^{1-\beta} (H_{nmo} - \underline{H}_n)^\beta, \tag{7}$$

where $C_{nmo}$ is the worker's consumption of the final good, $H_{nmo}$ is their consumption of residential floorspace, $B_n$ is the amenity level in neighborhood $n$, and $d_{nm}$ is an iceberg commuting cost. This commuting cost is a function of the commuting time $\tau_{nm}$ between neighborhoods $n$ and $m$, with $d_{nm} = \exp(\kappa\tau_{nm})$. $z_{no}^H$ and $z_{mo}^W$ are idiosyncratic shocks capturing workers' heterogeneous preferences for different home and work locations, respectively. I assume these shocks are drawn independently from Fréchet distributions with shapes $\varepsilon^H$ and $\varepsilon^W$—larger values of $\varepsilon$ correspond to more homogeneous worker preferences. I assume the following timing of shocks: workers draw $z_{no}^H$, decide where to live, and then draw $z_{mo}^W$ and choose where to work. Finally, housing is a necessity good, and workers must consume at least $\underline{H}_n$ sq. ft of housing to live in neighborhood $n$. Poorer households spend a larger share of their income on housing, and that share approaches $\beta$ as income grows.

In counterfactuals, I measure welfare changes for workers of each type as the equivalent variation—the income gain that would be required in the initial equilibrium to make workers achieve the expected utility level they reach in the counterfactual equilibrium.

**Migration and congestion.** As time passes, redevelopment increases the total amount of floorspace in the city, which tends to lower residential rents and increase wages. This raises residents' expected utility and causes the city's population to grow through migration. I assume that the number of workers of each skill level in the city grows with their expected welfare, with a migration elasticity $\varepsilon_M$ of 3 (this corresponds to a typical estimate in the literature—see, e.g., Bryan and Morten, 2019; Bilal, 2023; Hornbeck and Moretti, 2024).

Population growth increases congestion on transportation networks. To reflect this in the model, I assume that commuting times $\boldsymbol{\tau}$ increase with the total population of the city $\mathcal{L}$, with a congestion elasticity $\varepsilon_C$ of 0.15, on the higher end of values identified in the literature (Akbar and Duranton, 2017; Couture et al., 2018; Akbar et al., 2023).

[11] In the estimated model, neighborhoods correspond to NYC's 188 Neighborhood Tabulation Areas (NTAs) as well as an additional location corresponding to the rest of the metropolitan area (see Appendix E.3 for details). NTAs are defined by the NYC Department of City Planning as aggregates of census tracts that approximately correspond to historical neighborhoods of the city (e.g., Chinatown, Hamilton Heights). They are mapped in Figure 4.

**Firms.** Using as inputs labor $L_{Cm}^{\text{eff}}$ and floorspace $H_{Cm}$, firms in each neighborhood $m$ competitively produce a single final good that is freely traded within the city. Firms in neighborhood $m$ have access to the following Cobb-Douglas production technology:

$$Y_m = A_m \left(H_{Cm}\right)^{\alpha_m} \left(L_{Cm}^{\text{eff}}\right)^{1-\alpha_m}, \tag{8}$$

where $A_m$ is a productivity shifter and $\alpha_m$ governs the importance of floorspace relative to labor in production in neighborhood $m$. $L_{Cm}^{\text{eff}}$ is the total amount of efficiency units of labor provided by workers in $m$. The wage of an efficiency unit of labor provided in $m$ is denoted by $w_m$.

**Floorspace.** The amount of residential floorspace $H_{Rn}$ and commercial floorspace $H_{Cn}$ available in a neighborhood is given by the sum of the (quality-adjusted) floorspace supplied by all parcels in that neighborhood. Residential floorspace can be rented at a price $R_{Rn}$ and commercial floorspace can be rented at a price $R_{Cn}$. As richer households tend to own more real estate, I consider that rental income is redistributed to workers proportionally to their wage income.[12]

**Endogenous productivities and amenities.** New construction affects both local amenities and productivity. Indeed, increasing the housing stock in a neighborhood may make it more attractive by fostering social interaction or encouraging public investment. However, it also increases congestion, decreasing the neighborhood's amenity value. Similarly, building commercial floorspace in a neighborhood will increase the number of people working there and make it more productive through agglomeration spillovers. Firms' activity may also directly affect local amenities. These spillovers (whether real or perceived) motivated the introduction of zoning in NYC, whose early planners separated commercial areas from residential ones to mitigate the externalities of factories and stores on nearby residents.

To account for these potential spillovers, I follow Ahlfeldt et al. (2015) and allow amenity and productivity levels in a neighborhood to vary with the density of residents ($\tilde{L}_{Rn}$) and jobs ($\tilde{L}_{Cn}$) there:

$$B_n = \bar{B}_n \tilde{L}_{Rn}^{\gamma_{\text{RR}}} \tilde{L}_{Cn}^{\gamma_{\text{CR}}} \qquad\qquad A_m = \bar{A}_m \tilde{L}_{Rm}^{\gamma_{\text{RC}}} \tilde{L}_{Cm}^{\gamma_{\text{CC}}}. \tag{9}$$

Here, $\bar{B}_n$ and $\bar{A}_i$ measure the fundamental amenity and productivity attributes of neighborhoods, respectively, capturing exogenous features that make an area more productive or attractive (e.g., riverside views, access to parks, or proximity to key transportation nodes). The spillover parameters $\gamma$ capture agglomeration externalities. For instance, $\gamma_{\text{CC}}$ captures productivity spillovers leading firms to make other nearby firms more productive, and $\gamma_{\text{CR}}$

[12] Total rental income is given by $I_{\text{rent}} = \sum_n (R_{Rn} H_{Rn} + R_{Cn} H_{Cn})$, and the total income of worker $o$ is therefore given by $I_o = w_j s(\theta_o)(1+\mathcal{T}) \equiv w_j s(\theta_o)\left(1 + \frac{I_{\text{rent}}}{\mathcal{L}\mathbb{E}[ws(\theta)]}\right)$. The budget constraint they face is $I_o \geq C_{nmo} + R_{Rn} H_{nmo}$.

measures spillovers of commercial activity on nearby residents.[13]

The variables described above (floorspace, rents, wages, productivities, and amenities, in particular) vary from one period to the next. Here, their time subscripts have been omitted for simplicity.

## 4.3 Equilibrium

A dynamic equilibrium of the model is a path of floorspace supplies ($\boldsymbol{H_R}$, $\boldsymbol{H_C}$), rents ($\boldsymbol{R_R}$, $\boldsymbol{R_C}$), prices ($\boldsymbol{P_R}, \boldsymbol{P_C}$), population and jobs distributions ($L$, $\boldsymbol{L_R}$, $\boldsymbol{L_C}$, $\boldsymbol{L_C^{\text{eff}}}$), productivities $\boldsymbol{A}$, amenities $\boldsymbol{B}$, wages $\mathbf{w}$, transfers $\mathcal{T}$, and commuting costs $\boldsymbol{\tau}$ for each period $t$ such that:

1. The supply of floorspace on each parcel is governed by developers' profit maximization (1), floorspace supply in each neighborhood is the expected sum of the floorspace supplied by each of its constituent parcels, and floorspace prices are the discounted sum of rents (4).

2. In each period, $L, \boldsymbol{L_R}$, $\boldsymbol{L_C}$, $\boldsymbol{L_C^{\text{eff}}}$, $\boldsymbol{R_R}$, $\boldsymbol{R_C}$, $\mathbf{w}$, $\mathcal{T}$, and $\boldsymbol{\tau}$ are such that workers maximize utility (7), firms maximize profits (8), amenities and productivities are determined by equation (9), total population is governed by the migration elasticity $\varepsilon_M$, commuting times are governed by the congestion elasticity $\varepsilon_C$, and floorspace markets clear.

To find equilibrium paths, I use the iterative procedure described in Appendix F. Starting from a guess for the paths of prices and average densities in each neighborhood, I compute developers' expected path of decisions at the parcel level and aggregate them into neighborhood floorspace supplies for each year. I then solve the demand system year by year to recover rents, wages, commuting costs, amenities, and productivities that clear floorspace markets. Floorspace prices are finally computed as the discounted sum of rents, yielding updated price and density paths. An equilibrium is reached when the guessed and recovered paths coincide.[14]

[13] The parametrization I retain differs from that of Ahlfeldt et al. (2015) in two ways. First, Ahlfeldt et al. (2015) only consider spillovers of firms on firms and of residents on residents, i.e., both $\gamma_{\text{CR}}$ and $\gamma_{\text{RC}}$ are assumed to be zero. I allow these parameters to be non-zero here because spillovers across uses were a key justification for zoning. However, I estimate these parameters to be small, justifying Ahlfeldt et al. (2015)'s parametrization. Second, in Ahlfeldt et al. (2015), a location's amenity and productivity levels depend not only on the density of residents and jobs in that location, but also on the density of nearby locations. This is justified by the very granular scale of Ahlfeldt et al. (2015)'s analysis, where locations are city blocks. Here, the locations I consider are substantially larger, with the median neighborhood containing 135 city blocks. The existing literature and my analysis below suggest that agglomeration spillovers decay quickly over space, justifying my focus on within-neighborhood spillovers.

[14] The tractability of this procedure benefits substantially from multithreading: within each iteration, I parallelize the computation of developers' expected decision paths across parcels.

# 5 Model Estimation

## 5.1 Supply

To characterize developers' behavior, I estimate the parameters that determine redevelopment profits in turn: building prices, variable and fixed construction cost parameters, transaction probabilities, and the dispersion of idiosyncratic profit shocks.

**Parcel values.** To measure the value of buildings as a function of their characteristics, I estimate (separately for residential and commercial structures) on the real estate transactions data the following hedonic model, derived from equation (3):

$$\log(p_s) = P_{1,\theta n} + P_{2,\theta bt} + \boldsymbol{\beta}_\theta \cdot \mathbf{x}_s + \nu_s, \tag{10}$$

where $p_s$ is the price per sq. ft observed in sale $s$, $n$ (resp., $b$) is the neighborhood (resp., borough) where the sale took place, $t$ is the sale year, and $\nu_s$ is an idiosyncratic shock to the observed sale price. $\boldsymbol{\beta}_\theta$ measures the extent to which different parcel characteristics in $\mathbf{x}_s$ are valued. $\mathbf{x}_s$ includes the building's FAR, age, landmark status, quality grade, construction material, and broad type (e.g., office, retail, industrial), as well as the size of the unit(s) sold.

The value of buildings $\mathcal{P}(h, \boldsymbol{x})$ that developers consider when making decisions is the structure's use value (the discounted sum of future rents), which does not include the option value of redevelopment. Indeed, through redevelopment, developers forgo the use value of the building they demolish, and the new building's value reflects only its use value, as redevelopment is a terminal action. The transaction prices I observe, however, likely capture both use values and option values. To ensure my estimate of $\mathcal{P}(h, \boldsymbol{x})$ reflects only the former, I estimate equation (10) on the sample of parcels at or above the maximum FAR limit, which have a near-zero probability of redevelopment (0.02% each year) and whose option value of redevelopment is hence negligible. I report estimated parameters for equation (10) in Appendix Table D.1. They allow me to estimate the prices entering the developers' profit function.[15]

**Variable costs.** The second component of the profit function is variable costs, parameterized in equation (5). Their level depends on the cost of materials, $\alpha_{\theta it} e^{\eta_{it}}$, and the rate at which they grow with FAR is governed by the capital cost share $\zeta$.

In the absence of zoning regulations, developers would choose FARs equating the price of floorspace with its marginal cost of construction, and variable costs could be obtained by comparing the FARs chosen by developers with the floorspace prices they faced when making construction decisions. However, the presence of zoning constraints complicates estimation,

[15] To recover expected prices in levels from the coefficients of equation (10), estimated in logs, I assume that the price shock $\nu$ is distributed $\mathcal{N}(0, \sigma_\nu^2)$, giving $\hat{p} = \exp(\hat{P}_{1,\theta n} + \hat{P}_{2,\theta bt} + \hat{\boldsymbol{\beta}}_{\boldsymbol{\theta}} \cdot \mathbf{x} + \hat{\sigma}_\nu^2/2)$.

as the FAR chosen by a developer may no longer equalize the marginal construction cost of floorspace with its price. In many construction projects, maximum FAR limits are indeed binding, and the chosen FAR of new buildings is often close to the zoning code's maximum FAR (see Appendix Figure C.5).[16]

Despite these constraints, developers' choices respond strongly to prices. Appendix Figure C.6 shows that developers facing higher floorspace prices choose FARs that are higher and closer to the zoning limit. I exploit this variation—FARs chosen by developers whose optimal decisions lie below the zoning limit, and the probability that the zoning constraint binds—to identify the parameters of the floorspace production function.

Specifically, I parametrize $\alpha_{\theta it}$ as $\alpha^0 \alpha_{\theta b} \alpha_t$, where $b$ is the borough in which parcel $i$ is located. I calibrate the $\alpha_{\theta b}$ and $\alpha_t$ parameters using engineering estimates and estimate the baseline cost of materials $\alpha^0$.[17] Furthermore, I assume the cost shock $\eta_{it}$ is distributed $\mathcal{N}(0, \sigma_\eta^2)$. This lets me compute, for each new construction project, the probability that the developer chooses any FAR as a function of the price of floorspace, the zoning limit, and variable cost parameters. I estimate these parameters using maximum likelihood (see Appendix D.1 for details).[18]

The parameters I recover are shown in Table 1(a). They allow me to trace out the variable costs faced by developers as a function of the FAR of the structure they choose to build, as well as the typical FAR that developers will choose when faced with different price levels. These functions are plotted in Appendix Figure D.1. I estimate that, in 2019, building a small structure with an FAR of 1 would cost developers \$143/sq. ft on average. A mid-rise structure, with an FAR of 4, would typically cost \$535/sq. ft, and the average construction costs for a skyscraper (with an FAR of 20) would rise to \$2,468/sq. ft.

These results are consistent with available engineering estimates. RSMeans (2020) reports expected construction costs for a 1-to-3-story apartment building in Manhattan in 2019 at \$185/sq. ft. The New York Building Congress (2019), which tracks the construction costs of larger structures, reports average construction costs between \$400 and \$600/sq. ft. To benchmark my cost estimates for very tall buildings, I recovered the building costs of skyscrapers built since 2000 (which had an average FAR of 23.9). I find wide variation in their reported construction

[16]Many buildings have a built FAR above the maximum allowance, as developers can exempt part of the built floorspace from the limit (e.g., basements, attics, or mechanical space) or ask for a small relaxation of the FAR limit. To account for cases where developers build above the maximum allowed FAR, I assume that when making redevelopment decisions, developers face the constraint $h_{\theta it} \leq \bar{h}_{\theta it} = (1+b)\bar{h}_{\theta it}^{\text{code}}$, where $\bar{h}_{\theta it}^{\text{code}}$ is the maximum allowed FAR in the zoning code, and $b$ is a shock revealed to the developer at the same time as the cost shock and distributed according to an exponential distribution with parameter $\lambda$. I estimate $\lambda$ at 1.93, suggesting that in the median construction project, developers can exempt up to 26% of the floorspace they build from counting towards the FAR limit, which is consistent with the types of spaces that are excluded from the FAR limit.

[17]Specifically, I use the RSMeans (2020) time series for construction costs as well as estimates of the relative construction costs in different boroughs and for different building types. $\alpha^0$ captures the cost of capital for residential buildings in Manhattan in 2019.

[18]While the land use panel I constructed covers 2004–2022, I sometimes lack data on the characteristics of the buildings whose construction was not completed by 2022. Hence, I restrict my sample to 2004–2019 to estimate variable and fixed costs and simulate the city's evolution from 2019 onwards in counterfactuals.

costs, around an average of \$1,712/sq. ft (see Appendix Figure A.10). The estimated capital cost share $\zeta$, at 0.51, is similar to the estimate of 0.54 that Combes et al. (2021) report for Paris, and implies that variable construction costs, which are proportional to $h^{1/\zeta}$, increase almost quadratically with FAR.

**Table 1:** Cost parameter estimates

| | | | |
|---|---|---|---|
| **(a) Variable cost parameters** | | | |
| $\alpha^0$ | Baseline cost of materials | 80.4 | (2.3) |
| $\zeta$ | Capital cost share | 0.51 | (0.005) |
| $\sigma_\eta$ | Cost shock standard deviation | 1.08 | (0.02) |
| **(b) Fixed cost parameters** | | | |
| $\delta^0$ | Base fixed cost | 175.2 | (7.7) |
| $\delta^{\text{demolition}}$ | Demolition multiplier | 1853.8 | (37.6) |
| $\delta^{\text{density}}$ | Neighborhood density multiplier | 318.5 | (11.3) |
| $\delta^{\text{protected}}$ | Protected parcels multiplier | 0.77 | (0.03) |
| **(c) Profit shock parameters** | | | |
| $\sigma_\epsilon^0$ | Base profit shock variance | 73.7 | (2.9) |
| $\sigma_\epsilon^{\text{demolition}}$ | Demolition multiplier | 138.8 | (5.1) |
| $\sigma_\epsilon^{\text{density}}$ | Neighborhood density multiplier | 248.2 | (4.9) |

*Notes*: This table reports parameter estimates for the variable cost function (equation 5), the fixed costs that developers must pay if they redevelop a parcel (equation 6), and the $\sigma_\epsilon$ parameters determining the scale of the Type 1 Extreme Value distribution from which the profit shocks $\epsilon$ are drawn. All costs are reported in 2019 dollars.

**Transaction probabilities.** I observe the transaction of individual parcels in the real estate sales data, allowing me to estimate $p_i^{\text{transaction}}$. To account for the fact that some parcels are more likely to be transacted than others, I predict $p_i^{\text{transaction}}$ by estimating a probit regression of parcel sale dummies on parcel characteristics (see Appendix Table D.2). I find that buildings with multiple ownership, like condominiums, tend to be transacted much less frequently. Offices also tend to be transacted less frequently, consistent with the long durations of office leases (Gupta, Mittal and Van Nieuwerburgh, 2024).

**Fixed costs.** With estimates of the price function $\mathcal{P}$ and the variable cost function $VC$ in hand, I can compute the expected flow profit from redevelopment net of fixed costs: $\tilde{\pi}_{\theta it} = \mathbb{E}\left[\max_{h^{\text{new}} \leq \bar{h}_{\theta it}} \left\{\mathcal{P}_{it}(h^{\text{new}}, \mathbf{x}_{it}^{\text{new}}) - \mathcal{P}_{it}(h_i^{\text{old}}, \mathbf{x}_{it}^{\text{old}}) - VC_{\theta it}(h_{it}^{\text{new}})\right\}\right]$.[19] Intuitively, $\tilde{\pi}_{\theta it}$ is the surplus available to cover fixed costs if the parcel is redeveloped. Empirically, redevelopment probabilities are essentially zero when $\tilde{\pi} < 0$, but then increase sharply with $\tilde{\pi}$ when it is positive (see Appendix Figure D.2). Furthermore, conditional on $\tilde{\pi}$, redevelopment is less likely

[19] I set the characteristics $\mathbf{x}_{it}^{\text{new}}$ of new buildings to the average characteristics of buildings of type $\theta$ constructed after 2000 (except for the building's age, which is set to zero).

on parcels that are already densely built or in denser neighborhoods, suggesting higher fixed costs of redevelopment there. I leverage this variation to estimate fixed cost parameters.

Because development decisions are dynamic, estimation requires assumptions about developers' expectations regarding the evolution of variables after 2019. I assume developers expect zoning constraints, demand parameters (fundamental productivities and amenities), and cost parameters to stay at their 2019 level. Furthermore, developers form rational expectations about the path of prices and floorspace supplies after 2019: they expect floorspace quantities to evolve according to the supply model, rents to evolve according to the demand model, and prices to correspond to the sum of future rents, discounted at the rate $r$, which I calibrate to 5%.

I estimate fixed costs to best match the relationship between developers' decisions and the expected profit from different choices. This requires repeatedly solving the dynamic equilibrium for different candidate values of the fixed cost parameters. Indeed, the option value of future redevelopment depends on the entire future path of prices. This path is an equilibrium outcome determined by the collective behavior of all developers, which, in turn, depends on the very fixed costs being estimated. My estimation procedure extends Rust's 1987 nested fixed point algorithm to a spatial equilibrium setting. In the inner loop, I solve developers' dynamic decision problem given prices and fixed costs. In the middle loop, I impose spatial equilibrium each period to obtain the path of neighborhood prices. In the outer loop, I compute the likelihood that the developer takes each action $(\varnothing, R, C)$ in each period and recover fixed-cost parameters by maximum likelihood.

Table 1(b) reports the estimated fixed cost parameters. I find that fixed costs increase sharply with the size of the building to be demolished, and are also larger in denser neighborhoods. Therefore, construction creates large adjustment costs that hinder future redevelopment. Fixed costs are also estimated to be 77% higher for parcels that are landmarked or in a historic district.

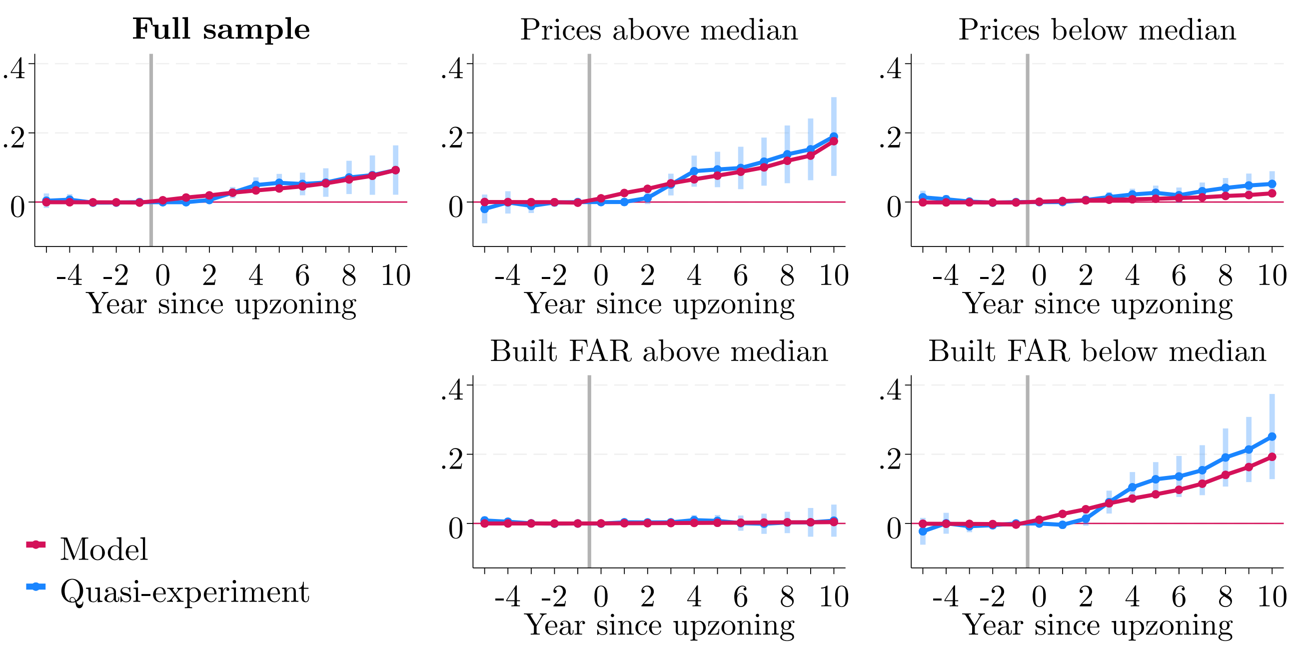
**Model validation.** My model aims to accurately predict developers' decisions on the extensive and intensive margins. On the extensive margin, I estimate the probability that a parcel will be redeveloped in any given year as a function of prices and zoning. On the intensive margin, I predict how much floorspace a developer will build if they proceed with redevelopment.

Appendix Figures D.3(a) and D.4 evaluate model fit on the extensive margin, and show that redevelopment probabilities in the model closely align with those observed in the data, both for the full sample and in different parts of the city. Appendix Figure D.3(b) focuses on the intensive margin: for redeveloped parcels, I compare the FAR chosen by developers with the model's prediction. Reassuringly, these two variables are tightly correlated. The model also successfully predicts whether developers build a commercial building or a residential one, conditional on proceeding with redevelopment—see Appendix Figure D.3(c).[20]

[20]In Appendix Figure D.5, I conduct a corresponding out-of-sample exercise: I reestimate the model using the first half of my panel (2004–2011), and then predict the evolution of the city over the second half of my panel

In counterfactuals, I use the model to predict the evolution of NYC if zoning were relaxed in different ways. Therefore, the model will be successful only if it can correctly predict the causal effect of upzoning. To assess whether this is likely the case, I exploit the fact that my model's estimation does not rely on Figure 3's difference-in-differences estimates of the effect of upzoning on construction. More generally, upzonings only play a limited role in estimation, as upzoned parcels account for only a small share of the city's parcels (6%) and redevelopment (10%). To validate my model, I first reestimate the model's cost parameters using only the sample of parcels that have not been upzoned. I then predict the evolution of the upzoned parcels with and without the policy change, yielding a model-implied causal effect of upzoning. I finally compare these estimates to the quasi-experimental estimates of Figure 3. The two align (see Figure 5), indicating that the model is successful at predicting the effect of zoning changes.

**Figure 5:** Model-implied vs. quasi-experimental effects of upzoning on built FAR




*Notes*: This figure compares the event study coefficients from Figure 3—which measure the effect of upzoning on built FAR, including floorspace under construction—with the model's predicted effects. To generate these predictions, I reestimate the model's cost parameters using only parcels that were not upzoned, and then simulate the impact of the observed upzonings.

## 5.2 Demand

The procedure I follow to calibrate the demand model builds on the quantitative spatial economics literature (e.g., Ahlfeldt et al., 2015; Redding and Rossi-Hansberg, 2017; Tsivanidis, 2019) and is described in detail in Appendices E.2 and E.3.

(2012–2019). The developers' predicted behavior on the intensive and extensive margins again aligns with their observed behavior.

First, I calibrate the distribution of worker skills to a truncated lognormal to match the observed income distribution in the ACS (after excluding households with an annual income below \$12,000). The ACS data also shows that the richest households in the NYC metropolitan area spend about 10% of their income on housing, and I therefore calibrate $\beta$ to 0.1.

Second, I estimate the dispersion of workers' idiosyncratic preferences $\varepsilon^W$ for work locations using data on commuting patterns in NYC. I extract from the LEHD Origin-Destination Employment Statistics (LODES) dataset the number of workers living and working in each neighborhood ($\boldsymbol{L_R}$ and $\boldsymbol{L_C}$), as well as commuting flows between them. I associate these flows with commuting times $\boldsymbol{\tau}$ taken from Google Maps. This allows me to estimate the commuting elasticity through a gravity equation following Ahlfeldt et al. (2015)—I find $\kappa\varepsilon^W$ to be approximately 0.044.[21] Assuming that the commuting cost parameter $\kappa$ is equal to 0.01 (following Ahlfeldt et al., 2015, and Tsivanidis, 2019), I find a preference heterogeneity parameter $\varepsilon^W$ equal to 4.4.

Third, I jointly calibrate wages $\boldsymbol{w}$, amenity levels $\boldsymbol{B}$, subsistence levels of housing $\underline{\boldsymbol{H}}$, and the dispersion of idiosyncratic preferences for home locations $\varepsilon^H$. Intuitively, wages can be estimated using the spatial distribution of jobs. Areas that attract many commuters are inferred to be high-wage locations, especially if they are far away from where workers live. Amenity levels can be derived from residential prices and the population distribution: neighborhoods that attract many residents despite high residential prices are inferred to provide high amenity levels. Subsistence levels of housing are estimated using data on residents' average spending on housing in each location—higher levels of $\underline{H}$ are associated with higher housing consumption. Finally, the dispersion of idiosyncratic preferences for home locations is calibrated from the observed sorting of workers across neighborhoods. In the absence of idiosyncratic preferences, workers would perfectly sort across neighborhoods as a function of their skill level, with high-skill workers systematically choosing high-amenity locations. The more dispersed idiosyncratic preferences are, the less pronounced such sorting patterns become. I calibrate $\varepsilon^H$ to 2.9 to match the observed variation in average incomes across neighborhoods.

Fourth, calibrated wages, along with the supply and price of commercial floorspace in each location, allow me to recover the parameters of the production function: location-specific productivities $\boldsymbol{A}$ and floorspace shares $\boldsymbol{\alpha}$.

**Spillovers.** The last parameters to calibrate are those governing agglomeration spillovers. One way to learn about these spillovers is to study the effects of new construction on the rents in nearby buildings. For example, suppose that constructing a commercial building in an area decreases the rents of nearby residential units. This would suggest that commercial activity

[21] Following Dingel and Tintelnot (2020), I estimate the commuting elasticity using a Poisson Pseudo-Maximum Likelihood (PPML) estimator, which corrects for the bias associated with origin-destination neighborhood pairs with no commuters.

induces negative externalities on nearby residents.

Therefore, to estimate $\gamma$, I identify large construction events, which I define as new buildings that increased the amount of residential or commercial floorspace within 500 ft by more than 10% and by more than 20,000 sq. ft. After isolating these events, I draw 500-ft-radius disks around them and track the rent levels of preexisting buildings within these disks.[22] Data on rents is available for 290 residential construction events and 112 commercial construction events. Appendix Figure E.2 shows their location in the city and Appendix Figure E.3 illustrates the construction of the disks used as the unit of analysis.

Comparing disks that received construction earlier vs. later allows me to evaluate the effect of new construction on rents. In Figure 6, I use the procedure of de Chaisemartin and d'Haultfœuille (2020) to measure the effect of new construction on the quantity and price of floorspace.[23]

Upon the completion of a large structure, the amount of floorspace within a disk rises sharply. Over time, this leads to a drop in rents in nearby structures of the same type. However, constructing one type of floorspace has no discernible effect on the other type of floorspace.

The procedure described above is similar to that proposed by Li (2022), who estimated the effects of constructing large residential towers on residential rents within 500 ft. My finding that increasing the housing stock lowers residential rents is consistent with hers, as well as those of the broader literature (Pennington, 2021; Asquith et al., 2023). I further find that these price effects decay quickly over space (they are not statistically significant beyond 500 ft—see Appendix Figure E.5), echoing previous findings (Arzaghi and Henderson, 2008; Ahlfeldt et al., 2015; Pennington, 2021; Li, 2022; Baum-Snow et al., 2024; Blanco and Sportiche, 2024).

The event studies of Figure 6 provide reduced-form estimates of the elasticities of local residential/commercial rents to the local residential/commercial floorspace supply, which I denote by $\varepsilon^{RR}, \varepsilon^{RC}, \varepsilon^{CR}$, and $\varepsilon^{CC}$. For instance, the elasticity of residential rents to residential floorspace supply, $\varepsilon^{RR}$, is estimated at -0.42.

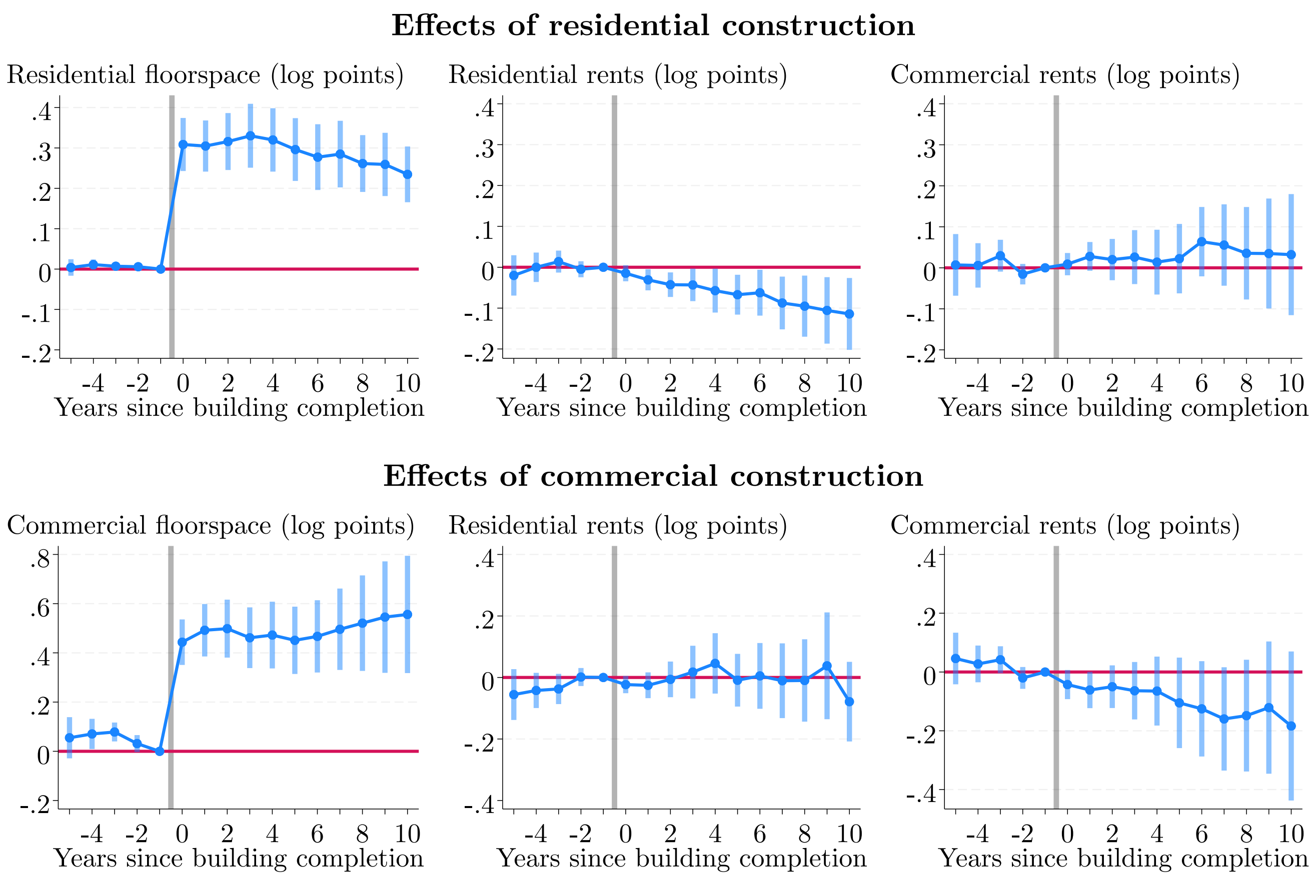
In the absence of agglomeration externalities, increasing the housing stock in an area leads to a decline in residential rents there. Negative externalities from residents on other residents ($\gamma^{RR} < 0$) will amplify the magnitude of this price response, while positive externalities ($\gamma^{RR} > 0$) will dampen it—with very large positive values of $\gamma^{RR}$, supply increases can even cause local price increases. Increasing the residential stock in a neighborhood also affects firms there, by making it easier for them to attract workers (and inducing rises in commercial rents). Positive externalities of residents on firms ($\gamma^{RC} > 0$) can lead to larger price increases.

More generally, there exists a mapping between values of $\gamma$ and values of $\varepsilon$ (illustrated in

[22]When computing rent levels, I exclude buildings with rent-stabilized units, as they might not appropriately reflect market conditions.

[23]In dense areas of the city, the disks used as the observation in this analysis sometimes overlap. I exclude such overlapping events from the event study, and show in Appendix Figure E.4 that the results of Figure 6 do not meaningfully change when these overlapping disks are included.

**Figure 6:** Effects of new construction on floorspace quantities and rents




*Notes*: This figure shows event studies estimating the effects of new construction projects on the quantities and rent prices of floorspace in a 500-ft-radius disk around the new building. In the top panel, I study the effects of constructing a new residential building that increases residential floorspace within 500 ft by more than 10% and by more than 20,000 sq. ft. I show effects on floorspace quantities as well as on the residential and commercial rents of preexisting buildings. The bottom panel shows analogous effects for new commercial buildings. Treatment effects are computed using the procedure of de Chaisemartin and d'Haultfœuille (2020), comparing areas that witnessed construction earlier vs. later. In regressions, I include one observation per event and year, and cluster standard errors at the neighborhood level.

Appendix Figure E.6), which can be recovered through simulation: for any set of values for $\gamma$, I can simulate in the model the price effects of increasing floorspace quantities. I therefore calibrate $\gamma$ such that the model matches the estimated reduced-form elasticities $\varepsilon$. The results of this indirect inference procedure are presented in Table 2.

Amenity levels in a neighborhood increase with the number of its residents, and its productivity grows with the number of jobs there. The agglomeration elasticities I find (0.11 and 0.07) align with existing estimates: the corresponding elasticities in Ahlfeldt et al. (2015), for instance, are 0.16 and 0.07. My results suggest small externalities across land uses.

**Model validation.** The calibrated demand model successfully matches a set of untargeted moments of the data, as shown in Appendix Figures E.7 and E.8. First, the model accurately replicates the Engel curve for housing. Second, it successfully predicts the sorting of workers

**Table 2:** Spillover parameter estimates

| Parameter | Interpretation | Calibrated value | Targeted elasticity |
|---|---|---|---|
| $\gamma^{RR}$ | Effect of residents on amenities | 0.11 | $\varepsilon^{RR}$ = -0.42 |
| $\gamma^{RC}$ | Effect of residents on productivity | 0.03 | $\varepsilon^{RC}$ = 0.14 |
| $\gamma^{CR}$ | Effect of jobs on amenities | -0.03 | $\varepsilon^{CR}$ = -0.03 |
| $\gamma^{CC}$ | Effect of jobs on productivity | 0.07 | $\varepsilon^{CC}$ = -0.28 |

*Notes:* This table reports parameter estimates for the spillover parameters $\gamma$. They are calibrated through indirect inference to match the reduced-form elasticities $\varepsilon$, estimated using the event studies of Figure 6. $\varepsilon^{XY}$ measures the effect of increasing the supply of type-X floorspace (residential or commercial) on type-Y rents (also residential or commercial). I measure these elasticities using the average of the coefficients for the last three periods of the event studies. While the $\gamma$ parameters are jointly calibrated to match all reduced-form elasticities, the value of $\gamma^{XY}$ is mostly determined by the value of the corresponding reduced-form elasticity $\varepsilon^{XY}$ (see Appendix Figure E.6).

across neighborhoods, with a correlation of 0.92 between the average neighborhood income in the model and that in the ACS. Third, the model reliably predicts commuting flows between neighborhood pairs. Fourth, the calibrated shares of floorspace in production $\alpha$ average 0.18 (with an interquartile range of 0.14 to 0.22), matching typical estimates in the literature (Valentinyi and Herrendorf, 2008; Ahlfeldt et al., 2015). Furthermore, neighborhoods whose commercial floorspace is primarily used for manufacturing or storage have higher calibrated values of $\alpha$ than neighborhoods where commercial floorspace is mostly office or retail space. Fifth, the calibrated subsistence housing levels $\underline{H}$ average 220 sq. ft (with an interquartile range of 166 to 260 sq. ft), about half the size of a studio, and corresponding well to what would plausibly be the minimum quantity of housing a person could consume. Moreover, the estimated $\underline{H}$ are positively correlated with the average unit size in each neighborhood, reflecting that workers tend to consume more housing in neighborhoods with larger housing units. Sixth, model-derived amenities $B$ are tightly correlated with residents' reported satisfaction with their neighborhood's cleanliness, access to parks, and public safety, among other amenities (see Appendix Table E.1).

# 6 Measuring the Effects of Relaxing Zoning Regulations

I use the estimated model to evaluate the effects of relaxing zoning on construction and prices. To do so, I simulate NYC's growth until 2060 under several zoning scenarios, assuming that fundamental amenities and productivities in each location stay fixed at their 2019 levels. To compute counterfactuals, I find a fixed point in the joint transition paths of floorspace and prices: floorspace is given by developers' optimal behavior given prices and zoning, and period-by-period prices are yielded by spatial equilibrium.

As a baseline, I consider a status quo scenario in which zoning regulations stay at their 2019 levels. I then compare this scenario to an upzoning in which regulations are substantially relaxed near transit stations. The reform I consider increases the maximum allowed FAR of parcels within 0.25 miles of a transit station to 6 (both for commercial and residential uses) and further increases the allowed FAR of parcels within 0.5 miles of a station to 4.[24] This policy change is realistic but ambitious, increasing the maximum allowable floorspace citywide by 59%. In an extreme counterfactual, I also consider fully removing zoning regulations across the city.[25] Finally, I compare the predictions of my dynamic model with a benchmark model that ignores the adjustment costs associated with redevelopment. This allows me to measure the extent to which these technological constraints restrict urban change beyond zoning.

In Section 6.1, I describe the aggregate effects of relaxing zoning. Section 6.2 then shows how these effects vary from one neighborhood to the next. Section 6.3 investigates the distributional effects of upzoning, and Section 6.4 compares upzoning to alternative policies promoting construction and affordability. In Section 6.5, I evaluate the extent to which zoning and historical persistence shape city structure. Finally, in Section 6.6, I show how my model can be used to measure neighborhood-level supply elasticities and how zoning shapes them.

## 6.1 What are the aggregate effects of relaxing zoning?

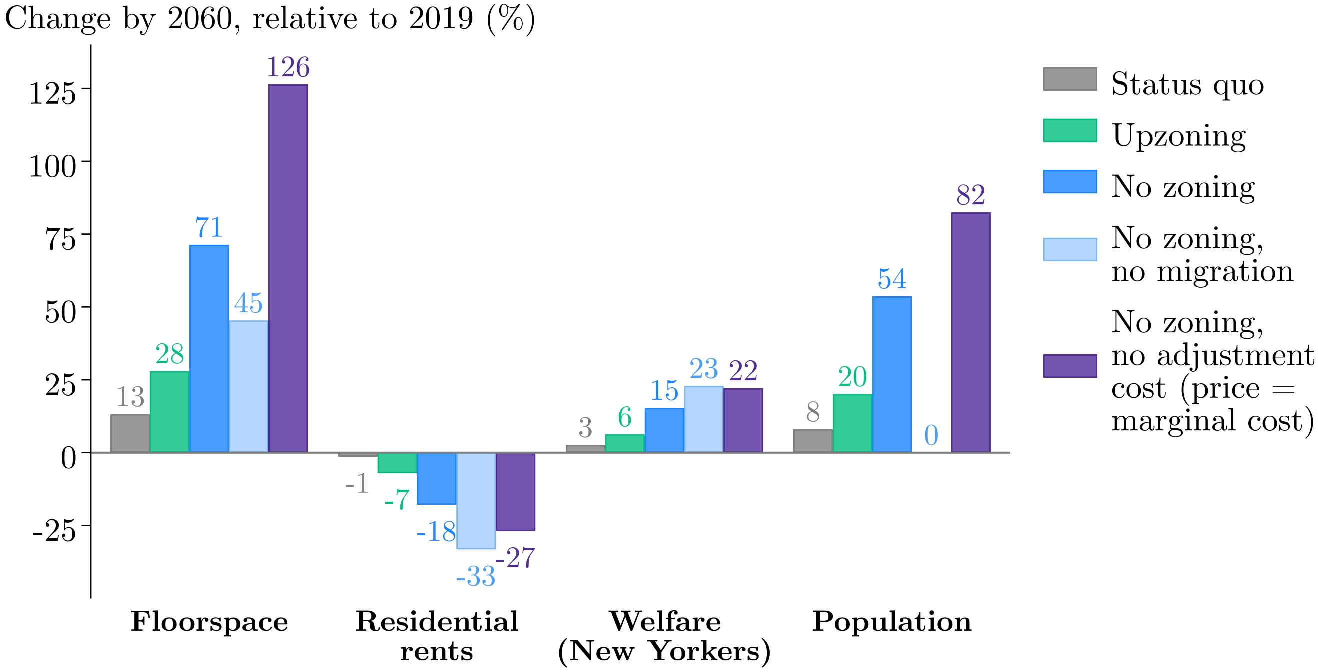
**Effects on construction.** In the status quo scenario, NYC continues to grow slowly, with its floorspace supply expanding by 13% and its population increasing by 8% between 2019 and 2060 (see Figure 7). I estimate that upzoning would substantially boost the city's growth, increasing floorspace supply by 15 pp and its population by 12 pp. This reform is projected to add 786 million sq. ft of floorspace to the upzoned areas by 2060. While this is considerable, it only corresponds to 18% of the 4.3 billion sq. ft of additional floorspace allowed by the zoning change. This highlights that, in many cases, simply allowing more floorspace will not yield more construction, as upzoning does not raise expected profits from redevelopment sufficiently to overcome the fixed costs of rebuilding. The upzoning policy I consider delivers about a quarter of the boost in construction that would be obtained from completely removing zoning. Indeed, in a no-zoning counterfactual, NYC's floorspace supply grows by 58 pp and its population by 46 pp. Removing zoning progressively expands the supply of floorspace by encouraging the redevelopment of more land (an extensive margin) and increasing the FARs of the new buildings constructed on that land (an intensive margin). Both margins play important roles, though the intensive margin has a slightly greater impact.[26]

[24]Parcels with higher FAR allowances at baseline are unaffected by the policy change. The upzoned parcels are primarily in Brooklyn and Queens and account for 37% of NYC's developable land (see Appendix Figure C.7).

[25]In the upzoning and no-zoning counterfactuals, I do not change regulations on parcels with landmarks and those in historic districts or flood zones.

[26]Between 2020 and 2060, the share of NYC's land that is redeveloped is twice as high in the no-zoning scenario than under the status quo (12% vs. 23%), and the average FAR of newly built structures is 2.5 times higher (4.0 vs. 1.6). Appendix Figures G.2 and G.3 show the distribution of the FAR of new buildings under both scenarios.

**Figure 7:** Effects of relaxing zoning




*Notes*: This figure shows the simulated evolution of NYC by 2060. In the status quo scenario, zoning regulations remain at their 2019 level. In the upzoning counterfactual, I upzone parcels located within 0.5 miles of a transit station (see Appendix Figure C.7). In the no-zoning counterfactual, I remove all zoning restrictions (excluding parcels that are landmarked, in a historic district, or in a flood zone). In the no-zoning and no-migration counterfactual, I remove all zoning restrictions and set the migration elasticity to zero, such that the population of the NYC metro area remains at its 2019 level. Finally, I compare the results of my model to those of a frictionless benchmark, in which the amount of floorspace in each neighborhood is determined by equating the price of floorspace with its marginal cost of construction, and where the price of residential floorspace is equal to that of commercial floorspace.

**Effects on prices and welfare.** While relaxing zoning yields large floorspace increases, its effects on rents are moderate—in the no-zoning counterfactual, they fall by 17 pp by 2060. This is because an increase in floorspace supply triggers migration to NYC, dampening local rent reductions while improving affordability in other cities. In a scenario with no net migration to NYC, the effects of removing zoning on rents would be fully concentrated in NYC and much larger (with a 32 pp drop in rents by 2060). This scenario can be interpreted as one in which utility in the rest of the country increases at the same rate as in NYC, for instance due to nationwide changes in zoning policy. Overall, my results suggest that while upzoning can produce sizable rent decreases, these price effects are very diffuse.

Beyond rent decreases, relaxing zoning also increases New Yorkers' welfare through higher wages (+4 pp in the no-zoning counterfactual—see Appendix Figure G.4). This is because upzoning increases the amount of commercial floorspace firms can use, and migration increases productivity through agglomeration effects. Increases in population density also benefit workers through higher amenity levels. Furthermore, relaxing zoning lowers the separation of land uses in the city.[27] This tends to reduce commuting times, although this effect is almost perfectly offset

[27] New construction also shrinks the gap between the price of residential and commercial floorspace described in

by increased congestion resulting from the city's growth. Overall, my model predicts that by 2060, removing zoning regulations would increase New Yorkers' welfare by 13 pp relative to the status quo, a substantial gain.

**Role of use vs. bulk regulations.** Zoning restricts both the use and density of new buildings. In Appendix Figure G.5, I explore the effect of both types of regulation on the city's trajectory. I find that relaxing only use limits would not substantially boost construction or increase welfare. Indeed, new construction in the city is primarily constrained by density limits, as most buildings are near or above the FAR limit, and redevelopment is generally only profitable when upward growth is permitted. Use limits are not irrelevant; rather, they interact with density limits, and relaxing both leads to significantly more construction than relaxing FAR limits alone.

**Transition path.** Appendix Figure G.6 shows the evolution of key variables under different zoning scenarios. The effects of relaxing zoning unfold very slowly. Only 23% of the long-run effect of upzoning on construction has materialized after 10 years, and half after 27 years (see Appendix Figure G.7).[28] Accordingly, it takes time for upzoning to deliver lower rents. However, the policy change causes an immediate drop in floorspace prices as agents correctly anticipate lower future rents.

**Comparison with a benchmark model ignoring adjustment costs.** If developers could frictionlessly adjust the amount of capital invested in each parcel, each parcel would, absent zoning constraints, reach an FAR that equalizes the marginal construction cost of floorspace with its price. Using this logic to evaluate the effects of removing zoning constraints would vastly overstate their true impact, predicting that the amount of floorspace in NYC would increase by 126% if zoning were abolished (see Figure 7). Even if zoning is a strong constraint on development and drives an important gap between floorspace prices and construction costs, removing zoning could not fully close that wedge. Technological constraints, i.e., the important costs associated with increasing the amount of floorspace on a parcel, are responsible for a large part of the disconnect between prices and marginal costs.[29]

Figure 4. However, these price differentials remain sizable in the medium run even in the absence of zoning.

[28]Here, I measure the long-term impact of upzoning as its effect by 2100.

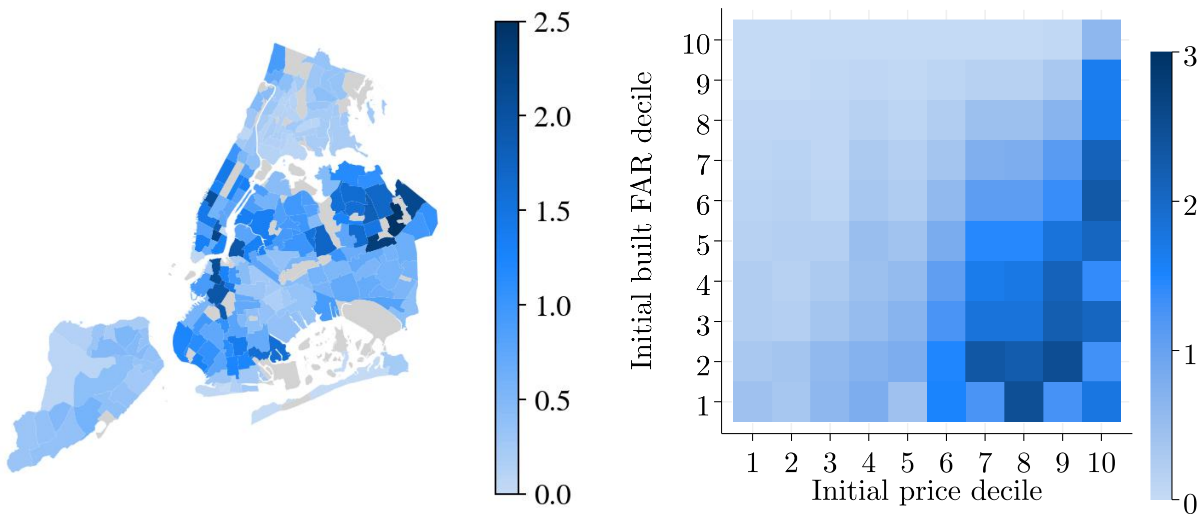
[29]The large adjustment frictions associated with demolition I find are consistent with studies of historical fires that destroyed large portions of cities (e.g., Hornbeck and Keniston, 2017; Siodla, 2015). Such studies find that burned areas become substantially denser than comparable unburned areas in the decades following the disaster. By paying the fixed cost associated with demolition, such fires pave the way for redevelopment, allowing for the construction of new, taller structures.

## 6.2 Where is zoning a binding constraint?

Figure 8(a) shows neighborhood-level effects of removing zoning on floorspace growth by 2060. Interestingly, the effects of relaxing zoning vary widely from one neighborhood to the next. These differences are easily rationalized by the basic economics of redevelopment. In Figure 8(b), I show the average effect of removing zoning on the additional FAR built by 2060 for different deciles of floorspace price and initial FAR levels. In neighborhoods where floorspace is inexpensive, redevelopment is usually unprofitable and therefore rare. The parcels that are redeveloped there tend to be vacant or minimally developed (see Appendix Figure G.9), and new buildings tend to be smaller, often below the zoning limit. Hence, zoning only moderately distorts the growth of neighborhoods where prices are low. In NYC, this suggests that upzoning most parts of the Bronx would not produce much additional growth.[30]

**Figure 8:** Heterogeneous effects of removing zoning on additional built FAR by 2060

**(a)** Additional built FAR by 2060 **(b)** Split by initial FAR and price levels




*Notes*: The left panel shows the effect of removing zoning on the amount of floorspace built by 2060 in each neighborhood. In the right panel, I compute for each parcel the expected effect of removing zoning on FAR built by 2060, and show the average effects of the policy change for each decile of floorspace price and initial built FAR.

Similarly, parcels that are already densely built are unlikely to be redeveloped, as the fixed costs associated with doing so are particularly high. Hence, zoning limits do not usually distort the amount of floorspace supplied there. Accordingly, my model predicts that removing zoning would only slightly boost the growth of Midtown Manhattan despite the high floorspace prices there.

The areas that would grow the most in the absence of zoning are those with high prices but low density levels, as the fixed costs of redevelopment there are low and expected developer

[30] Appendix Figure C.8 maps floorspace prices across NYC's neighborhoods. Floorspace prices are lowest in the Bronx and highest in the lower half of Manhattan. In Appendix Figure G.10, I show the share of parcels at or above the zoning limit for different price and density levels.

profits are high. This is why I find that removing zoning would boost floorspace supply the most in Western Brooklyn and Northern Queens, which have low-to-medium density levels, relatively high prices, and where most parcels are already built at or above the maximum allowed FAR. Removing zoning would also lead to large floorspace increases in some areas of Manhattan, notably Hell's Kitchen and the East Village, where many buildings have four stories or fewer despite extremely high prices.

Overall, the distortive effects of zoning are spatially concentrated. In the no-zoning counterfactual, 39% of the additional floorspace is built on 10% of the upzoned area (see Appendix Figure G.11). If rezoning neighborhoods is politically costly, policymakers wishing to favor construction may want to focus their efforts on the areas where upzoning is likely to lead to important shifts in supply.[31] This appears to have been the behavior of planners in NYC over the past decades: I find that uniformly increasing a neighborhood's maximum allowed FAR by 1.0 raises built FAR by 0.03 on average over the subsequent 10 years, substantially less than the average effect of 0.09 reported in Figure 3 (see Appendix Figure G.13). This suggests that the recently upzoned parcels were ripe for redevelopment and strongly responsive to policy changes.

These results have two important implications for the external validity of studies of zoning changes. First, measuring the effects of past rezonings may be an imperfect guide to predicting the impact of potential future zoning changes. Upzoned neighborhoods are selected based on their suitability for redevelopment, and upzoning other neighborhoods in the same city might lead to less new construction. Second, while relaxing zoning constraints would substantially boost floorspace in NYC, doing so would likely have more limited effects in less expensive cities. In Appendix Figure G.14, I show how NYC would evolve in the coming decades if its floorspace price levels were comparable to those of Miami (with 50% lower prices) or Chicago (67% lower prices). In these scenarios, NYC's future growth would be very limited, and removing zoning would lead to only small increases in the city's overall floorspace supply.

## 6.3 Who benefits from relaxing zoning?

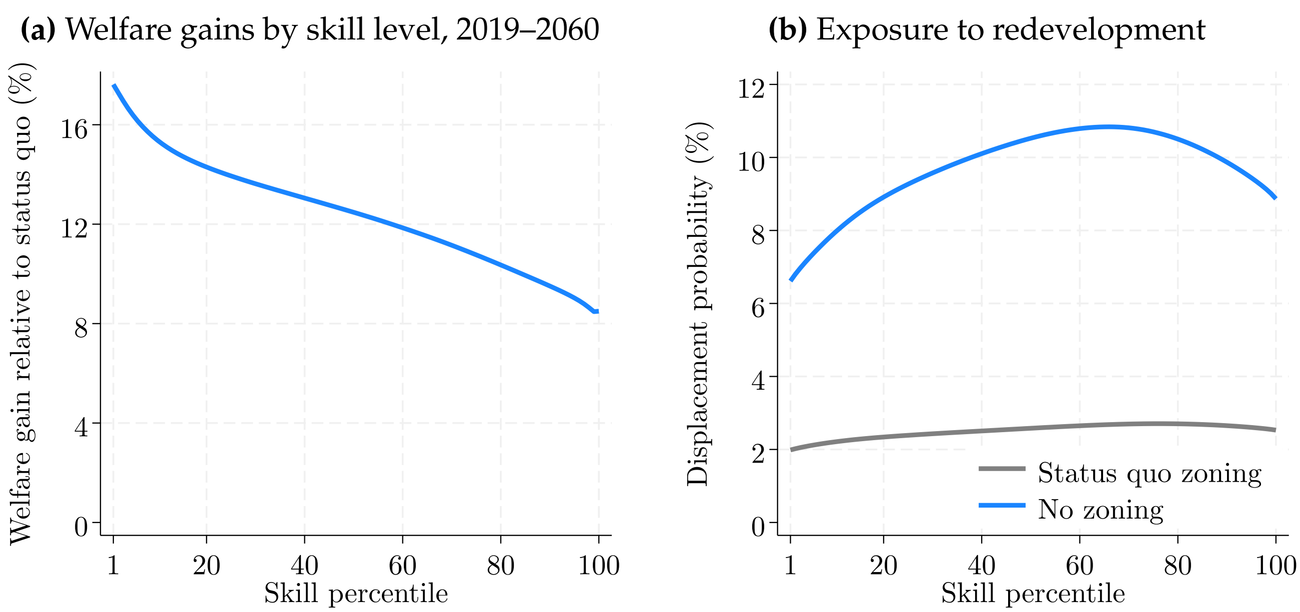
In Panel (a) of Figure 9, I show how the welfare gains of removing zoning would be distributed across workers' skill distribution. I find larger gains for lower-income workers, who disproportionally benefit from rent decreases (see Appendix Figure G.15).[32] Indeed,

[31] In Appendix Figure G.12, I describe a counterfactual where I remove zoning on parcels with built FARs below the 60th percentile in neighborhoods with floorspace prices above the 60th percentile. This policy upzones 14% of NYC's developable land and delivers 49% of the floorspace gains of the no-zoning scenario.

[32] The welfare changes I report do not include profits from redevelopment. I do not redistribute these profits to workers in the model to better compare my counterfactuals with the frictionless benchmark, where there are no profits from redevelopment. The model predicts that in the status quo scenario, redevelopment profits would average \$3.9 billion per year over 2020–2060. This corresponds to \$448 per worker, or 0.9% of New Yorkers' income in 2019. In the no-zoning counterfactual, redevelopment profits grow to \$13 billion per year, corresponding to

poorer workers spend a larger fraction of their income on housing, making rent decreases more consequential for them. Furthermore, increasing housing supply in the city leads to larger rent drops in neighborhoods with lower amenity levels, where poorer households tend to live. This is because increasing the housing supply in high-amenity neighborhoods allows workers living in lower-amenity neighborhoods to move there and climb the neighborhood quality ladder. This lowers housing demand in low-amenity neighborhoods, which leads to lower rents there. This mechanism, illustrated in Appendix Figure G.16, is a neighborhood analog to the vacancy chain mechanism typically described in housing economics, where the supply of new high-quality housing units triggers a chain of moves along the housing quality ladder, eventually lowering the price of the low-quality housing units in which poorer households live (Mast, 2023; Bratu, Harjunen and Saarimaa, 2023; Kindström and Liang, 2024).

**Figure 9:** Distributional effects of removing zoning




*Notes*: Panel (a) shows the welfare gains from removing zoning (by 2060) for different worker types. Panel (b) displays, for each worker type, the average share of residential floorspace in their initial neighborhood that will be redeveloped. If, within a neighborhood, the redevelopment probability of a parcel is uncorrelated with the skill level of the people living there, this share corresponds to the probability that a worker's initial dwelling will be demolished by 2060.

Another informative measure of the potential distributional consequences of upzoning is workers' exposure to redevelopment. While redevelopment eventually benefits households through lower rents and a more efficient allocation of land uses, they may be forced to move because their initial housing unit is redeveloped or otherwise suffer in the short run from the disamenities associated with construction.

$1,242 per worker or 2.5% of New Yorkers' income in 2019. These estimates are in line with the overall size of the construction sector in NYC, with construction spending in the city totaling $60.6 billion in 2019 (Office of the New York State Comptroller, 2021).

Using the model, I can predict the share of the residential floorspace in each neighborhood that will be redeveloped by 2060—these shares are mapped in Appendix Figure G.17. I can then compute, for each worker type, the average share of residential floorspace in their initial neighborhood that will be redeveloped. This share, a proxy for the probability that a worker will be displaced by redevelopment, is plotted in Figure 9(b). While there is overall limited heterogeneity in workers' exposure to redevelopment across types, workers at the upper-middle of the income distribution tend to be more exposed to redevelopment, consistent with the greater likelihood of redevelopment in more expensive neighborhoods.[33]

## 6.4 How efficient are policies favoring construction and affordability?

Upzoning is only one of several policies hailed as a means to encourage construction and increase affordability (Lebret, Liu and Valentin, 2025). Over the past decades, construction costs have increased much more rapidly than overall inflation, contributing to the housing affordability crisis. Policymakers are therefore exploring ways to reduce these costs, for instance by simplifying construction regulations or promoting modular and prefabricated buildings. Cities also routinely incentivize new construction with property tax breaks on newly built structures. Finally, to directly promote affordable housing construction, municipalities are increasingly adopting inclusionary zoning policies. These require or incentivize developers to reserve a portion of newly built units—typically 10–30%—as affordable housing.

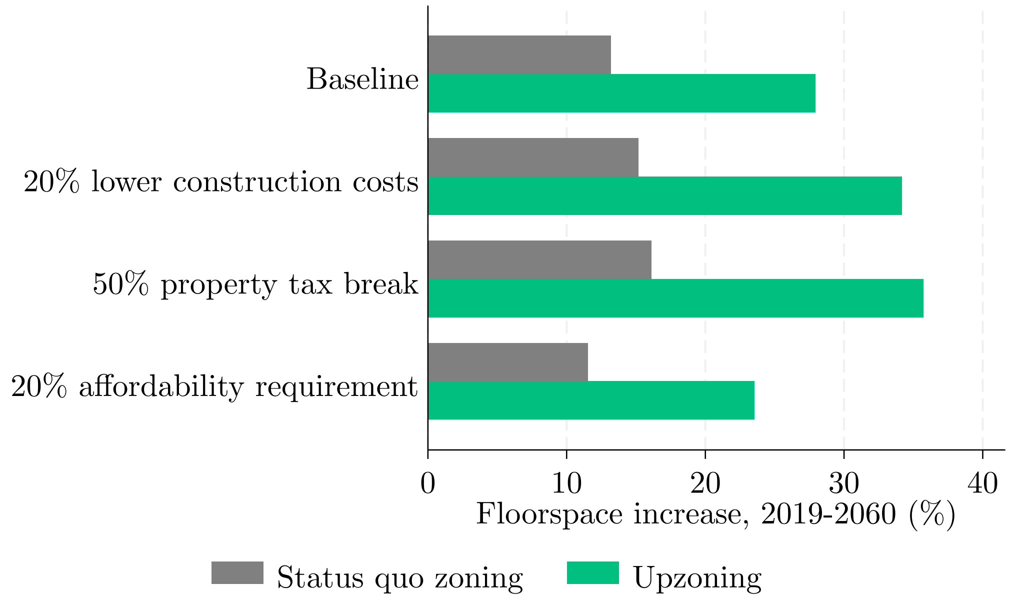
To evaluate these alternative policies, I consider three additional counterfactuals. First, I examine a scenario in which variable construction costs are reduced by 20%, erasing the growth of inflation-adjusted construction costs over 2004–2019. Second, I consider a policy that reduces the property taxes on new buildings from 2% to 1%. Third, I analyze a mandatory inclusionary zoning policy requiring that 20% of all newly built floorspace be rented at half the market rate.

Because these policies are sometimes used in conjunction with upzoning, I evaluate their effect on floorspace growth over 2019–2060 both in a status quo zoning scenario and under the upzoning considered above. Figure 10 reports my results.

Under status quo zoning, lowering construction costs by 20% increases the amount of floorspace added to the city by 2060 by 15%, relative to the baseline. A generous tax break policy has a slightly larger effect on new construction (+22%), but is particularly costly, as property taxes are reduced for all new structures, including those that would have been built in the absence of the subsidy. I find that on average, forgoing \$1,000 of property taxes (in net present value) leads to the construction of only 1.4 additional sq. ft of floorspace. In other words, incentivizing the construction of a 1,000 sq. ft unit typically requires forgoing \$720,000

[33] Workers at the very top of the skill distribution are less exposed to redevelopment as they tend to live in the dense neighborhoods of Manhattan, where buildings have a low probability of being redeveloped due to their high existing FAR.

**Figure 10:** Effects of alternative policies on floorspace growth




*Notes*: This figure shows the effects of three policies (lower construction costs, lower property taxes on new structures, and mandatory inclusionary zoning) on floorspace supply growth between 2019 and 2060, both under status quo zoning and the upzoning described at the start of Section 6.

of property tax revenue.[34] Both policies are much less effective than zoning reform: upzoning increases the amount of floorspace added to the city over 2020–2060 by 112%.[35]

Under a mandatory inclusionary zoning policy, NYC's floorspace growth over 2020–2060 is reduced relative to the baseline scenario (+12% instead of +13%). This highlights the fundamental tradeoff posed by such policies: mandating affordable housing construction enables some households to rent at below-market prices but discourages developers from building, thereby reducing the overall housing supply. Between 2020 and 2060, the inclusionary zoning policy leads to the construction of 73 million sq. ft of affordable floorspace, but lowers the total amount of floorspace in the city by 400 million sq. ft. In other words, for each sq. ft of affordable floorspace created by the policy, the overall available floorspace drops by 5.5 sq. ft.

## 6.5 How do zoning and historical persistence shape city structure?

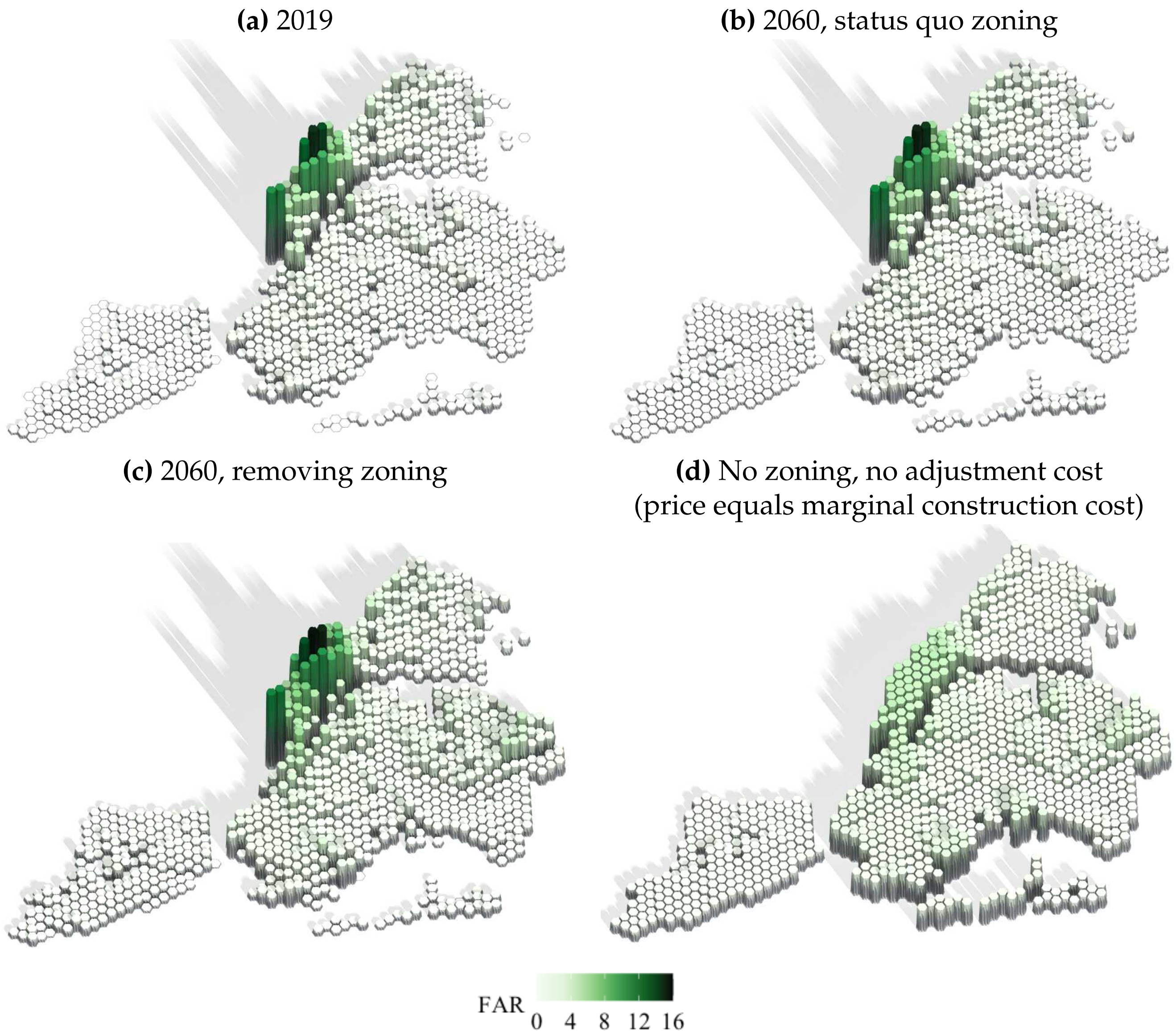
To evaluate the extent to which zoning and technological constraints shape city structure, I consider the density profile of NYC in different scenarios. Figure 11(a) shows the distribution of built FAR in NYC in 2019, with most of the city's density concentrated in Manhattan. My

[34]Such a high estimate is consistent with previous findings: Soltas (2024) finds that the typical fiscal cost of incentivizing the construction of an additional low-income housing unit in NYC is $1.6 million.

[35]Cost reductions and tax breaks also appear to be complementary to upzoning. Under upzoning, reducing construction costs and tax breaks lead to larger increases in floorspace than under status quo zoning (+22% and +28%, respectively). Upzoning also slightly increases the efficiency of tax breaks by making it less costly to incentivize the construction of additional floorspace.

model predicts that if zoning remained unchanged, NYC's structure would stay stable in the next decades—see Figure 11(b). Eliminating zoning constraints would stimulate development in Brooklyn and Queens, leading to a more gradual decline in density as one moves away from the city center, as shown in Figure 11(c).

**Figure 11:** Counterfactual FAR profiles of NYC




*Notes*: This figure shows the FAR profile of NYC for different counterfactual scenarios. Panel (a) shows FAR levels in 2019. Panel (b) (resp., c) shows expected FAR levels in 2060 if zoning were to remain at its 2019 level (resp., was removed). Panel (d) shows the distribution of FAR that equalizes the construction cost of the marginal sq. ft of floorspace with its price. In this figure, I aggregate data to hexagonal grid cells using Uber's H3 indexing system.

Using a model that assumes away adjustment costs yields a vastly different prediction of the effects of removing zoning on NYC's structure. Figure 11(d) shows the distribution of density in NYC that equalizes floorspace prices with its marginal construction cost, displaying a much smoother density gradient. One neighborhood in which the two approaches diverge the most is Midtown Manhattan. The dynamic model predicts that this very dense area would see its floorspace grow by 7% by 2060 if zoning were removed. In the frictionless benchmark, where the height of buildings can adjust costlessly up or down, Midtown instead shrinks by 61% (see Appendix Figure G.8). Indeed, large floorspace increases in the peripheral neighborhoods of NYC lower prices in the city center, leading to lower equilibrium heights of buildings there.

This shows that taking into account the technological constraints to redevelopment is key to producing credible counterfactuals. It also shows that historical persistence is essential in explaining cities' structure.

## 6.6 How does zoning affect floorspace supply elasticities?

Another way to assess zoning's impact on NYC's evolution is by measuring its effect on the floorspace supply elasticity, which determines how much the city grows as more households and firms want to locate there. One strength of the model developed in this paper is that it allows me to quantify the effect of demand shocks on construction, and therefore supply elasticities, at a granular scale and across various time horizons.[36] Figure 12(a) shows NYC's overall supply elasticity at different horizons, and Figure 12(b) shows how supply elasticities vary across neighborhoods.

I estimate that under current zoning regulations, NYC's overall supply elasticity reaches 0.13 at a 40-year horizon. These estimates are substantially smaller than those typically estimated at the metropolitan area level, consistent with the results of Baum-Snow and Han (2024), who show that supply elasticities sharply decrease close to cities' central business districts. While supply elasticities are somewhat lower in denser neighborhoods, they correlate much more strongly with zoning limits. Appendix Figure G.18(a) illustrates the tight correlation between a neighborhood's estimated supply elasticity and the share of the maximum FAR allowed by the zoning code (called the zoning envelope) that has already been built.

I estimate that removing zoning constraints would more than quintuple the city's floorspace supply elasticity, which would reach 0.73 over 40 years. In that counterfactual scenario, neighborhood-level supply elasticities are strongly negatively correlated with existing density levels—see Appendix Figure G.18(b).

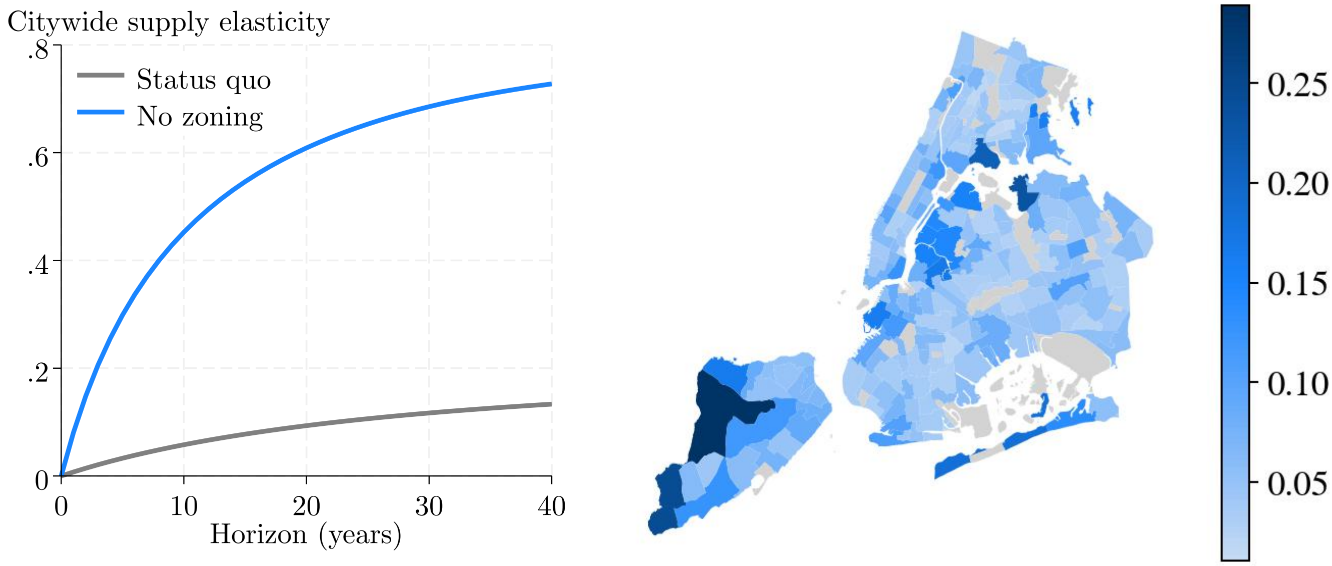
Even in the absence of zoning, estimated supply elasticities are also much lower than what standard static models would suggest, as these models assume that the capital stock in a neighborhood can be frictionlessly adjusted up or down. For instance, the parameterization of Ahlfeldt et al. (2015) implies a floorspace supply elasticity of three everywhere in the city.

[36] The floorspace supply elasticity at horizon $h$ is defined as the increase in floorspace (in pp) observed $h$ years after a permanent shock to fundamental amenities and productivities that raises residential and commercial rents by 1% on impact.

**Figure 12:** Floorspace supply elasticities

**(a)** Aggregate supply elasticity at different time horizons

**(b)** Neighborhood-level supply elasticities (40-year time horizon, status quo zoning)




*Notes*: Panel (a) plots estimates of NYC's overall floorspace supply elasticity at different time horizons, both under status quo zoning and no zoning. Panel (b) maps neighborhood-level supply elasticities at a 40-year horizon, under status quo zoning.

# 7 Why did NYC's planners impose such costly regulations?

The substantial welfare cost imposed by NYC's stringent zoning is reflected in the large gap between the price of floorspace and its marginal construction cost. In 2019, building an additional housing unit in NYC cost about $400,000, while the average home sale price approached $1 million. For such construction to reduce welfare, it would need to generate a net negative externality of at least $600,000—an implausibly large effect. If anything, the evidence points in the opposite direction: new development in NYC seems to create positive externalities. Therefore, when zoning prevents the construction of a new housing unit, it typically results in a welfare loss of several hundred thousand dollars. This raises the question of why urban planners impose such costly policies. I argue that the inadequacy of NYC's zoning code stems from the economic conditions at the time of its initial adoption, combined with the strong persistence of zoning policy, which is more enduring than planners often anticipate.

When NYC's current zoning resolution was drafted in the late 1950s, population growth had come almost to a halt and land values were below their historical trend (see Appendix Figure B.9). At the time, urban planners believed the city had nearly reached its ultimate size, and their main aim was to guide NYC's future growth, which they believed would be limited, particularly by promoting tower-in-the-park architecture and further separating commercial development from residential areas. Such separation of land uses was partly justified by the negative externalities of manufacturing, which accounted for approximately 30% of employment in NYC until the 1960s (Harrison, Ballard & Allen, 1950; Voorhees Walker Smith & Smith, 1958).[37]

In the mid-20th century, floorspace prices in NYC were roughly equal to marginal construction costs.[38] Therefore, small negative externalities could make new construction welfare-decreasing and justify zoning restrictions. Furthermore, as new construction did not yield substantial surplus, limitations on floorspace supply were not particularly socially costly. Hence, when the 1961 resolution was adopted, its potential costs were limited and the existence of a large manufacturing sector made zoning potentially beneficial.

Economic conditions in NYC have changed dramatically since the 1960s. With floorspace prices rising well beyond construction costs, the costs of zoning have increased significantly. Furthermore, the potential benefits of the 1961 zoning resolution have likely faded as the externalities associated with commercial land uses have evolved. In fact, contemporary planners typically favor mixed-use developments and oppose tower-in-the-park projects, in striking contrast to their predecessors. Yet, despite these radical shifts, the numerous amendments to NYC's zoning resolution since 1961 have mainly brought minor changes, and the city's current zoning map almost perfectly aligns with its 1960s version (see Appendix Figure B.10).

Appendix Section B.1 provides a historical perspective on NYC's zoning and shows that the issues that led planners to establish various zoning regulations often disappeared in subsequent decades. Yet, these regulations persist far longer than planners anticipate or intend. Such persistence is not unique to NYC,[39] and does not seem to stem from urban planners' resistance to change but rather from political constraints, as the rezoning process is slow, contentious, and vulnerable to obstruction by officials and interest groups with a stake in the status quo.

# 8 Conclusion

Cities can expand outward or upward. In the 1990s, 80% of rapidly growing urban areas were doing so mostly outward, by spreading. In the 2010s, this figure had shrunk to 28% (Frolking et al., 2024), as many cities reached a mature stage. Redevelopment has therefore become an increasingly important phenomenon in urban areas, allowing them to increase their floorspace supply and to reallocate land to its most profitable use.

This paper provides a framework for analyzing this process, leveraging the detailed and increasingly available microdata describing urban land uses. Tracking the city's evolution at the parcel level allows modeling and separating two important barriers to redevelopment: the

[37] While new industrial construction is now rare in NYC, I find some evidence suggesting that it decreases nearby residential rents (see Appendix Figure G.19), consistent with such land uses inducing negative externalities.

[38] In 1950, construction costs were around \$10/sq. ft (or \$10,000 per dwelling unit) for small structures, and twice as large for taller structures (U.S. Department of Labor, 1950; RSMeans, 2020; Willis, 1995; Engineering News-Record, 2025; Office for Metropolitan History, 2023). In the 1950 Census, the average reported value of a housing unit in NYC was approximately \$12,500, or about \$13 per square foot. Real estate transaction data from Real Estate Board of New York (1950) suggests that properties typically traded at lower prices, around \$5/sq. ft.

[39] See Shertzer, Twinam and Walsh (2018) and Twinam (2018) for case studies of Chicago and Seattle.

substantial costs associated with tearing down existing structures to replace them with new ones, and zoning restrictions on the use and size of new buildings.

This framework can be used to evaluate the effects of transit upgrades, property taxation, or structural transformation. In this paper, I use it to study a pressing policy question: the effects of zoning on construction and affordability. I find that redevelopment is usually unprofitable in inexpensive or densely developed neighborhoods, severely hindering their ability to change regardless of the stringency of zoning. Zoning regulations primarily distort development in areas with high floorspace prices and low density. In NYC, I show that the targeted upzoning of these neighborhoods can substantially boost floorspace supply. However, the effects of upzoning take time to materialize, and its impact on rents is diffuse. Local upzonings may thus initially appear disappointing to policymakers aiming to improve affordability, but over time and in aggregate, they yield large gains.

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# Appendix

## A Data

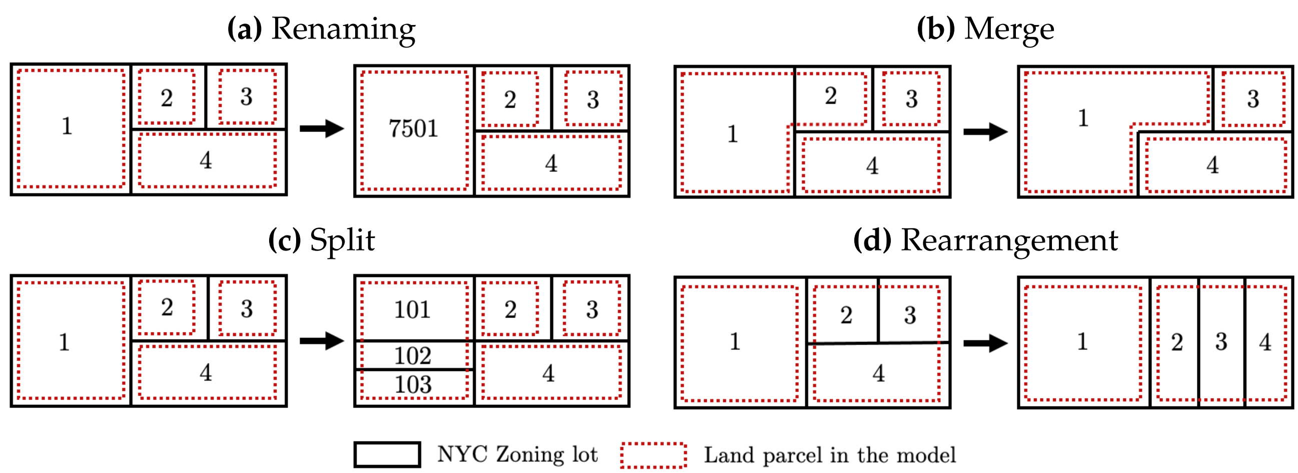
### A.1 Parcel boundaries

**Zoning lots.** Each year, the NYC Department of City Planning publishes the Primary Land Use Tax Lot Output (PLUTO) dataset, which contains detailed information about each "zoning lot" in NYC. A zoning lot can be vacant or contain one or several buildings. In most cases (about 70%), a zoning lot is associated with a single building. Only 1% of the zoning lots in NYC are associated with more than 2 buildings. Importantly, the PLUTO datasets are associated with GIS tax maps indicating the boundaries of each lot.

**Defining land parcels.** Zoning lots in NYC are identified by their Borough, Block, and Lot code, or BBL. It is a 10-digit number where the first digit indicates the borough in which the lot is located, the next five digits indicate a block number, and the last four digits correspond to the lot number within that block. In 2022, there were about 859,000 zoning lots in NYC, grouped into about 29,000 blocks.

While the yearly releases of the PLUTO dataset provide a high-quality repeated cross-section of the buildings in NYC, they cannot readily be used to construct a panel of land use at the lot level. This is because of numerous changes in the tax maps that took place over time. I describe in Figure A.1 the four types of changes that can be found in the data.

**Figure A.1:** Types of lot boundary changes




*Notes*: This figure shows examples of lot boundary changes in the PLUTO data. Solid black lines correspond to the boundaries of zoning lots, the most granular partition of land in NYC for which data on land use is available in any given year. Dotted red lines correspond to the boundaries of the parcels I use as the partition of NYC in the model. They are the smallest amount of land for which I can track land use over time.

First, there are instances in which the same piece of land changes its BBL over time (panel a). Second, there are lot mergers. The lot stemming from the merger can take the BBL of one of the original lots involved in the merger, as is the case in panel (b), or a new BBL. Third, lots are sometimes split into several new lots (panel c). Finally, there are rarer instances in which a set of lots is merged and then split into a new set of lots (panel d).

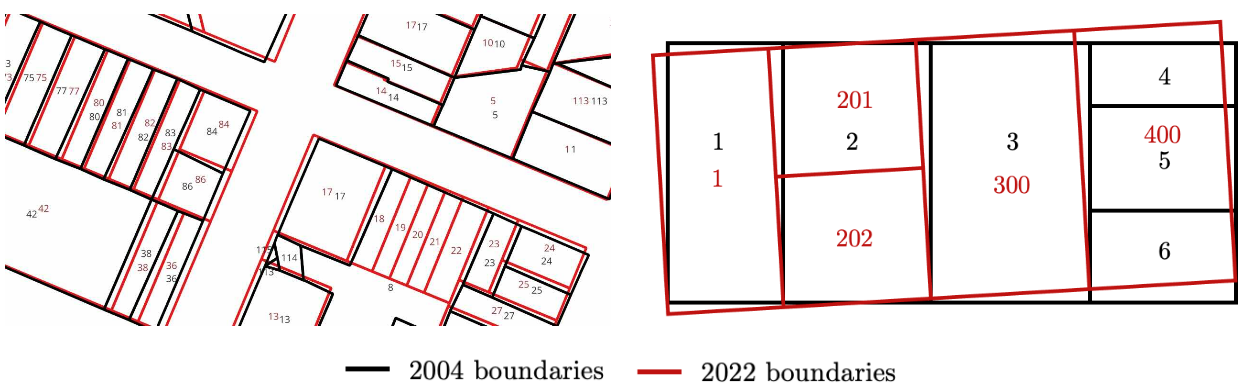
When mapping my model to the data, I consider that the land parcels developers control are the smallest portions of land for which I can track land use over time. For instance, if zoning lots 1 and 2 eventually merge to give a new zoning lot (as in Figure A.1b), I consider the union of these zoning lots to be a land parcel in my model. I therefore consider that zoning lots 1 and 2 are controlled by the same agent, who periodically considers redeveloping the parcel made up of these two lots. This assumption is justified by the fact that the merger of the zoning lots implies that they were owned by the same individual or firm before the merger. Figure A.1 shows how I define parcels for other types of lot boundary changes.

**Detecting lot boundary changes.** Because the same BBL can be used to identify different portions of land at different points in time, a list of lot boundary changes is necessary to build a panel of land use in NYC at the parcel level. Unfortunately, no dataset documents such changes in the tax maps, and there does not seem to be any systematic rule governing changes in the numbering of lots when they occur. Sometimes, the same BBL will be used at different periods of time to identify completely different parts of a given block. To model and analyze redevelopment decisions at the parcel level, I created a database of the lot boundary changes that took place in NYC between 2004 and 2022 using tax maps for these two years.

The main issue that arises when comparing tax maps across years is that they are not perfectly aligned. As shown in Figure A.2(a), land parcels that did not change over time are not exactly superimposed when overlaying tax maps for different years.

**Figure A.2:** Detecting lot boundary changes

**(a)** Tax maps for 2004 and 2022, overlaid **(b)** Illustration of the algorithm




*Notes*: This figure illustrates the procedure I use to detect lot boundary changes. Panel (a) overlays the tax map of a portion of the Bronx in 2004 on the 2022 tax map. Panel (b) illustrates the algorithm that I use to detect boundary changes, and is described in the text.

To detect lot boundary changes despite this issue, I used the following algorithm. After overlaying the 2004 tax map on the 2022 tax map, I considered a 2004 zoning lot $A$ to be connected with a 2022 zoning lot $B$ if they have a sufficiently large overlap—specifically, if $\text{area}(A \cap B) \geq 0.15 \cdot \text{area}(A)$ or $\text{area}(A \cap B) \geq 0.15 \cdot \text{area}(B)$. Then, I built a graph assembling all these links and extracted the list of its connected sets.

This procedure is illustrated in Figure A.2(b). In that figure, lot 1 is the only one that remains unchanged over time. Among the remaining lots, overlaying the 2004 boundaries and the 2022 boundaries allows us to find the following links between lots: (2, 201), (2, 202), (3, 300), (4, 400), (5, 400), (6, 400). The connected sets in the graph defined by these edges are: {2, 201, 202}, {3, 300}, {4, 5, 6, 400}. This allows me to detect that lot 2 split into lots 201 and 202, that lot 3 was renamed to lot 300, and that lots 4, 5, and 6 merged to give lot 400. More generally, a connected set with one 2004 lot and one 2022 lot corresponds to a renaming, a connected set with several 2004 lots and one 2022 lot corresponds to a merge, a connected set with one 2004 lot and several 2022 lots corresponds to a split, and a connected set with several 2004 lots and several 2022 lots corresponds to a rearrangement (a merge followed by a split). Requiring a sufficient overlap between lots to consider that they are linked limits the issues caused by the imperfect alignment of tax maps.

After detecting boundary changes using this algorithm, I checked that I could map every piece of land included in the 2004 tax map to a piece of land in the 2022 tax map. Unfortunately, in many cases, the misalignment of tax maps was severe, which caused the algorithm to fail to detect correct boundary changes. Fortunately, however, errors in the dataset of boundary changes lead the mapping from lots in 2004 to lots in 2022 to be incomplete, allowing for an easy detection of the algorithm's failures. When the algorithm could not correctly code a boundary change, I visually compared the 2004 and 2022 tax maps and manually coded boundary changes.

I found about 21,700 lot boundary changes that took place between 2004 and 2022, affecting about 15% of the available land in NYC.[40] Most of these could be coded using the algorithm described above, but approximately 5,700 boundary changes had to be coded manually to ensure that I could accurately track land uses in NYC.

Accounting for these boundary changes is critical to studying redevelopment: 74% of the floorspace and 69% of the buildings constructed between 2004 and 2022 are on lots that have seen boundary changes. Hence, without a dataset documenting such changes, one could not correctly map new buildings to the ones they replaced.

## A.2 Parcel characteristics

**Baseline characteristics.** I recovered most parcel characteristics from the PLUTO datasets, which include variables gathered by the NYC Department of Finance for property taxation purposes. These variables include a description of the parcel's use (e.g., two-family brick dwelling, stand-alone food establishment), land area, total amount of floorspace (and its allocation across uses—residential, office, retail, garage, storage, factory, and other), number of buildings (typically one), number of stories, number of residential and commercial units, and the year in which the parcel was developed.

**Floorspace.** While property tax records include data on the total amount of floorspace on a parcel as well as the size of individual condominium units, they do not record the floorspace area of individual non-condominium residential units. To obtain data on the size of such units, which regularly appear in real estate sales data, I relied on StreetEasy, the NYC subsidiary of Zillow. The StreetEasy website features dedicated pages for hundreds of thousands of buildings in NYC, providing information on current and past listings associated with them. Importantly, these listings usually report information about units' floorspace, as illustrated in Appendix Figure A.3.

To extract this information, I first identified 235,399 pages on the website, corresponding to separate NYC buildings. From each of these pages, I then extracted the building's characteristics, the list of all its units in StreetEasy's database, and past sales and rental listings associated with them. This procedure allowed me to recover information on 1.6 million residential units.

[40] Among the boundary changes, about 8,000 were splits, 5,800 were mergers, 4,700 were renamings, and 2,400 were rearrangements. Additionally, 430 lots appeared and 438 disappeared from the data over 2004–2022.

**Figure A.3:** Example of scraped StreetEasy listings

| OFF-MARKET DATE | UNIT | PRICE | BEDS | BATHS | SIZE |
|---|---|---|---|---|---|
| 08/31/24 | #PHL | **$7,735** | 2 beds | 2 baths | 953 $ft^2$ |
| 08/29/24 | #PHJ | **$7,841** | 2 beds | 2 baths | 984 $ft^2$ |
| 08/19/24 | #11K | **$4,252** | Studio | 1 bath | 502 $ft^2$ |
| 08/02/24 | #9K | **$4,252** | Studio | 1 bath | 502 $ft^2$ |
| 08/02/24 | #10X | **$5,400** | 1 bed | 1 bath | 684 $ft^2$ |

*Notes*: This figure shows an example of StreetEasy listings for the apartment building at 111 Worth Street in Manhattan. I scraped these listings to extract unit characteristics from them.

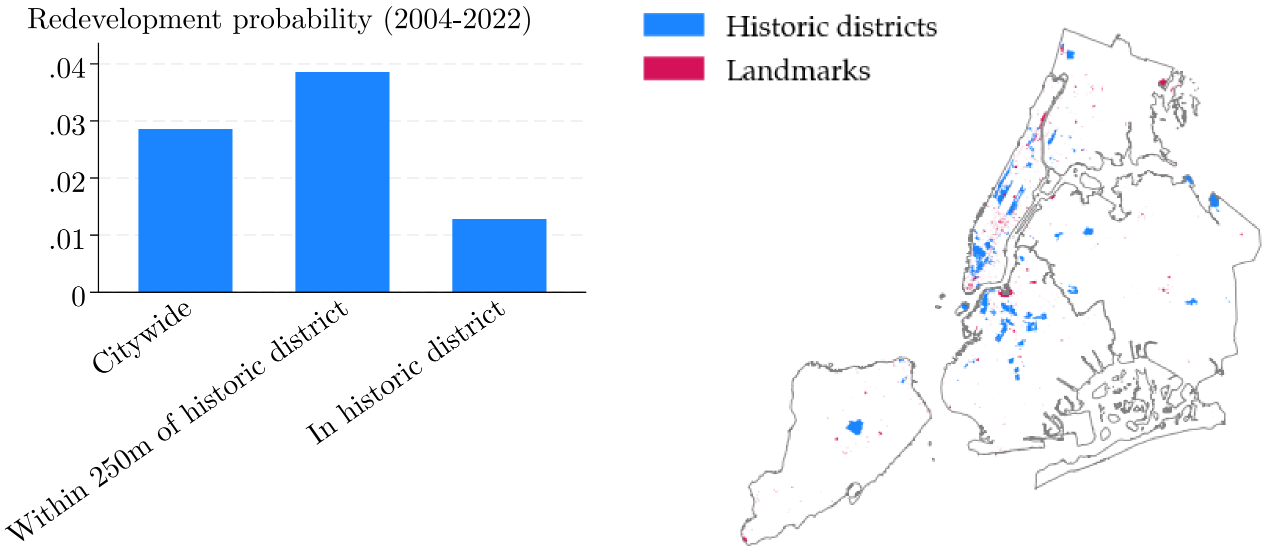
To match this dataset with NYC's administrative data, I associated buildings in StreetEasy's database with their BBL code. To do so, I first matched buildings' addresses in StreetEasy with those reported in the PLUTO database. When no match was found, I relied on NYC's Department of City Planning ZoLa tool, which allows users to search for a parcel using an address.

**Landmarks and historic districts.** Since the establishment of NYC's Landmarks Preservation Commission in 1962, 1,462 buildings in NYC have been landmarked, and 156 areas have been designated as historic districts, covering about 32,000 parcels. To preserve the historic or architectural value of these areas, alterations of the parcels protected under one of these designations are strictly regulated and must be approved by the Landmarks Preservation Commission.

These constraints strongly reduce the probability that a parcel will be redeveloped. As shown in the left panel of Appendix Figure A.4, the redevelopment probability of a parcel in a historic district is about a third of that of a parcel in the immediate vicinity of one. The right panel of Appendix Figure A.4 shows that these protected areas are primarily found in Manhattan and downtown Brooklyn.

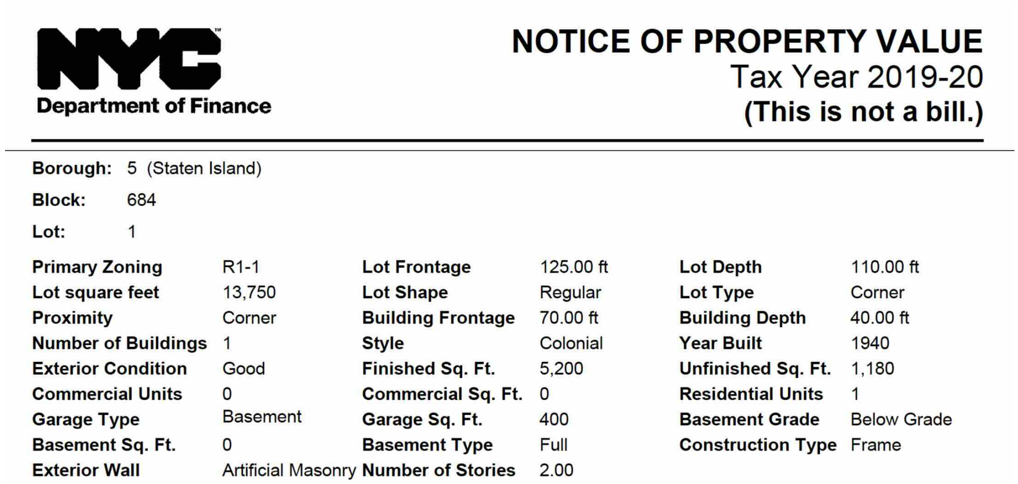
**Building construction materials and condition.** To recover information on buildings' construction materials and condition, I relied on Notices of Property Value (NOPVs). These documents are sent yearly by the NYC Department of Finance to property owners to inform them of the latest determination of their property's taxable value. Appendix Figure A.5 shows an extract of an NOPV. These documents contain information on a range of building characteristics, including data on the building's condition and its construction materials. These variables used to determine tax assessments are not reported in the PLUTO dataset or the tax rolls published by the city. I recovered the data contained in NOPVs from three sources. First, the NYU Furman Center shared with me data from NOPVs issued between 2005 and 2015, used in Li (2022). Second, I scraped NOPVs issued between 2016 and 2023 from the NYC Department of Finance Property Tax web portal. Third, through FOIA requests to the NYC Department of Finance, I recovered the data used to compile the NOPVs issued between 2019 and 2023.

**Figure A.4:** Parcels protected by the Landmarks Preservation Commission




*Notes*: This figure illustrates the protection of some parcels by the NYC Landmarks Preservation Commission, from which I recovered the map of historic districts and landmarks. The left panel shows the probability that a parcel is redeveloped over 2004–2022 for three subsamples: the entire city, parcels that are not protected but within 250 meters of a historic district, and parcels that are in a historic district. The right panel maps the areas of NYC that are protected either as landmarks or historic districts.

**Figure A.5:** Example of an NOPV



NYC Department of Finance

**NOTICE OF PROPERTY VALUE**
Tax Year 2019-20
**(This is not a bill.)**

**Borough:** 5 (Staten Island)
**Block:** 684
**Lot:** 1

| | | | | | |
|---|---|---|---|---|---|
| **Primary Zoning** | R1-1 | **Lot Frontage** | 125.00 ft | **Lot Depth** | 110.00 ft |
| **Lot square feet** | 13,750 | **Lot Shape** | Regular | **Lot Type** | Corner |
| **Proximity** | Corner | **Building Frontage** | 70.00 ft | **Building Depth** | 40.00 ft |
| **Number of Buildings** | 1 | **Style** | Colonial | **Year Built** | 1940 |
| **Exterior Condition** | Good | **Finished Sq. Ft.** | 5,200 | **Unfinished Sq. Ft.** | 1,180 |
| **Commercial Units** | 0 | **Commercial Sq. Ft.** | 0 | **Residential Units** | 1 |
| **Garage Type** | Basement | **Garage Sq. Ft.** | 400 | **Basement Grade** | Below Grade |
| **Basement Sq. Ft.** | 0 | **Basement Type** | Full | **Construction Type** | Frame |
| **Exterior Wall** | Artificial Masonry | **Number of Stories** | 2.00 | | |

*Notes*: This figure shows a portion of an NOPV sent in 2019 to a property owner in Staten Island.

**Rent stabilization.** In NYC, landlords must report the list of their rent-stabilized apartments to New York State's Division of Housing and Community Renewal (DHCR). I retrieved data on rent stabilization from amirentstabilized.com, a website that provides a dataset of the rent-stabilized parcels reported to the DHCR, accessed through FOIA requests.

This allows me to identify about 46,000 parcels with rent-stabilized units (5.6% of the total number of parcels). These parcels contain a total of 1.4 million residential units (39.4% of NYC's total housing stock), but only account for 8.9% of the city's developable land.

**Excluded parcels.** In estimation and counterfactuals, I excluded from the sample about 7,000 parcels that were used in 2019 as a park or cemetery, or for transportation or utilities, and further excluded about 3,000 parcels with less than 500 sq. ft of land.

## A.3 Zoning

Each year, NYC's Department of City Planning releases zoning maps in GIS format, associating parcels with their zoning districts. When rezonings occur, the Department of City Planning also releases GIS files of the boundaries of the rezoned areas. I used these files to isolate rezoned parcels.

After associating parcels with zoning districts, I used the city's zoning resolution to identify the maximum permitted FARs for residential and commercial structures across NYC's 180 zoning districts. In Appendix Table A.1, I show summary statistics describing parcels in NYC and the zoning regulations pertaining to them.

**Table A.1:** Parcel characteristics

| | Mean | P1 | P10 | P25 | P50 | P75 | P90 | P99 |
|---|---|---|---|---|---|---|---|---|
| Lot area (sq. ft) | 6,257 | 840 | 1,740 | 2,000 | 2,530 | 4,000 | 6,302 | 48,232 |
| Floorspace (sq. ft) | 6,457 | 0 | 1,056 | 1,376 | 2,000 | 3,032 | 5,933 | 91,100 |
| Residential floorspace (sq. ft) | 4,286 | 0 | 0 | 1,254 | 1,814 | 2,640 | 4,079 | 58,631 |
| Commercial floorspace (sq. ft) | 2,171 | 0 | 0 | 0 | 0 | 0 | 1,200 | 33,000 |
| Building age (years) | 80 | 7 | 33 | 64 | 89 | 99 | 109 | 139 |
| Max. allowed FAR (res. uses) | 1.3 | 0.0 | 0.5 | 0.5 | 0.8 | 2.0 | 3.0 | 7.5 |
| Max. allowed FAR (com. uses) | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 6.0 |
| Max. allowed FAR | 1.4 | 0.5 | 0.5 | 0.5 | 0.8 | 2.0 | 3.0 | 9.0 |
| Parcel FAR | 1.1 | 0.0 | 0.3 | 0.5 | 0.7 | 1.2 | 2.1 | 5.4 |
| Binding FAR limit | 0.613 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| Landmark or historical district | 0.039 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Redeveloped over 2004–2019 | 0.027 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

*Notes*: This table reports summary statistics for the parcels in my panel of land use in NYC. All variables are measured in 2019. I consider that the FAR limit is binding for a parcel if its FAR is above the maximum allowed FAR, or within 0.25 FAR points of the maximum allowed FAR.

## A.4 Construction timelines

For each parcel redeveloped between 2004 and 2022, I identified the year in which redevelopment started and the year in which it was completed.

To identify redevelopment start dates, I used the dataset of permits issued by the NYC Department of Buildings, which makes available the list of construction permits issued since 1989. When a developer wishes to construct a new building, the project is assigned a job number. I consider the construction start year to be the year in which the first construction permit for the job was issued.

When construction is finalized, a Certificate of Occupancy is issued by the NYC Department of Buildings. Until this certificate is issued, nobody can legally occupy the building. Hence, I define a building's completion year as the year in which the first Certificate of Occupancy associated with the construction project's job number is issued. I obtained data on Certificates of Occupancy from three sources. First, certificates issued after July 2012 are recorded in a dataset made available by the NYC Department of Buildings. Second, the NYU Furman Center has compiled a dataset of Certificates of Occupancy issued for residential structures between 2000 and 2009. For buildings and time periods not covered by these two sources, I relied on the NYC Buildings Information System, which makes available scans of Certificates of Occupancy issued since the beginning of the 20th century (see Figure A.6 for examples). After scraping the relevant documents (about 250,000 in total), I used OCR software to extract the date on which they were issued.

**Figure A.6:** Examples of scraped Certificates of Occupancy


*Notes*: This figure shows the headers of four Certificates of Occupancy scraped from the NYC Buildings Information System. I extracted from these Certificates of Occupancy the date on which they were issued, highlighted in the figure.

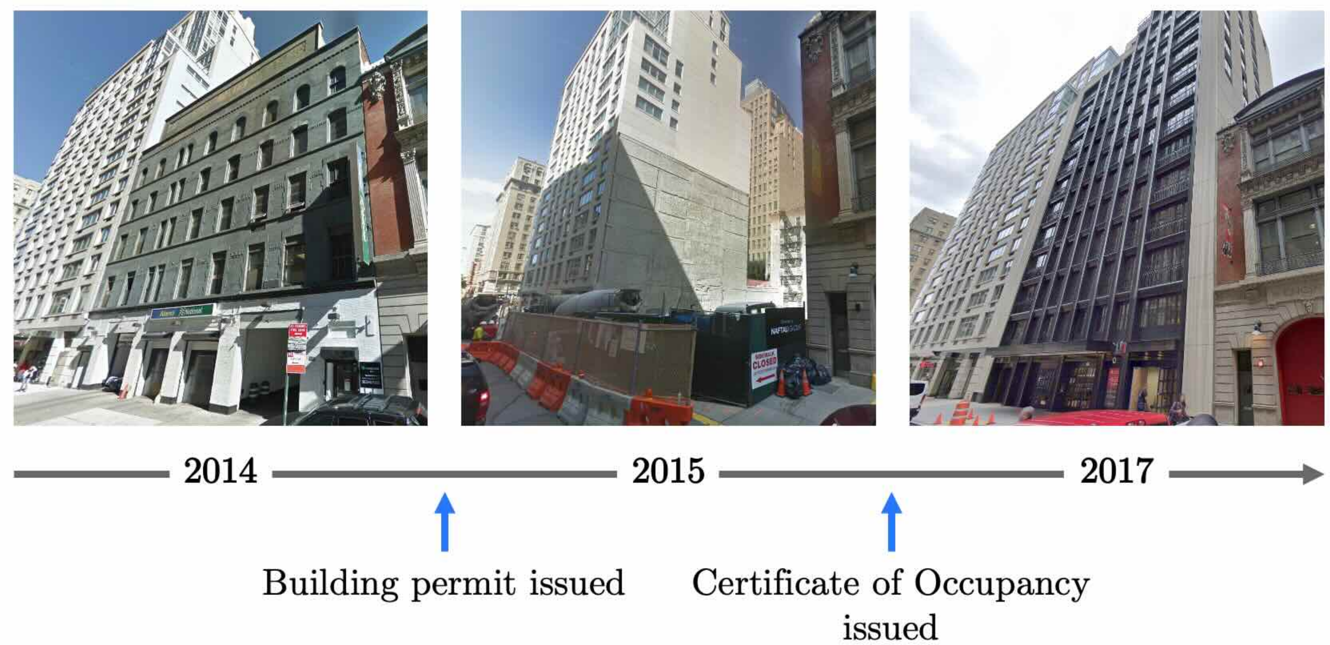
Using archival images from Google Street View, I checked the validity of the data recovered using this method. In Appendix Figure A.7, I illustrate the redevelopment timeline for a recently constructed building.

## A.5 Sales data

To compute the price of commercial and residential floorspace in NYC, I relied on the NYC Department of Finance Property Sales Files, a dataset of all property transactions that took place between 2003 and 2022. This dataset contains data on the location of properties sold and many of their characteristics, such as the type of building, the amount of floorspace and land sold, the sale price, and the number of commercial and residential units in the property. I merged the Property Sales Files with the PLUTO and StreetEasy datasets to better characterize the properties sold and measure the amount of floorspace transacted when it was not reported.

To assess whether each sale was a sale of commercial or residential space, I primarily used data on the number of residential and commercial units sold. If the Property Sales File records that only commercial units (resp., residential units) were sold, I considered that the transaction was a sale of commercial (resp., residential) floorspace. I excluded from the analysis sales that included both commercial and residential units. When data on the type of units sold (residential

**Figure A.7:** Example of a redevelopment timeline




*Notes*: This figure illustrates the redevelopment timeline of one parcel in my dataset, located at 206 West 77th Street in Manhattan's Upper West Side. At the beginning of the panel, the parcel is associated with a 42,058 sq. ft, six-story office and garage building built in 1929. This building was associated with BBL no. 1011680038. In 2014, a building permit was issued, and the parcel was redeveloped into an 73,760 sq. ft, 18-story structure. In property tax records, this new building is associated with BBL no. 1011687503.

or commercial) is missing, I inferred the type of sale from the building's description, when there was no ambiguity about its use. For instance, I considered that sales of single-family homes are residential sales and that sales of retail buildings are commercial sales.

When computing property prices, I excluded from the dataset properties that were transferred without being sold (which appear in the database with a sale price of $0) and hotel sales. To avoid having results driven by outliers, I trimmed from the data sales with a price per sq. ft above 10 times the median price per sq. ft (about $4,000) or below a tenth of the median price per sq. ft (about $40).

Overall, I have data on the sale price, amount of floorspace, and type of floorspace (residential or commercial) for about 930,000 property sales, of which a large majority (95%) are residential.

## A.6 Rents

Each year, owners of income-producing properties with an assessed value exceeding $40,000 are required to file a Real Property Income and Expense (RPIE) statement and report the rental income derived from their property to the NYC Department of Finance. While the information reported in RPIE statements is confidential, the Department of Finance reports in NOPVs the estimated income derived from properties, albeit with a two-year lag (see Li, 2022, for additional details). This allowed me to recover building-level estimates of rents.

My dataset of rents builds on the data collected in Li (2022), extracted from NOPVs issued between 2005 and 2015 (with, therefore, data on rents from 2003 to 2013). By scraping NOPVs issued between 2016 and 2023, I extended this dataset of rents to cover 2014–2021.[41] There are

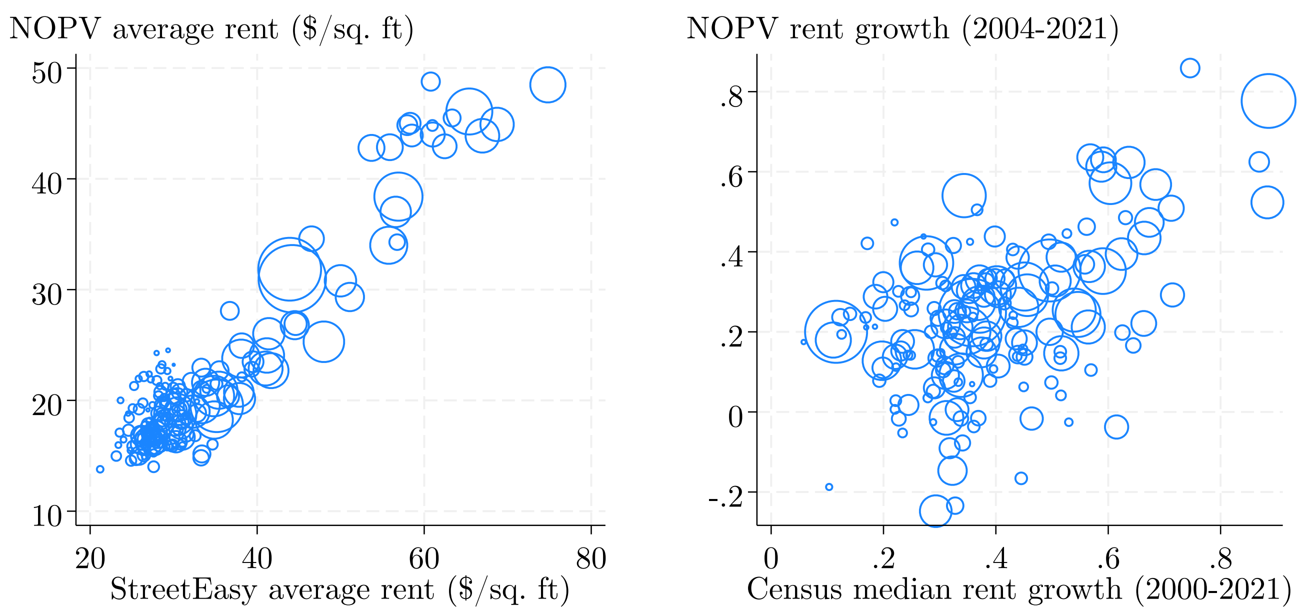
[41]Large fines are imposed on property owners who do not file an RPIE. However, expected rental incomes are

40,259 BBLs for which rent data is available over 2004–2021, the period covered in event studies. These BBLs contain 1.4 million units out of the 4 million in the city.

In Appendix Figure A.8(a), I show that the rent measures extracted from NOPVs tightly correlate with the average rents observed in the StreetEasy database.[42] Furthermore, the growth in rents observed in the NOPVs is consistent with that reported in Census estimates—see Appendix Figure A.8(b).

**Figure A.8:** Benchmarking of rents in NOPVs

**(a)** Rent levels (in 2019) **(b)** Rent changes




*Notes*: This figure compares residential rent estimates provided in Notices of Property Values (NOPVs) with available benchmarks. In panel (a), I compare the reported rents in NOPVs for 2019 with those listed on StreetEasy for the same year. In panel (b), I compare average rent increases in NOPVs over 2004–2019 with increases in the median paid rent between the 2000 Census and the 2021 5-year ACS (changes are measured in log points, and rents are adjusted for inflation). In both panels, each dot corresponds to a neighborhood, and observations are weighted by the number of BBLs with available NOPV data.

## A.7 Additional data sources

**Smartphone location data.** To explore contemporary trends in the use of commercial spaces in NYC, I gathered smartphone data from Advan, which measures the number of monthly visits to about 500,000 points of interest in the city (e.g., stores, restaurants, and banks).

**Commuting flows.** I extracted data on commuting flows from the LEHD Origin-Destination Employment Statistics (LODES) database. I gathered information from the 2019 version of the dataset on each neighborhood in NYC and the broader New York–Newark–Jersey City

sometimes not reported in NOPVs for some years. When rents are missing for a year within a BBL, I infer rents by linearly interpolating between the closest years for which data is available.

[42] Rent levels in StreetEasy tend to be higher than those in NOPVs, consistent with apartment units listed on that website tending to be of higher-than-average quality.

metropolitan area. Specifically, I collected data on the number of workers and jobs in each location, as well as the number of commuters traveling between any two locations.

To preserve privacy, the LEHD adds noise to the data it collects, which creates issues in some neighborhoods. For instance, about 8,000 people are reported to live in NYC's parks and cemeteries. I isolated outlier data points by computing the available residential floorspace per resident and commercial floorspace per job in each neighborhood. I adjusted the number of workers and jobs in different locations to winsorize these ratios at the 1st and 99th percentiles.

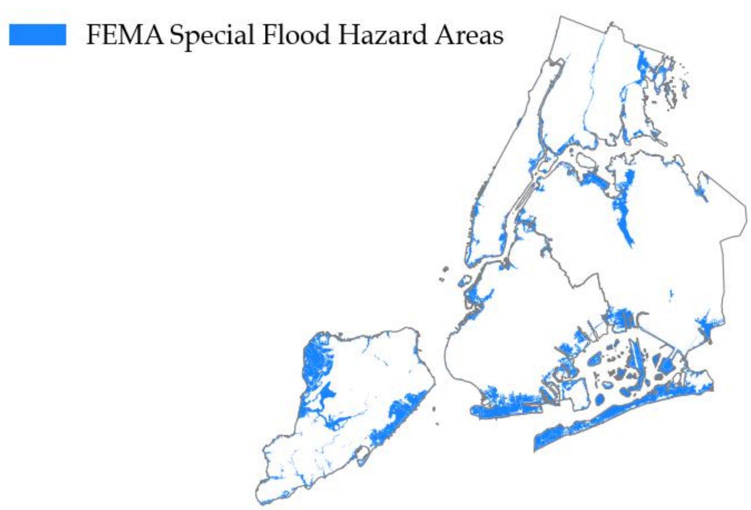
Finally, I normalized the number of workers in the NYC metropolitan area to its 2019 population of 19.2 million. Hence, expected incomes and floorspace consumption are measured in per capita terms, facilitating their interpretation.

**Commuting times.** I measured the travel time between any two locations using public transit or a car with the Google Maps API. Travel times were measured for a typical Monday at 8 a.m. and include traffic-induced slowdowns. I set the travel time between neighborhoods in NYC and the rest of the metropolitan area to an hour.

**Train stops.** I retrieved from the Baruch College Newman Library GIS Lab the locations of the train stations of the NYC Subway, the Staten Island Railway (SIR), the Long Island Rail Road (LIRR), the Metro-North Railroad, and the Port Authority Trans-Hudson (PATH).

**Flood maps.** I retrieved from FEMA the parts of NYC designated as Special Flood Hazard Areas, defined as areas that have a probability of being flooded in a given year exceeding 1%. These flood zones are shown in Appendix Figure A.9.

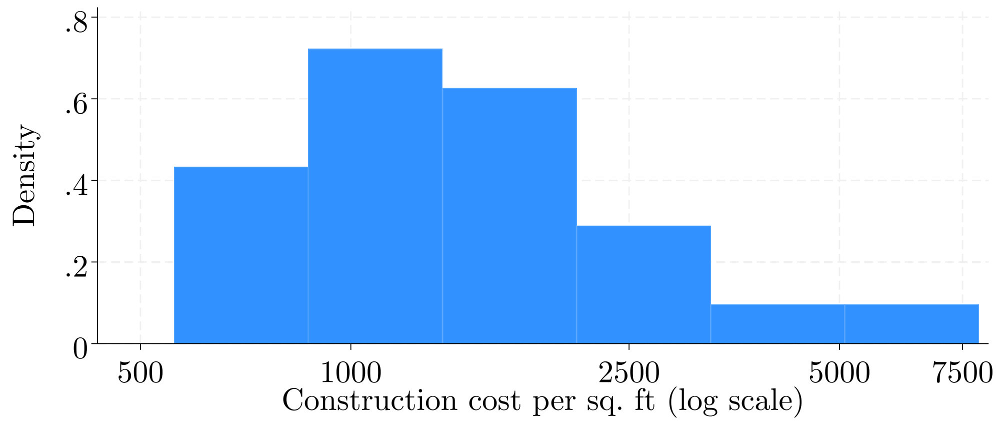
**Figure A.9:** Flood zones




*Notes*: This figure shows high-risk flood zones in NYC, i.e., the parts of the city that FEMA designates as having a yearly flood probability exceeding 1%.

**Skyscraper construction costs.** To benchmark the construction costs of very tall structures, I gathered the list of buildings constructed after 2000 that exceed 650 ft in height and recovered their construction costs from newspapers (primarily the New York Times), specialized websites (e.g., The Real Deal, Commercial Observer, NY YIMBY), and Wikipedia pages.[43] I recovered cost estimates for 47 buildings, which have an average FAR of 23.9. Their construction cost averaged $1,712 per sq. ft, with much variance across skyscrapers: the standard deviation of these construction costs is $1,365 per sq. ft (see Appendix Figure A.10).

**Figure A.10:** Skyscraper construction costs




*Notes*: This figure shows the distribution of observed construction costs per sq. ft for skyscrapers built after 2000. Construction costs are reported in 2019 dollars.

**Historical building permits.** The Office for Metropolitan History provides abstracts of building permit applications for new structures filed in Manhattan between 1900 and 1986. I extracted information on reported construction costs and building characteristics from these data. Permits filed between 1955 and 1965 report construction costs averaging $16/sq. ft (in 1960 dollars).

**Historical building sales.** Throughout most of the 20th century, the Real Estate Board of New York gathered data on arm's-length real estate transactions in Manhattan and documented them in volumes published each year. Appendix Figure A.11 illustrates the information displayed in these documents.

From Columbia University Libraries, I scanned and digitized volumes published between 1950 and 1985. This allows me to measure floorspace price levels when the 1961 zoning resolution was drafted. Between 1955 and 1965, the average reported sale price of floorspace was $8/sq. ft (in 1960 dollars).

[43]To make reported construction costs comparable over time, I adjusted them using the construction price indices reported by RSMeans (2020).

**Figure A.11:** Excerpt of a digitized REBNY volume

| Address<br>Block & Lot Number<br>Month in which Sale Occurred | Size of Plot<br>Type of Building | Consideration<br>Mortgage and<br>Terms (if available) | Assessed Valuation<br>L: Land only<br>T: Total |
|---|---|---|---|
| 148 E 57 St<br>1311-45 Apr | 18x100.5<br>C9 2 sty bldg | 72,590# | L 57,000<br>T 65,000 |
| 211-215 E 57 St<br>1331-7 May | 80x100.5<br>C4 3-5 sty tnts & strs | 240,000<br>109,739 50,261 new pb | L 175,000<br>T 195,000 |
| 422-426 E 57 St<br>1368-39 Feb | 66.3x110.1ir<br>D1 6 sty apt | 184,500<br>118,753 | L 165,000<br>T 195,000 |
| 243 E 58 St<br>1332-120 Jun | 20x100.5<br>C9 4 sty apt & str | 34,000<br>15,000 | L 17,500<br>T 30,000 |
| 411 E 58 St<br>1370-6 Jan | 16.8x100.4<br>C4 4 sty dwg | 51,000 | L 14,500<br>T 32,000 |
| 122 E 60 St<br>1394-64 Mar | 20x100.5<br>A4 4 sty dwg | 62,500<br>52,500 (2 mtgs) | L 44,000<br>T 49,000 |
| 207 E 60 St<br>1415-5 Mar | 20x100.5<br>A4 4 sty apt | 28,500<br>15,000 | L 20,000<br>T 24,000 |

*Notes*: This figure illustrates the information presented in the "Manhattan Real Estate Open Market Sales" volumes of the Real Estate Board of New York. Each observation corresponds to an arm's-length sale.

# B Historical and Policy Context

## B.1 A short history of zoning in NYC

**Early planning and the 1916 zoning resolution.** In the 19th and early 20th centuries, NYC grew tremendously as it industrialized and became a major entry point for immigrants to the United States. To fight unsanitary conditions in the city's poorest neighborhoods, New York State passed legislation in 1867, 1879, and 1901 (the "Tenement Acts") to ensure that newly built dwellings provided sufficient fire protection, sanitation, ventilation, and light to their residents.

To more thoroughly regulate urban form, NYC adopted in 1916 a comprehensive zoning ordinance, becoming the first American city to do so. The motivations of the architects of the 1916 resolution are summarized in the report accompanying the rules they proposed (New York City Board of Estimate and Apportionment, 1916). These early urban planners were, as the designers of the Tenement Acts, chiefly concerned with the effects of uncontrolled development on public health. Density limits, enacted through mandatory setbacks and height limits, would increase buildings' access to light and air, curtailing the spread of disease. A key concern was tuberculosis, which killed thousands of people each year in the city. Density limits were also justified as a means to limit the potential damage caused by fires.

On top of imposing density limits, the new zoning resolution favored the separation of residential and commercial land uses by restricting the areas where the construction of commercial buildings could take place. Such regulations aimed to segregate land uses perceived as incompatible. One reason for incompatibility was pollution and noise, which justified the separation of factories from dwellings. Interestingly, the planners of the 1916 resolution also largely advocated for the separation of land uses on moral grounds. The presence of stores where "much loafing is done" was believed to have "a very undesirable moral effect on the children living nearby" because of the "sordid atmosphere of the ordinary business street." Stores were harshly denounced as "invading residence streets" and mixed-use buildings as "undesirable as homes and unprofitable as stores." Edward Bassett, who wrote the first comprehensive zoning ordinance of NYC, assessed that "Stores with families above should be relegated to the dark ages of the past. The play spaces of small children ought not to be near fruits and vegetables for sale. [...] One of the best tendencies of zoning is to make business streets business only and residence streets residences only" (Bassett, 1926, as cited by Hirt, 2015).

**The 1961 zoning resolution.** By the end of the 1940s, support for rezoning New York had grown enough for the city to commission the drafting of a new zoning resolution. A first plan was proposed in 1950 by the architectural consulting firm Harrison, Ballard & Allen. While the city rejected this plan, it served as a foundation for the work of another consulting firm, Voorhees Walker Smith & Smith, which drafted in 1958 the zoning resolution that would eventually be adopted in 1961.

One key motivation for overhauling zoning regulations was the perceived ineffectiveness of existing rules. When NYC's initial zoning ordinance was enacted, the U.S. Supreme Court had not yet confirmed the constitutionality of zoning, and the 1916 resolution only modestly restricted development. Urban planners had computed that if NYC were developed to the full extent allowed by the 1916 ordinance, it would provide dwellings for 70 million residents and workspace for 300 million employees (Harrison, Ballard & Allen, 1950). Therefore, the architects of the new zoning resolution tightened restrictions to make them substantially affect urban form.

The economic and public health challenges that the city faced in the 1950s had also substantially changed since the turn of the century. Tuberculosis had been brought under control in the United States, and improved building codes had substantially reduced fire risk. Traffic congestion and the lack of parking space, however, had become a major issue as the automobile became a primary mode of transportation. Furthermore, in the post-war era, small neighborhood shops closed throughout NYC as they faced increasing competition from supermarkets, leading to vacant storefronts and blighted neighborhoods.

To draft a new zoning code, the mid-20th-century urban planners predicted how the city's needs for residential and commercial space would grow until 1970. They then assigned density and use limits to different areas of NYC to guide this growth in the direction they viewed as most beneficial to the city.

The new zoning code would promote "tower in the park" developments, consisting of high-rise buildings surrounded by green spaces and parking lots. These structures, popularized by Le Corbusier, were particularly popular when NYC's zoning resolution was drafted. They were seen as an efficient way to provide ample light, air, open space, privacy, and parking for city residents. To favor the construction of such developments, planners adopted maximum FAR limits as the primary lever to regulate land uses in the city instead of the previous height limits and mandated setbacks, which favored buildings fronting sidewalks.

Urbanistic trends of the 1960s also favored the separation of commercial spaces from residential ones. The new zoning resolution, therefore, reduced the amount of land zoned for commercial uses in residential neighborhoods, while substantial portions of the city would be zoned exclusively for commercial uses, particularly for manufacturing.[44]

**Zoning in the 21st century.** Views of what constitutes desirable land use patterns have profoundly changed since the 1960s. Tower in the park developments have largely fallen out of favor in urban planning, and contemporary approaches favor mixed-use developments that dedicate less space to parking and integrate commercial and residential spaces. Recent neighborhood rezonings in NYC have favored such mixed-use architecture.

As housing costs have sharply increased in NYC, city planners have also leveraged zoning to increase the supply of affordable housing. In 2016, NYC adopted Mandatory Inclusionary Housing zoning requirements, which mandate that new developments in recently rezoned areas allocate a share of newly built floorspace for affordable housing.

Another important challenge facing the city is the heightened risk of catastrophic weather events due to climate change. In 2012, Hurricane Sandy severely hit the city, causing an estimated 19 billion dollars in damages. In the aftermath of this disaster, NYC adjusted zoning to increase the resilience of flood-prone areas.

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[44] The abundant provision of land for manufacturing purposes was justified in the following way in Harrison, Ballard & Allen (1950): as NYC "does not raise its own food, nor mine [its] coal [...], the workers of New York City must fabricate goods or perform services that will pay for these indispensable imports of food and raw materials. [...] There is little opportunity to increase materially the employment in wholesale trade, in the retail stores, in finance, insurance [...] due to the fact that [the city] already has the lion's share in these activities. Factory production [will therefore] give much of the basic employment needed to sustain the City's economy." This reasoning was natural: for the preceding century, NYC's economy had largely thrived because of a dynamic manufacturing sector, which provided approximately 30% of jobs in the city. Planners assumed this would continue to be the case in the future. Yet, events took a different course: manufacturing started to decline precipitously in the 1960s, and it only provides a residual share of total employment in the city today. This decline, however, was more than compensated for by the expansion of the service sector.

**The restrictiveness, persistence, and gradual complexification of zoning.** Zoning regulations in NYC became much more restrictive, persistent, and complex than the planners who designed them had anticipated. While the 1961 zoning rules were much more stringent than the ones NYC had adopted in 1916, the planners who designed them did not view them as imposing tight constraints on the city's growth. Urbanists at the time considered that NYC would not substantially grow in the foreseeable future. Harrison, Ballard & Allen (1950) indicated, for instance, that "a population of about 8,600,000, predicted to be reached by 1970, should be regarded as the probable ultimate, i.e., stabilized, population of the city." The final zoning plan, "based on the concept of a city that can grow to a population of some 11,000,000 persons," was viewed as generously allowing new development (Voorhees Walker Smith & Smith, 1958). Even today, a naive observer of NYC's zoning ordinance might conclude that it does not restrain NYC's growth much. Indeed, two-thirds of the parcels in NYC have a built FAR below the maximum allowed by zoning, and if these parcels were built up to their FAR limit, NYC would have 69% more floorspace. This paper shows that despite the apparent large potential for growth under current regulations, the large fixed costs associated with redevelopment make zoning a strong constraint on densification.

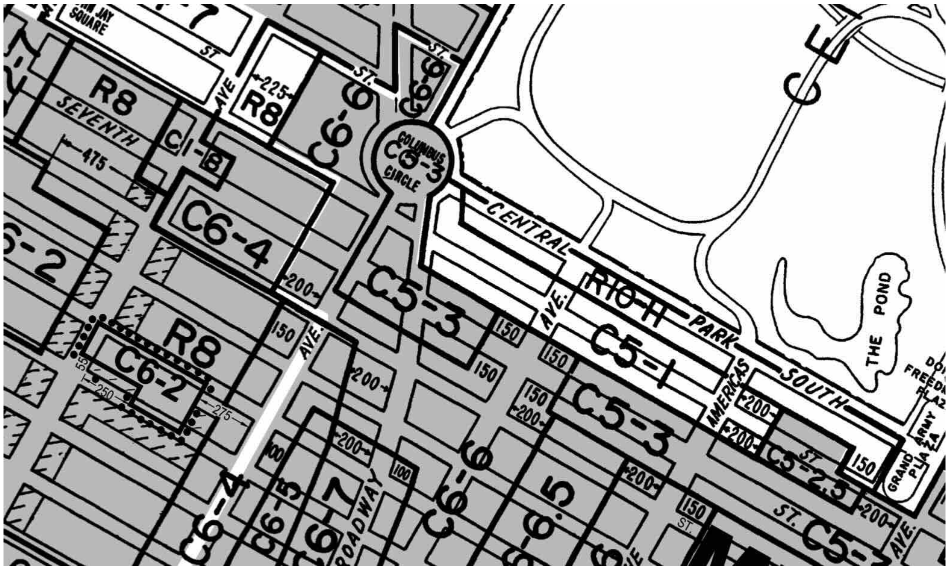
The designers of NYC's zoning resolutions never intended these planning instruments to be final or inflexible. The crafters of the 1916 zoning ordinance insisted that "no limit can be set to the growth and expansion of the city. [...] We cannot adopt a plan and make that the Procrustean mold for all future time. The plan must develop and change with the advance of civilization." (New York City Board of Estimate and Apportionment, 1914). Similarly, the planners who first drafted the 1961 zoning resolution focused on the city's short-to-medium-run evolution and designed rules that would accompany the city's growth until 1970 (Harrison, Ballard & Allen, 1950), anticipating that zoning regulations would be adjusted in the future to guide longer-term changes in the city. While most neighborhoods of NYC have been rezoned in some way since 1961, these policy changes have typically been marginal, leading the overall zoning patterns in the city to be remarkably persistent, as shown in Appendix Figure B.10.

One of the aims of the 1961 resolution was to make zoning rules easier to understand. In part because of the 2,500 amendments added to the 1916 ordinance in the decades following its approval, the constraints imposed on construction were complex and opaque. While the 1961 resolution simplified many existing rules, the progressive amendment of the zoning code did not stop, leading to gradual complexification. Over 60 years, the length of the zoning resolution grew tenfold, reaching 3,400 pages as of 2024.

The crafters of the 1961 resolution knew that the regulatory overhaul they proposed "[would] meet opposition—from those who resist change in general, from those who feel that they have a vested interest in the present resolution or who can exploit its weaknesses, and from those who honestly believe that continued piecemeal amendment is the best way to accomplish our ends" (Voorhees Walker Smith & Smith, 1958). If anything, zoning changes have become more politically contested over time, as citizens have become more involved in regulatory processes (Brooks and Liscow, 2023). Proposed upzonings—in NYC and other American cities—are routinely protested against, usually because they are perceived as driving gentrification, changing neighborhoods' character, or primarily benefiting developers instead of residents. However, the recent housing affordability crisis has sparked movements like YIMBY (Yes In My Back Yard), which advocate for reforms broadly relaxing zoning regulations.

## B.2 Additional figures

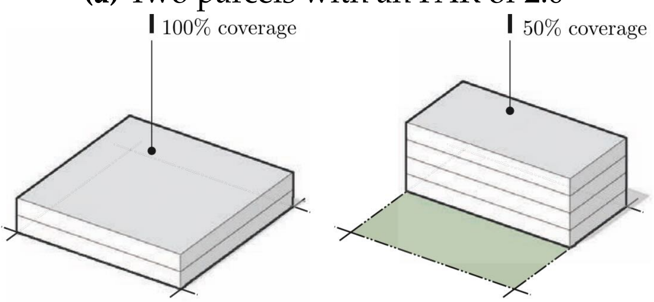
**Figure B.1:** NYC's zoning map around Columbus Circle




*Notes*: This figure maps zoning districts in the area surrounding Columbus Circle. Each parcel in NYC is associated with a zoning district (e.g., R8, C5-1, C6-2). Zoning districts, in turn, are associated with restrictions on the characteristics of newly built structures.

**Figure B.2:** Illustration of zoning restrictions in NYC

**(a)** Two parcels with an FAR of 2.0

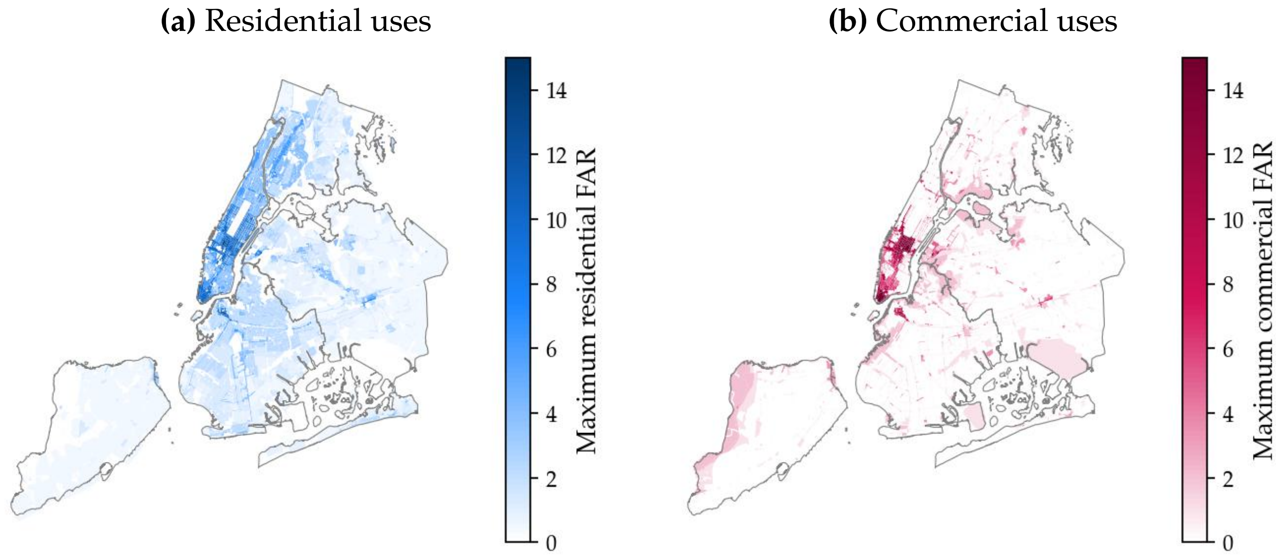



**(b)** Examples of zoning districts in NYC

| Zone | Max res. FAR | Max com. FAR |
|---|---|---|
| R1 | 0.5 | – |
| R5 | 1.25 | – |
| M1-4 | – | 2 |
| C6-6 | 10 | 15 |

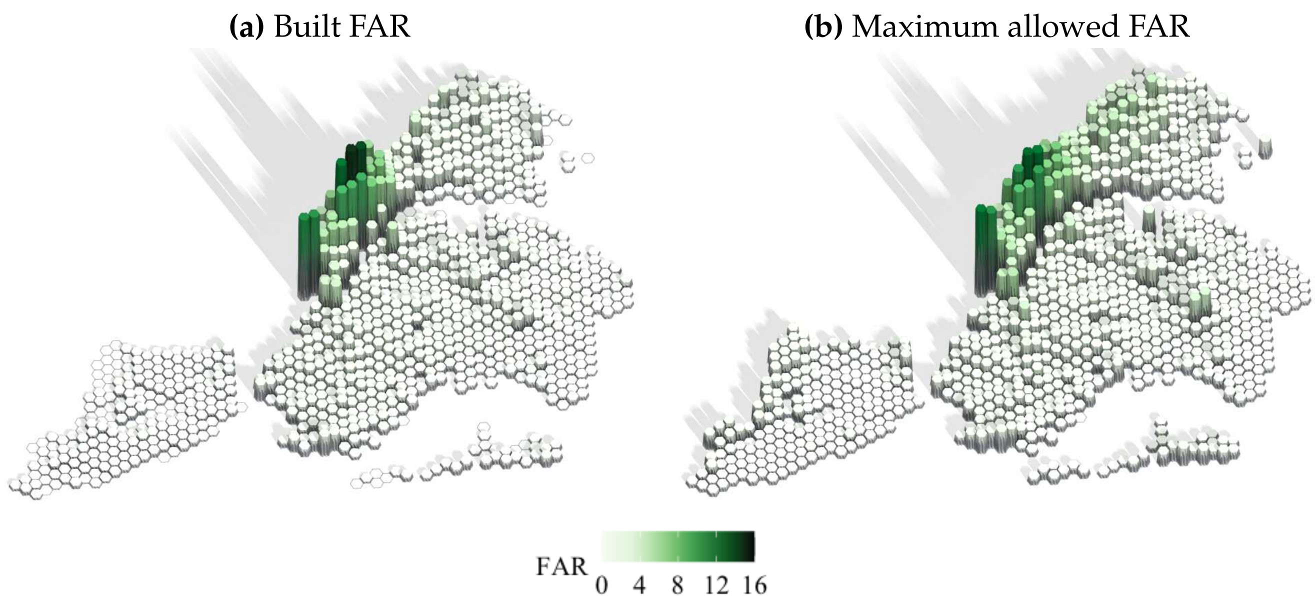
*Notes*: Panel (a) shows an illustration of the Floor Area Ratio (FAR) by the NYC Department of City Planning. It is defined as "the ratio of total building floor area to the area of its zoning lot." Panel (b) shows the maximum FAR limits for residential and commercial buildings in four zoning districts. R1 is a residential district for single-family homes. R5 is a medium-density residential district. M1-4 is a medium-density light manufacturing district that allows a broad range of commercial uses, including offices, but not residential uses. C6-6 is a high-density district that allows both residential and commercial uses but favors the latter.

**Figure B.3:** FAR allowances in NYC's zoning map




*Notes*: This figure maps the maximum FAR allowances in NYC for residential and commercial uses.

**Figure B.4:** Built and allowed FARs in NYC

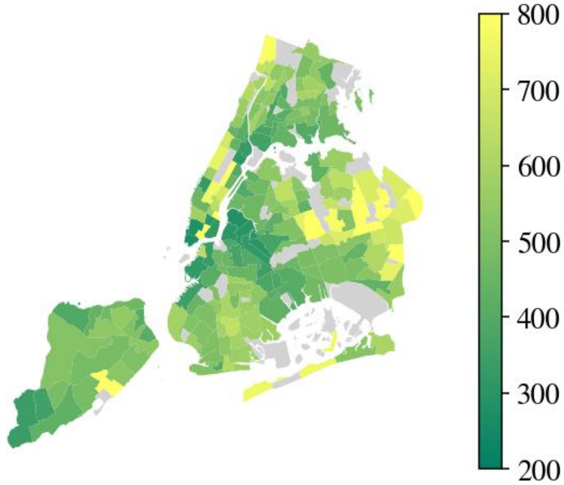



*Notes*: This figure maps built and allowed FARs in NYC in 2019. In this figure, I aggregate data to hexagonal grid cells using Uber's H3 indexing system.

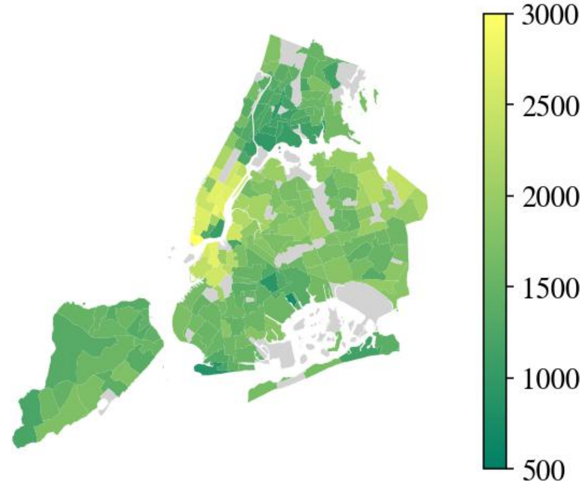
**Figure B.5:** NYC's central neighborhoods have become more attractive to residents over time

**Panel A**: Median residential rents (dollars per month)

**(a)** 1950

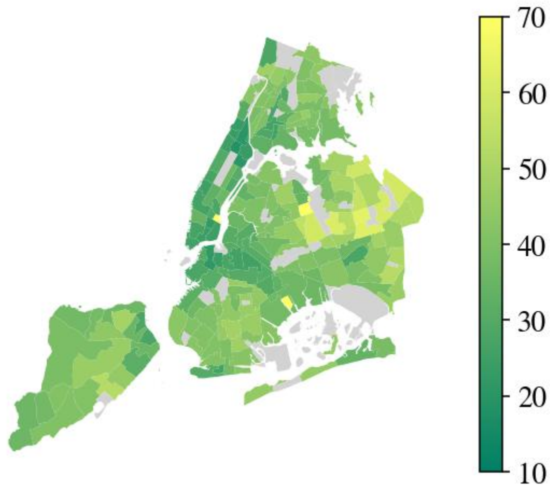



**(b)** 2019

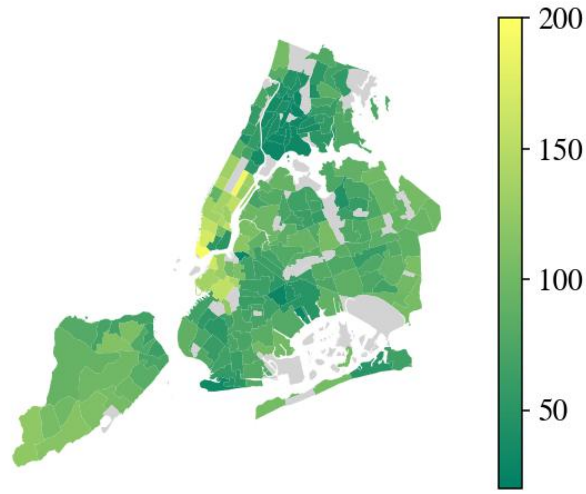



**Panel B**: Median income (thousands of dollars per year)

**(a)** 1950

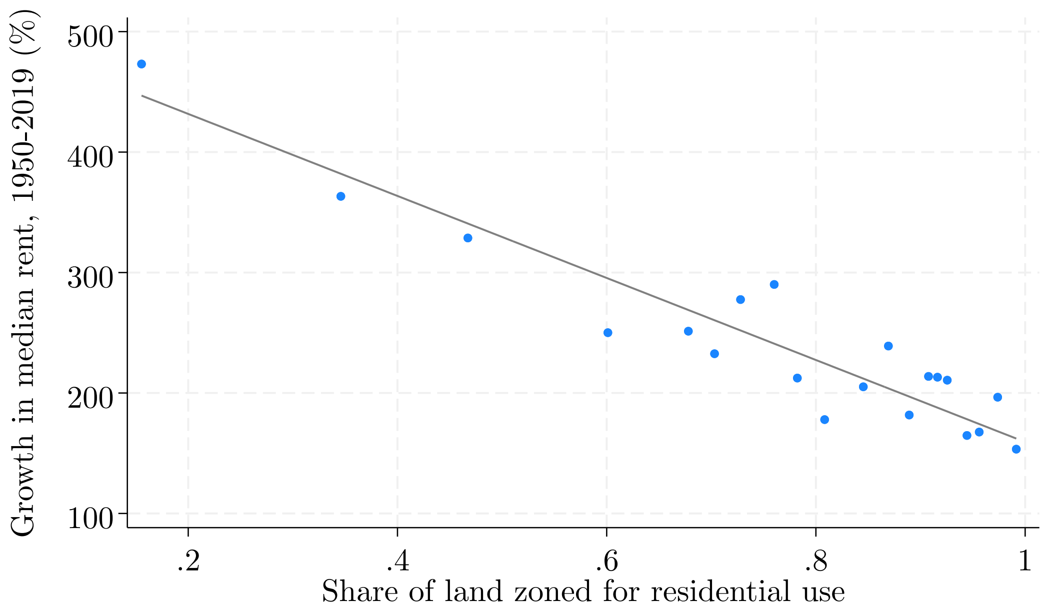



**(b)** 2019



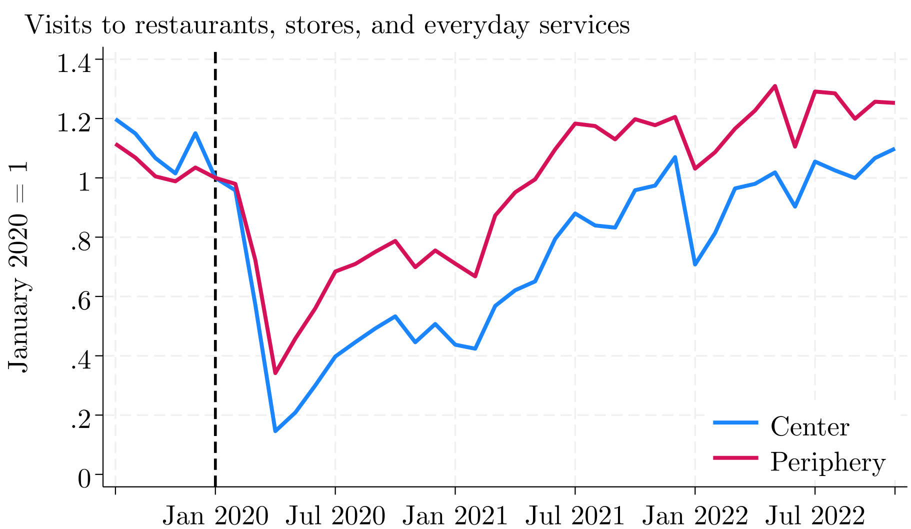

*Notes*: This figure compares two measures of neighborhood attractiveness in 1950 and 2019. Panel A reports median monthly rents for rented dwelling units, and Panel B reports median household incomes. Data from 1950 is taken from the decennial census, while data for 2019 is taken from the 2017-2021 five-year ACS. All prices are adjusted for inflation and reported in 2021 dollars.

**Figure B.6:** Residential rents grew faster in areas of NYC zoned for commercial purposes



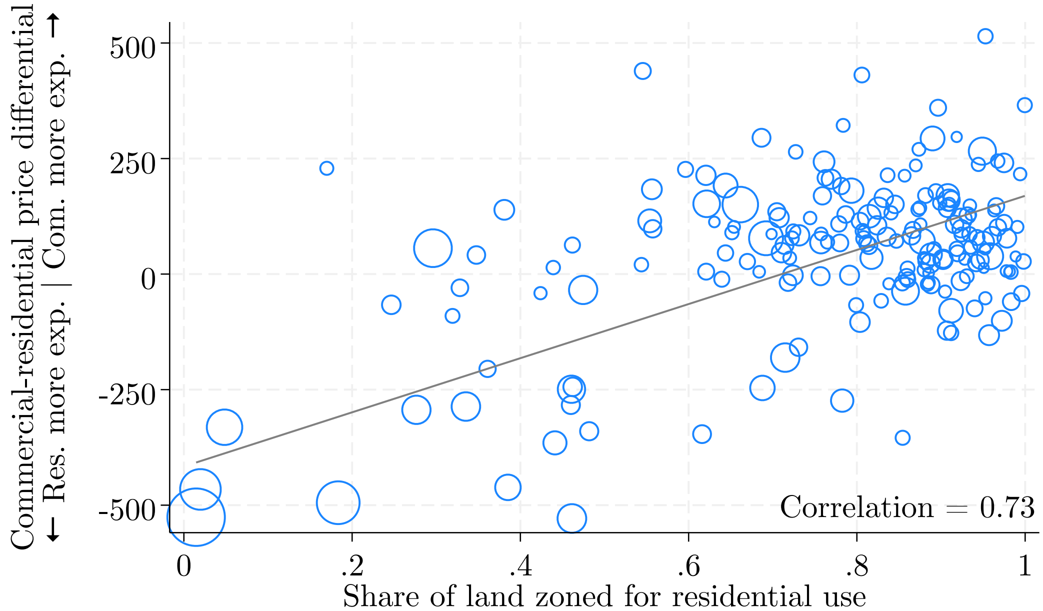

*Notes*: This figure illustrates the neighborhood-level negative correlation between the growth in median residential rents (adjusted for CPI inflation) between 1950 and 2019 (shown in Appendix Figure B.5) and the share of land that was zoned for residential purposes in 1961.

**Figure B.7:** Following the COVID-19 pandemic, demand for local services shifted towards the city's periphery




*Notes*: This figure shows the evolution of the number of recorded visits to restaurants, stores, and everyday services (e.g., dry cleaners, banks) in the aftermath of the COVID-19 pandemic. I extract these trends from smartphone data provided by Advan, which measures the number of monthly visits to about 500,000 points of interest in NYC. I normalize the total number of visits in January 2020 to one and show separate trends for the center and periphery of the city. Central neighborhoods are areas in the lower half of Manhattan (below Central Park) and the Neighborhood Tabulation Area of Downtown Brooklyn. All other neighborhoods in the city are classified as peripheral.

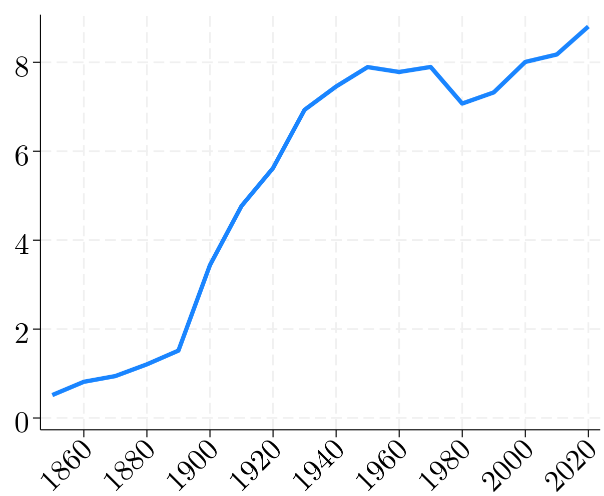
**Figure B.8:** Use restrictions likely hinder the reallocation of land uses in NYC



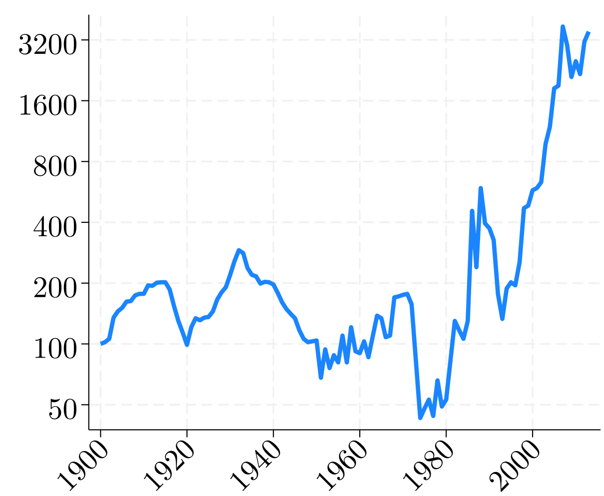

*Notes*: This figure illustrates the neighborhood-level correlation between the commercial–residential price differential plotted in Figure 4(b) and the share of land zoned for residential purposes. Observations are weighted by the amount of floorspace in each neighborhood.

**Figure B.9:** Historical population and land values

**(a)** NYC population (millions)

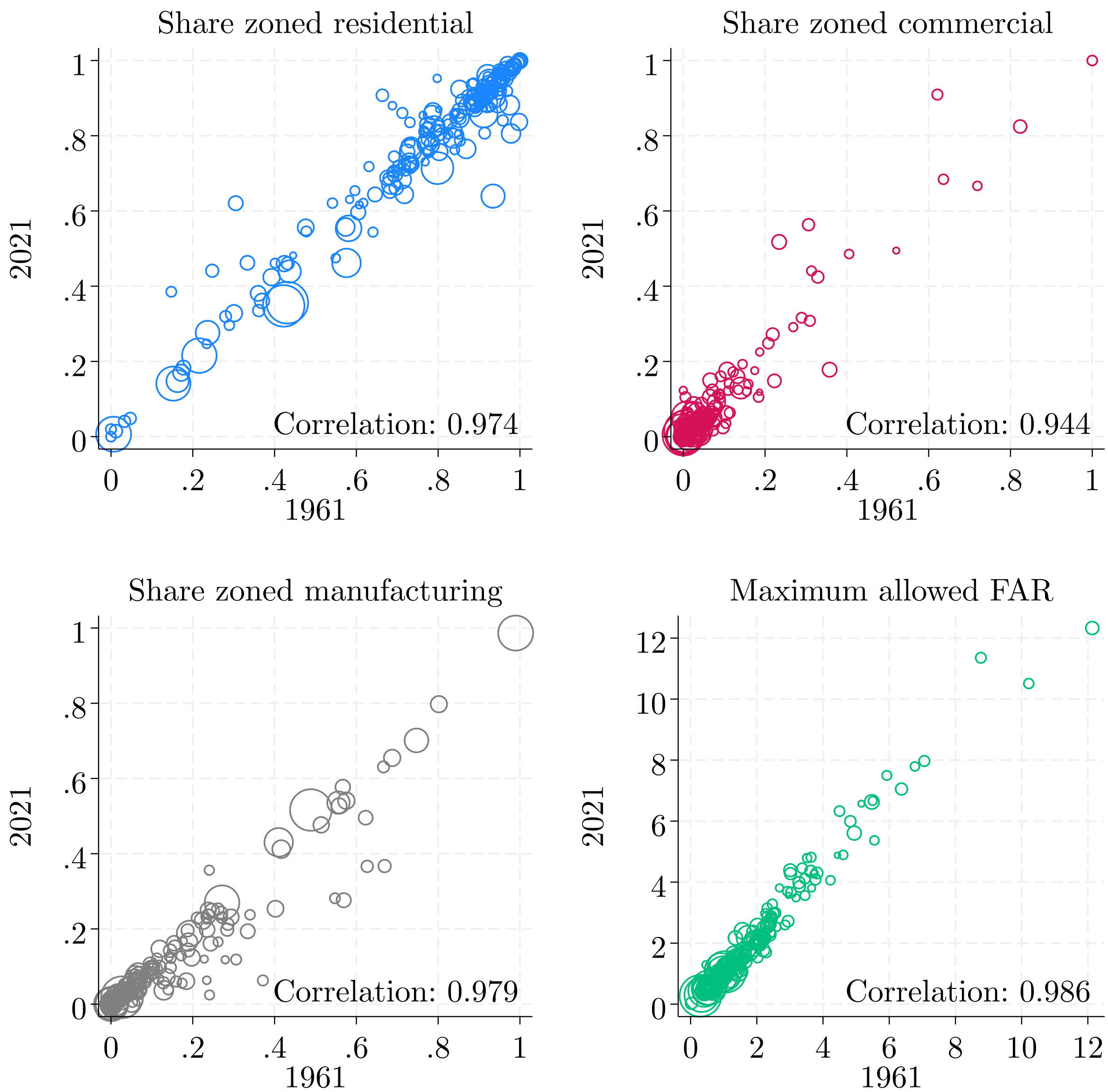



**(b)** Manhattan land values (1900 = 100)




*Notes*: Panel (a) shows the evolution of NYC's population. Panel (b) shows the evolution of land values in Manhattan, reproduced from Barr (2016).

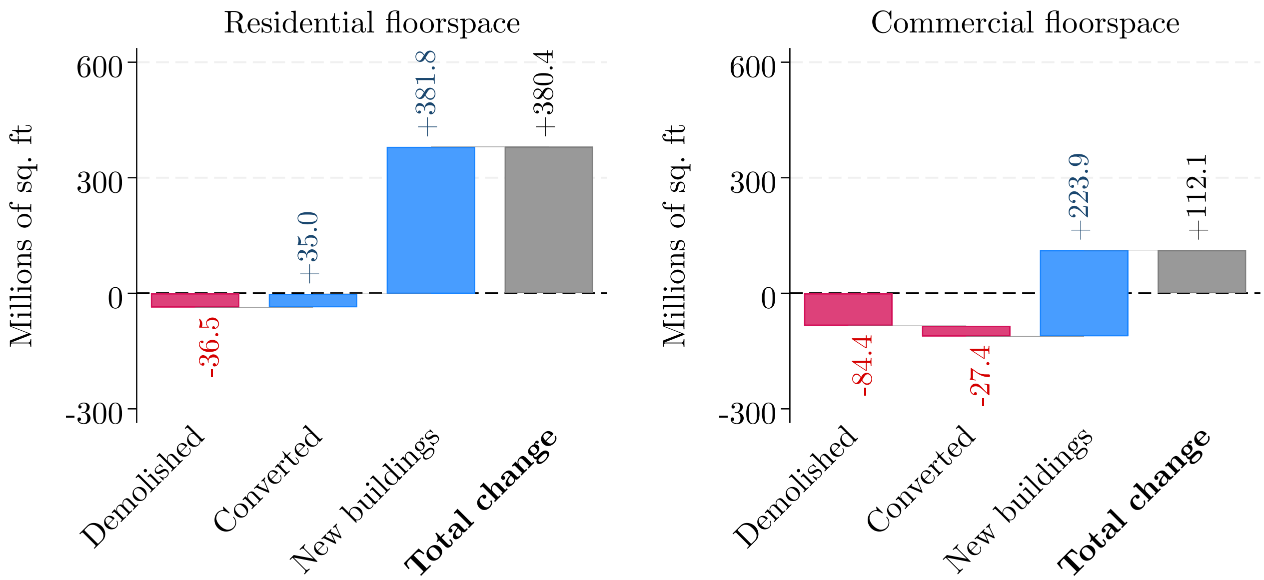
**Figure B.10:** Persistence of zoning regulations




*Notes*: This figure shows the persistence of zoning regulations by comparing the zoning maps of 1961 and 2021. I plot for each neighborhood in both years the share of land in a residential, commercial, or manufacturing zone, as well as the average maximum allowed FAR. Neighborhoods are weighted by their land area.

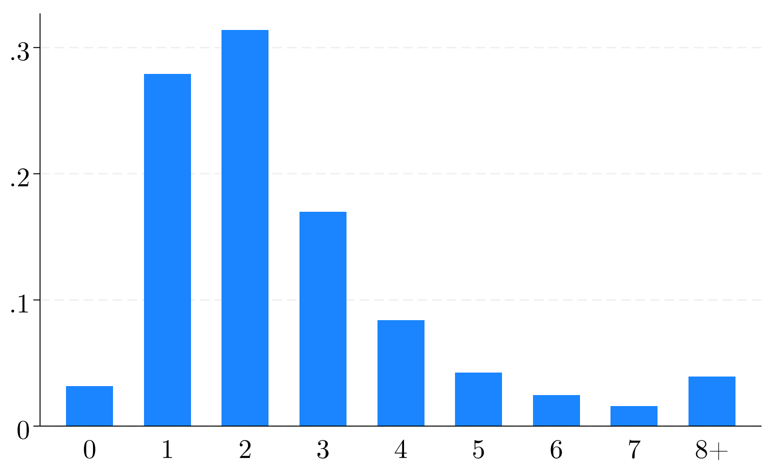
# C Additional Descriptive Statistics

**Figure C.1:** Changes in floorspace, 2004–2022



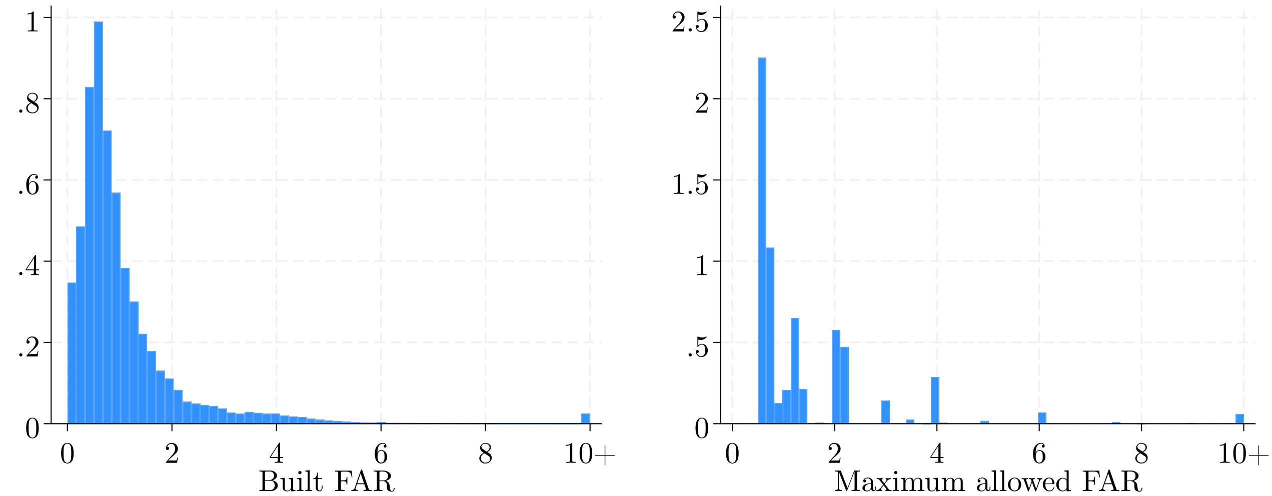

*Notes*: This figure decomposes the change in residential and commercial floorspace in NYC over 2004–2022 as the sum of demolished floorspace, converted floorspace, and newly built floorspace. In 2022, the city had 5.6 billion sq. ft of floorspace (1.9 billion sq. ft of commercial floorspace and 3.7 billion sq. ft of residential floorspace). The residential floorspace created (on net) by conversions is not exactly equal to the commercial floorspace lost because of conversions. This is because the amount of floorspace in a building recorded in the tax data sometimes changes when conversions take place.

**Figure C.2:** Redevelopment duration (in years)



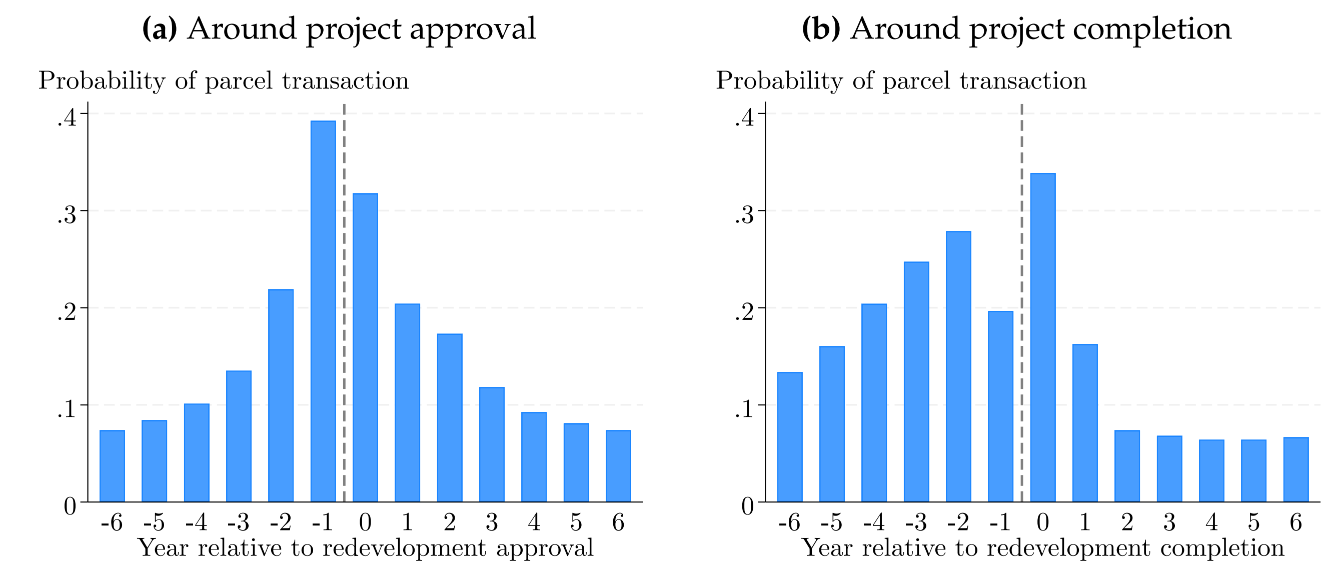

*Notes*: This figure plots the distribution of the duration of redevelopment projects (in years). I measure the duration of a project as the time elapsed between the approval of the building permit and the issuance of a certificate of occupancy, indicating that the building is suitable for use.

**Figure C.3:** Distribution of parcel FARs (built and allowed)



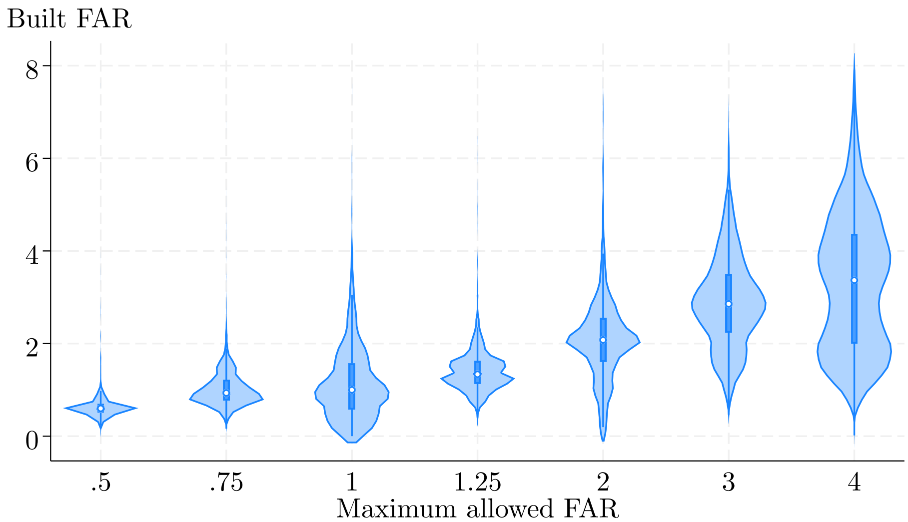

*Notes*: The left (resp., right) panel plots the distribution of the built (resp., allowed) FARs in NYC in 2022.

**Figure C.4:** Probability of parcel transaction around redevelopment events




*Notes*: This figure plots, for redeveloped parcels, the probability of observing these parcels being transacted in the sales data. I show probabilities for each year around the issuance of a building permit in panel (a), and for each year around the issuance of a certificate of occupancy in panel (b). Parcel transactions are measured in the sales data. I consider that a parcel is sold in a given year if any of its constituent zoning lots is sold that year, and I label a zoning lot as being sold during a year if more than 80% of its units were sold that year. The unconditional probability of a parcel being sold in a given year is 5.6%.

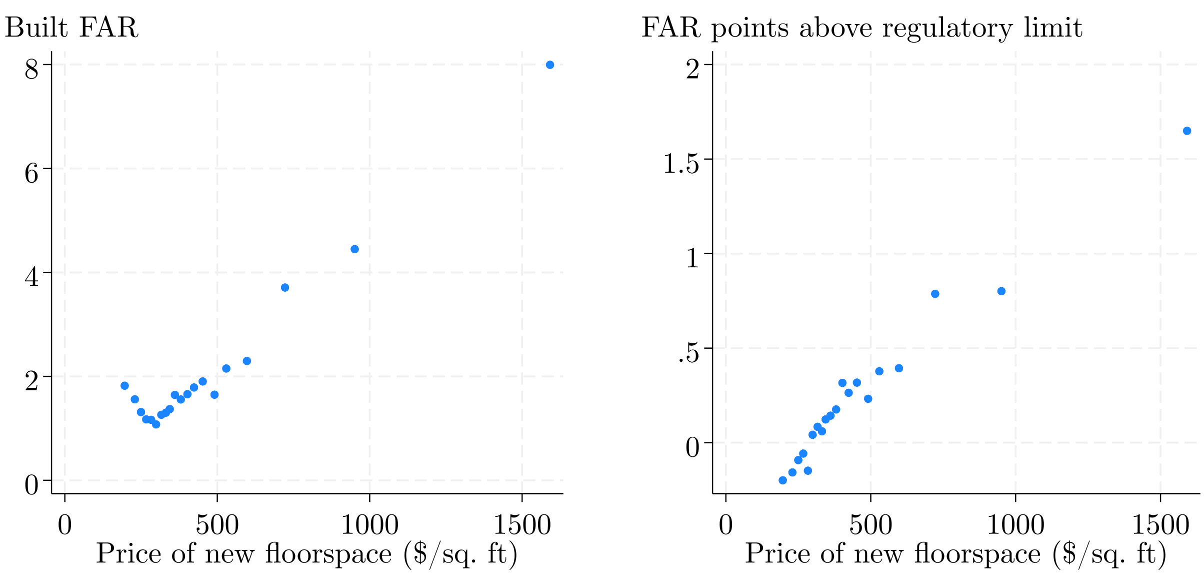
**Figure C.5:** Built and maximum allowed FARs




*Notes*: This figure plots the distribution of the built FAR of new buildings for seven common levels of the maximum allowed FAR: 0.5, 0.75, 1, 1.25, 2, 3, and 4.

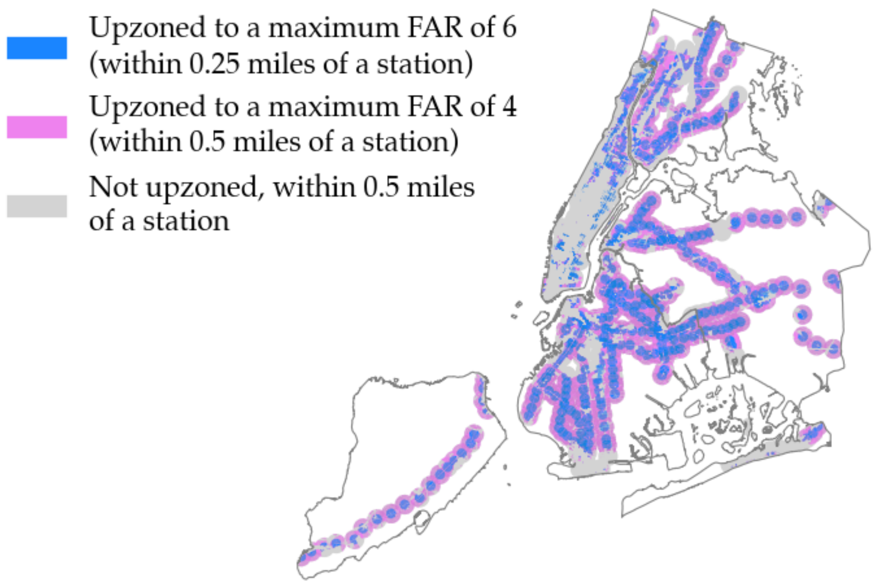
**Figure C.6:** Developers' choices and floorspace prices

**(a)** Chosen FARs **(b)** Distance to FAR limit




*Notes*: This figure illustrates relationships between developers' choices and the floorspace prices they face. Panel (a) illustrates, for newly constructed buildings, the positive relationship between floorspace prices and the FARs they choose to build. Panel (b) shows the relationship between floorspace prices and the distance between the FAR chosen by developers and the maximum allowed FAR in the zoning code. Negative values correspond to developers building below the FAR limit. Developers often choose FAR levels slightly above the nominal FAR limit because some floorspace does not count towards this limit (e.g., attics, cellars, or mechanical space).

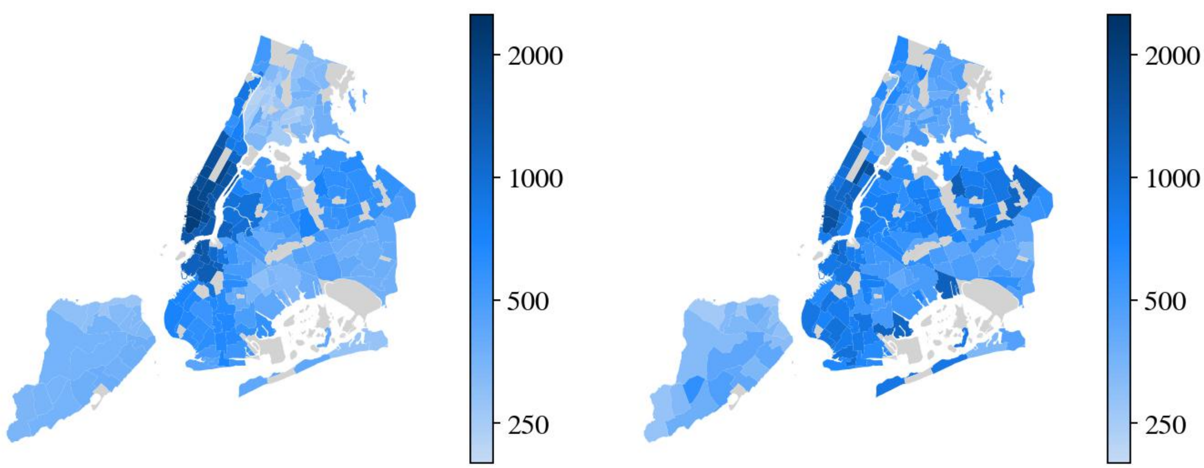
**Figure C.7:** Counterfactual upzoning




*Notes*: This figure maps the parcels upzoned in the upzoning counterfactual studied in Section 6. In this counterfactual, parcels within 0.25 miles of a subway, SIR, LIRR, Metro-North, or PATH station are upzoned to an FAR allowance of 6 for both residential and commercial uses. Furthermore, the FAR allowance is raised to 4 within 0.5 miles of a station. Parcels with higher FAR allowances at baseline are not upzoned, leading many parcels in Manhattan to remain unaffected by the policy despite their proximity to transit stations. Furthermore, I exclude from the upzoning parcels with landmarks, and those in historic districts or flood zones.

**Figure C.8:** Floorspace price levels ($/sq. ft)

**(a)** Residential prices **(b)** Commercial prices




*Notes*: This figure shows prices of residential and commercial floorspace in 2019, adjusted for quality using the hedonic regression described in Section 5.1.

# D Supply of Floorspace: Additional Estimation Details

## D.1 Variable costs estimation

**Developer's problem.** Developers choose the FAR of new buildings to maximize the variable profit from construction under the zoning constraint:

$$\max_{h^{\text{new}} \leq (1+b)\bar{h}^{\text{code}}_{\theta it}} \mathcal{P}_{it}(h^{\text{new}}, \mathbf{x}^{\text{new}}_{it}) - VC_{\theta it}(h^{\text{new}}) = p_{\theta nt} \cdot (h^{\text{new}})^{1+\beta_{\theta,\text{FAR}}} - \alpha^0 \alpha_{\theta b} \alpha_t e^{\eta_{it}} \cdot (h^{\text{new}})^{1/\zeta}, \tag{D.1}$$

where $p_{\theta nt} = \exp(P_{1,\theta n} + P_{2,\theta bt} + \sigma_v^2/2)$ is the price index for buildings of type $\theta$ in neighborhood $n$ in year $t$, estimated in the first step of the estimation procedure, and $\beta_{\theta,\text{FAR}}$ is the hedonic coefficient on log(FAR) in $\boldsymbol{\beta_\theta}$. As $h^{\text{new}}$ increases, the marginal value of a sq. ft of floorspace decreases (when $\beta_{\theta,\text{FAR}}$ is negative), for instance because adding stories to a building requires allocating a larger share of the floorspace to elevators. The marginal construction cost of this floorspace also increases, and, in the absence of zoning constraints, the developer chooses an FAR $h^*$ equating the marginal value of floorspace with its marginal cost:

$$h^* = \left[\frac{(1+\beta_{\theta,\text{FAR}})\zeta p_{\theta nt}}{\alpha^0 \alpha_{\theta b} \alpha_t e^{\eta_{it}}}\right]^{\frac{1}{1/\zeta - 1 - \beta_{\theta,\text{FAR}}}}. \tag{D.2}$$

If $h^* > (1+b)\bar{h}^{\text{code}}_{\theta it}$, the zoning constraint will be binding and the developer will choose to build up to this limit.

**Likelihood function.** If we observe a developer choosing an FAR $h \leq \bar{h}^{\text{code}}_{\theta it}$, we know that zoning was not a binding constraint, and that the developer drew a cost shock

$$\eta^* = \log\left(\frac{(1+\beta_{\theta,\text{FAR}})\zeta p_{\theta nt}}{\alpha^0 \alpha_{\theta b} \alpha_t}\right) + \left(1 + \beta_{\theta,\text{FAR}} - \frac{1}{\zeta}\right)\log(h). \tag{D.3}$$

The likelihood of this observation is

$$\ell(h) = -\frac{1}{h}\left(1 + \beta_{\theta,\text{FAR}} - \frac{1}{\zeta}\right)\varphi_{\sigma_\eta}(\eta^*), \tag{D.4}$$

where $\varphi_{\sigma_\eta}$ is the PDF of a normal distribution with standard deviation $\sigma_\eta$. However, if $h > \bar{h}^{\text{code}}_{\theta it}$, the FAR limit may have been binding. In that case, the likelihood of observing a chosen FAR $h$ is given by

$$\ell(h) = \left(-\frac{1}{h}\left(1 + \beta_{\theta,\text{FAR}} - \frac{1}{\zeta}\right)\varphi_{\sigma_\eta}(\eta^*) + \Phi_{\sigma_\eta}(\eta^*)\frac{\lambda}{\bar{h}^{\text{code}}_{\theta it}}\right)\exp\left[-\lambda\left(\frac{h}{\bar{h}^{\text{code}}_{\theta it}} - 1\right)\right], \tag{D.5}$$

where $\Phi_{\sigma_\eta}$ is the CDF of a normal distribution with standard deviation $\sigma_\eta$. These expressions allow us to estimate the variable cost parameters $\alpha^0$, $\zeta$, $\lambda$, and $\sigma_\eta$ through maximum likelihood estimation, and compute the expected FAR of new structures as

$$\mathbb{E}[h] = \int h\ell(h)\,\mathrm{d}h. \tag{D.6}$$

## D.2 Fixed costs estimation

**Expected profits from redevelopment.** To estimate fixed costs, I first compute for each parcel, year, and type of structure (residential or commercial) the developer's expected profit from redevelopment net of fixed costs, $\tilde{\pi}_{it}^{\theta}$.

In the absence of zoning constraints, a developer receiving a profit shock $\eta$ would choose to build up to an FAR of $h^*(\eta)$, given by equation (D.2). If $h^*(\eta) \leq \bar{h}^{\text{code}}$, then the zoning constraint does not bind and the developer receives the following profit (suppressing parcel, time, and building type indices for conciseness):

$$\tilde{\pi}(\eta) = ph^*(\eta)^{1+\beta_{\text{FAR}}} - \mathcal{P}^{\text{old}} - \alpha h^*(\eta)^{1/\zeta} e^{\eta}, \tag{D.7}$$

where $\mathcal{P}^{\text{old}} = \mathcal{P}(h^{\text{old}}, \mathbf{x}^{\text{old}})$ is the value of the structure that is redeveloped. If $h^*(\eta) > \bar{h}^{\text{code}}$, however, the developer will be constrained by zoning if the $b$ shock it receives is low enough. In that case, the developer's expected profit is given by

$$\tilde{\pi}(\eta) = \underbrace{\int_0^{\bar{b}(\eta)} \left[ p(\bar{h}^{\text{code}}(1+b))^{1+\beta_{\text{FAR}}} - \mathcal{P}^{\text{old}} - \alpha(\bar{h}^{\text{code}}(1+b))^{1/\zeta} \right] \lambda e^{-\lambda b} \mathrm{d}b}_{\text{When zoning is binding}} + \underbrace{\int_{\bar{b}(\eta)}^{\infty} \left[ ph^*(\eta)^{1+\beta_{\text{FAR}}} - \mathcal{P}^{\text{old}} - \alpha h^*(\eta)^{1/\zeta} e^{\eta} \right] \lambda e^{-\lambda b} \mathrm{d}b}_{\text{When zoning is not binding}}, \tag{D.8}$$

where $\bar{b}(\eta) = \frac{h^*(\eta)}{\bar{h}^{\text{code}}} - 1$ is the lowest draw of $b$ that leaves the developer unconstrained by zoning. This expression can be more easily computed as

$$\begin{aligned} \tilde{\pi}(\eta) = \Bigg( & \frac{p(\bar{h}^{\text{code}})^{1+\beta_{\text{FAR}}} e^{\lambda}}{\lambda^{1+\beta_{\text{FAR}}}} \left[ \Gamma(2+\beta_{\text{FAR}}, \lambda) - \Gamma(2+\beta_{\text{FAR}}, (1+\bar{b}(\eta))\lambda) \right] \\ & - \alpha e^{\eta+\lambda} \left( \frac{\bar{h}^{\text{code}}}{\lambda} \right)^{1/\zeta} \left[ \Gamma(1+\frac{1}{\zeta}, \lambda) - \Gamma(1+\frac{1}{\zeta}, (1+\bar{b}(\eta))\lambda) \right] \Bigg) \\ & + \left( ph^*(\eta)^{1+\beta_{\text{FAR}}} - \alpha h^*(\eta)^{1/\zeta} e^{\eta} \right) e^{-\lambda \bar{b}(\eta)} - \mathcal{P}^{\text{old}}, \end{aligned} \tag{D.9}$$

where $\Gamma(\cdot, \cdot)$ is the incomplete gamma function. The expected profit of developers before drawing the cost shock $\eta$ is then given by

$$\tilde{\pi} = \int \tilde{\pi}(\eta) \varphi_{\sigma_\eta}(\eta) \mathrm{d}\eta, \tag{D.10}$$

which can be computed by numerical integration.

**Value function.** Equipped with a guess for the path of prices $P_{\theta nt}$ and density levels $\bar{h}_{nt}$ in each neighborhood, as well as the fixed cost parameters ($\delta$ and $\sigma$), I can compute for each parcel and year the expected profit from redevelopment (ignoring the idiosyncratic profit shocks $\epsilon$), $\pi_{it}^{\theta} = \tilde{\pi}_{it}^{\theta} - FC_{it}$, as well as the dispersion $\sigma_{it}$ of developers' idiosyncratic shocks.

In each period, the option value of deciding not to redevelop and waiting for a better redevelopment opportunity in the future is given by

$$V_{it}^{\varnothing} = \frac{1}{1+r}\Bigg\{(1 - p_i^{\text{transaction}})V_{i,t+1}^{\varnothing} + p_i^{\text{transaction}}\sigma_{i,t+1}\log\left[\exp\left(\frac{V_{i,t+1}^{\varnothing}}{\sigma_{i,t+1}}\right) + \sum_{\theta\in\theta_{i,t+1}^{\text{allowed}}\subset\{R,C\}}\exp\left(\frac{\pi_{i,t+1}^{\theta}}{\sigma_{i,t+1}}\right)\right]\Bigg\}. \tag{D.11}$$

I compute these option values iteratively. I consider that at a sufficiently distant time horizon $\bar{T}$, $\pi_{i,t}^{\theta} = \pi_{i,\bar{T}}^{\theta}$ and $\sigma_{i,t} = \sigma_{i,\bar{T}}$ for all $t > \bar{T}$. Then, $V_{it}^{\varnothing}$ is constant for $t \geq \bar{T}$ and can be computed as a fixed point of equation (D.11). Given this terminal value of $V^{\varnothing}$, I can compute the full path of continuation values using equation (D.11) again. In estimation, I set $\bar{T}$ to 2100.

**Fixed costs parameter estimation.** The probability of observing the redevelopment of parcel $i$ in year $t$ into a structure of type $\theta$ is positive only if $\theta$ is an allowed use, and, in that case, given by

$$\ell_{it}^{\theta} = \frac{\exp\left(\pi_{it}^{\theta}/\sigma_{it}\right)}{\exp\left(V_{it}^{\varnothing}/\sigma_{it}\right) + \sum_{\theta\in\theta_{it}^{\text{allowed}}\subset\{R,C\}}\exp\left(\pi_{it}^{\theta}/\sigma_{it}\right)}. \tag{D.12}$$

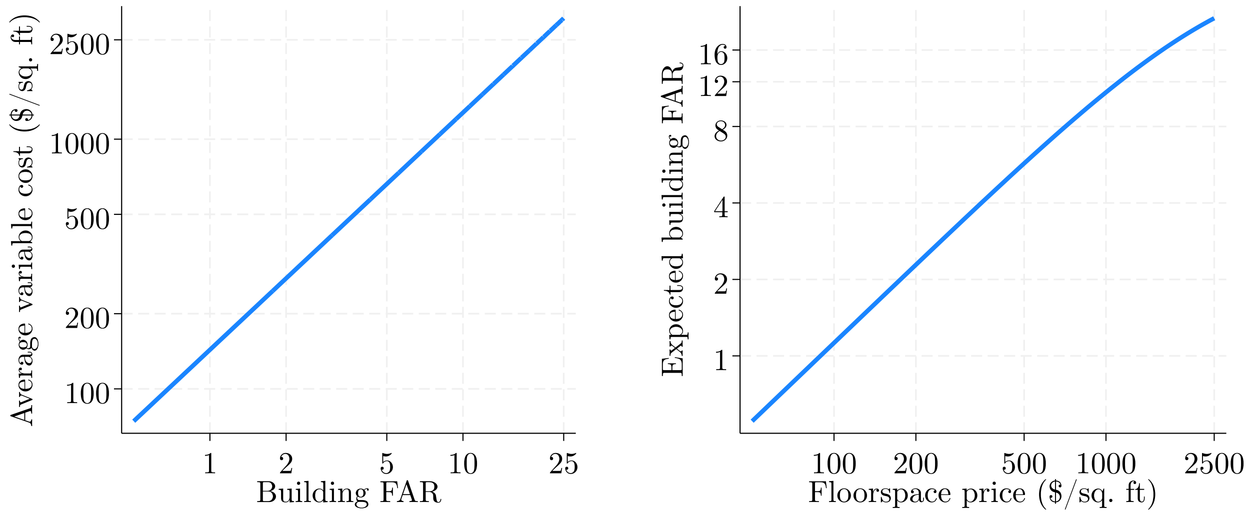
To recover fixed cost parameters, I start with an initial guess for the full path of prices and density levels. I then estimate the $\delta$ and $\sigma$ parameters using maximum likelihood. Using these parameters and the initial guess, I can predict the behavior of developers each period, compute the expected supply of floorspace over time in each neighborhood, use the demand model to estimate corresponding market-clearing rents, and compute the associated path of floorspace prices. This provides a new initial guess which I can use to repeat this procedure until all parameters have converged.

## D.3 Parameter estimates and model fit

**Figure D.1:** Estimated variable costs

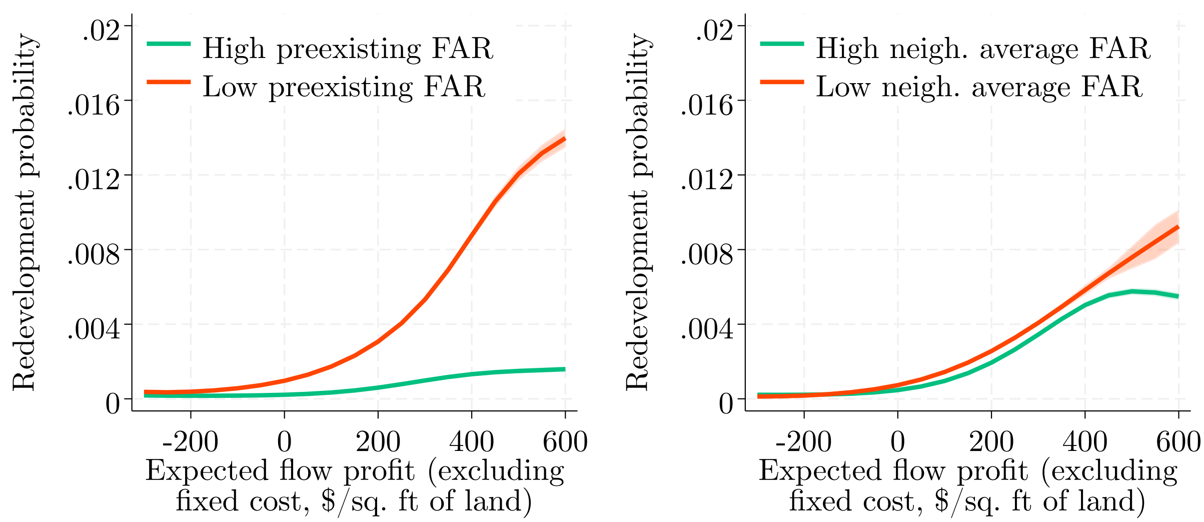
**(a)** Average variable cost per sq. ft for buildings of different FARs

**(b)** Expected FAR of new buildings as a function of floorspace prices, without zoning




*Notes*: This figure presents estimation results for variable costs. Panel (a) shows the average construction cost that a developer has to pay to build a structure at different FAR levels, and panel (b) shows the expected FAR (in the absence of zoning) of a new building for different price levels faced by developers. In both panels, I use the estimated construction costs for residential structures in Manhattan in 2019.

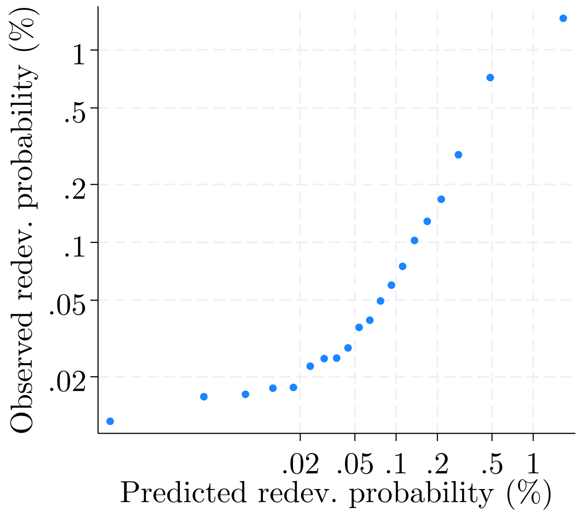
**Figure D.2:** Yearly redevelopment probabilities and expected flow profits



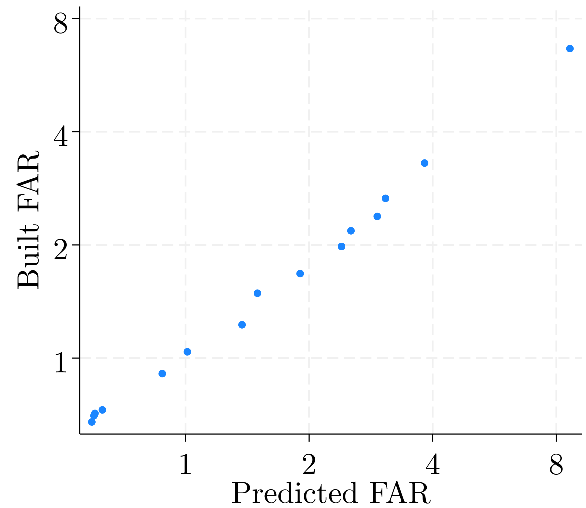

*Notes*: This figure shows observed probabilities of redevelopment as a function of the expected flow profit from the most profitable redevelopment opportunity, $\max(\tilde{\pi}_{it}^{R}, \tilde{\pi}_{it}^{C})$, where $\tilde{\pi}_{\theta it} = \mathbb{E}\left[\max_{h^{\text{new}} \leq \bar{h}_{\theta it}} \left\{\mathcal{P}_{it}(h^{\text{new}}, \mathbf{x}_{it}^{\text{new}}) - \mathcal{P}_{it}(h_i^{\text{old}}, \mathbf{x}_{it}^{\text{old}}) - VC_{\theta it}(h_{it}^{\text{new}})\right\}\right]$. In the left panel, I split parcels based on whether they have a built FAR above or below the median. In the right panel, I split parcels based on whether the average built FAR in their neighborhood is above or below the median.

**Figure D.3:** Model fit

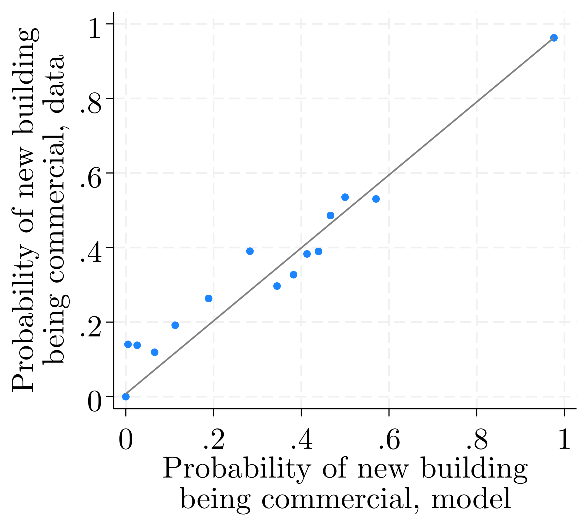
**(a)** Extensive margin: Predicted vs. observed redevelopment probabilities




**(b)** Intensive margin: Predicted vs. observed FAR of new buildings

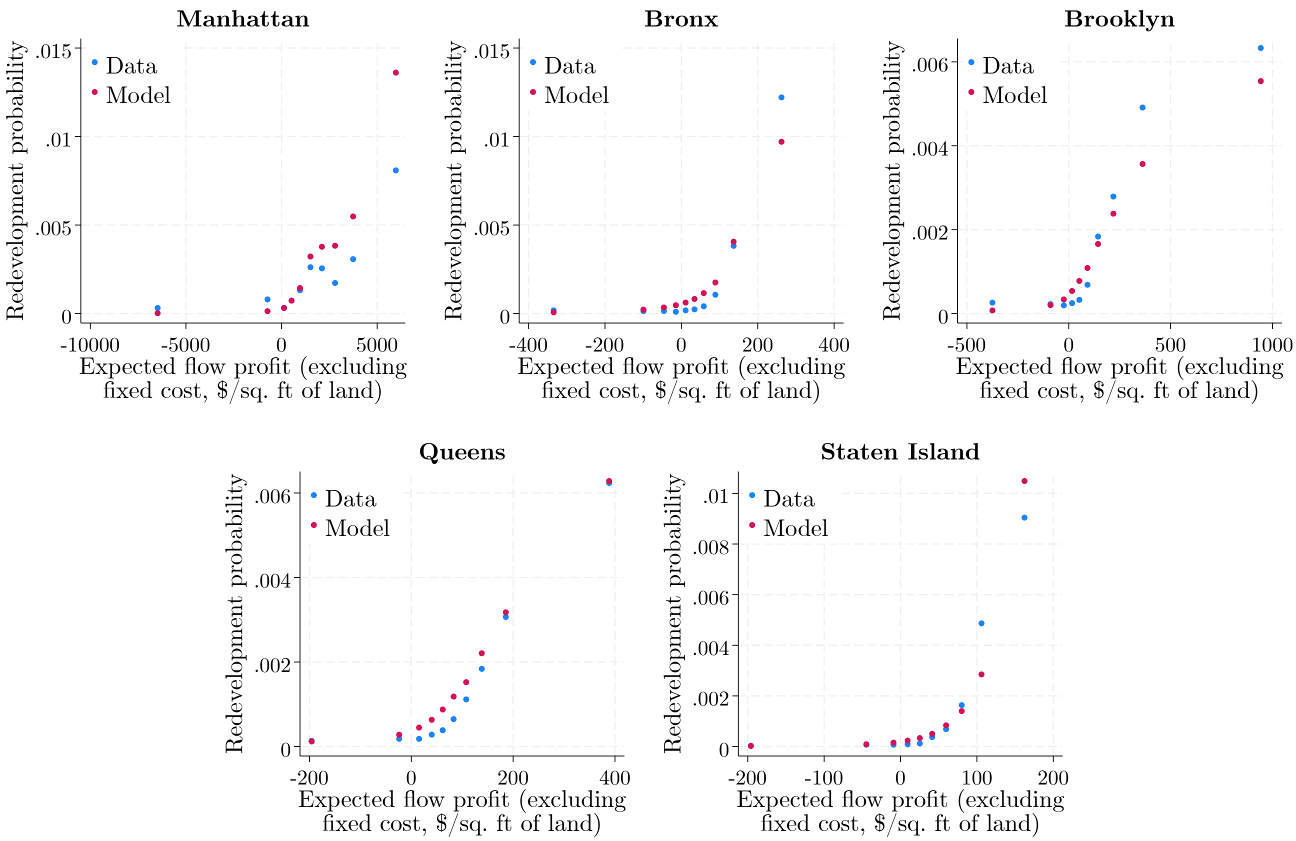



**(c)** Probability of commercial vs. residential construction



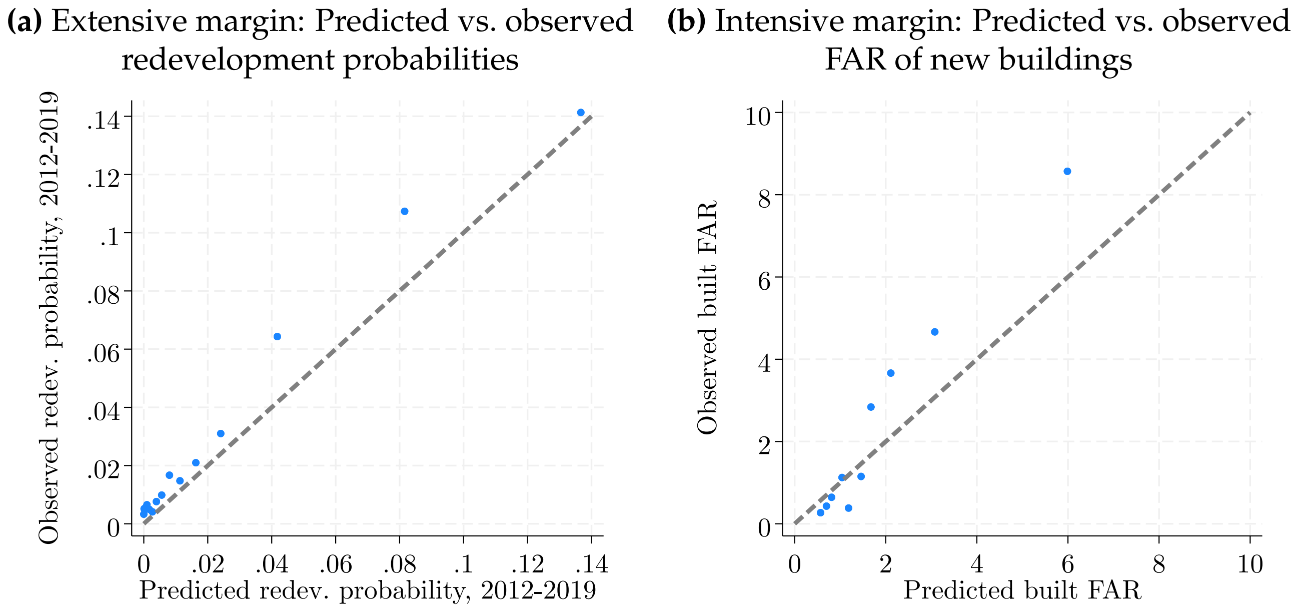

*Notes*: Panel (a) compares the model's predicted probability that a parcel will be redeveloped during a given year with the redevelopment probability observed in the data. Panel (b) compares, for buildings constructed between 2004 and 2019, the expected FAR of the structure according to the model with the observed built FAR. Panel (c) compares the model's predicted probability that a developer chooses to build a commercial structure (conditional on redevelopment) with developers' observed choices.

**Figure D.4:** Redevelopment probabilities and expected flow profits, by borough




*Notes*: This figure shows, for each borough, the probability of redevelopment (both in the data and as predicted by the model) as a function of the expected flow profit from the most profitable redevelopment opportunity, $\max(\tilde{\pi}^R_{it}, \tilde{\pi}^C_{it})$, where $\tilde{\pi}_{\theta it} = \mathbb{E}\left[\max_{h^{\text{new}} \leq \bar{h}_{\theta it}} \left\{\mathcal{P}_{it}(h^{\text{new}}, \mathbf{x}^{\text{new}}_{it}) - \mathcal{P}_{it}(h^{\text{old}}_i, \mathbf{x}^{\text{old}}_{it}) - VC_{\theta it}(h^{\text{new}}_{it})\right\}\right]$.

**Figure D.5:** Out-of-sample validation: Predicting developers' behavior over 2012–2019 using data from 2004–2011




*Notes*: This figure compares developers' observed behavior over 2012–2019 with the model's prediction, after estimating the model using data from 2004–2011 only.

**Table D.1:** Hedonic regression coefficients

| | (1) Residential | | (2) Commercial | |
|---|---|---|---|---|
| (log) Built FAR | -0.027 | (0.002) | -0.091 | (0.011) |
| (log) Unit size | -0.065 | (0.002) | -0.108 | (0.005) |
| Age | -0.002 | (0.000) | 0.000 | (0.000) |
| Rent-stabilized | -0.336 | (0.002) | | |
| Landmark | -0.078 | (0.006) | 0.087 | (0.060) |
| Grade A | 0.162 | (0.003) | 0.222 | (0.032) |
| Grade B | 0.025 | (0.002) | 0.095 | (0.019) |
| Grade C | 0.007 | (0.002) | -0.024 | (0.019) |
| Brick | -0.155 | (0.003) | -0.001 | (0.084) |
| Frame | -0.068 | (0.003) | -0.224 | (0.118) |
| Masonry | -0.156 | (0.003) | -0.071 | (0.019) |
| Office building | | | 0.147 | (0.025) |
| Retail building | | | 0.222 | (0.021) |
| Garage building | | | 0.004 | (0.025) |
| Industrial building | | | 0.030 | (0.025) |
| Hotel | | | 0.352 | (0.048) |
| Neighborhood FE | Yes | | Yes | |
| Borough $\times$ Year FE | Yes | | Yes | |
| Observations | 428,338 | | 15,795 | |

*Notes*: This table reports estimation results for the hedonic model of equation (10). Unit size corresponds to the size of the unit sold if only one unit is sold and to the average unit size if several are. Brick, Frame, and Masonry are dummies indicating the building's main construction material.

**Table D.2:** Estimation of parcel sale probabilities

| | Probit coefficients | |
|---|---|---|
| Parcel sold | | |
| Office space (% of total floorspace) | -0.076 | (0.006) |
| Retail space (% of total floorspace) | -0.018 | (0.004) |
| Garage space (% of total floorspace) | 0.000 | (0.007) |
| Storage space (% of total floorspace) | 0.033 | (0.009) |
| Factory space (% of total floorspace) | 0.001 | (0.007) |
| Hotel space (% of total floorspace) | -0.015 | (0.020) |
| Other space (% of total floorspace) | -0.327 | (0.006) |
| Condo/Coop | -0.684 | (0.008) |
| Parcel in Bronx | 0.051 | (0.003) |
| Parcel in Brooklyn | 0.038 | (0.003) |
| Parcel in Queens | 0.036 | (0.003) |
| Parcel in Staten Island | 0.023 | (0.003) |
| Constant | -1.615 | (0.003) |
| Observations | 13,156,064 | |

*Notes*: This table reports estimated coefficients of a probit regression of a dummy indicating whether a parcel was sold in a given year on parcel characteristics.

# E Demand for Floorspace: Additional Details

## E.1 Benchmark model

In this section, I calibrate a simple quantitative spatial model where agents have homogeneous skills and homothetic preferences, and where floorspace quantities are a structural residual, as in Ahlfeldt et al. (2015). These structural residuals poorly match the floorspace quantities I observe in the data, suggesting that this benchmark model fails to correctly predict household demand for floorspace in the context of NYC.

Consider a simplified version of the model presented in Section 4.2 where all agents can provide a single unit of labor and have the following utility function:

$$U_{nmo} = \frac{B_n z_{nmo}}{d_{nm}} C_{nmo}^{1-\beta} H_{nmo}^{\beta}, \tag{E.1}$$

where $z_{nmo}$ is an idiosyncratic shock, drawn from Fréchet distribution with shape $\varepsilon = 4.4$, and where all agents spend a share $\beta = 0.33$ of their income on housing. Other variables are defined as in Section 4.2.

Using data on the distribution of residents and jobs, I can calibrate the wages offered in each location as in Ahlfeldt et al. (2015) as the solution to the following system of equations:

$$L_{Cm} = \sum_n \left( \frac{(w_m/d_{nm})^{\varepsilon}}{\sum_s (w_s/d_{ns})^{\varepsilon}} L_{Rn} \right), \tag{E.2}$$

where $L_{Cm}$ denotes the number of jobs in location $m$ and $L_{Rn}$ is the number of residents of location $n$.

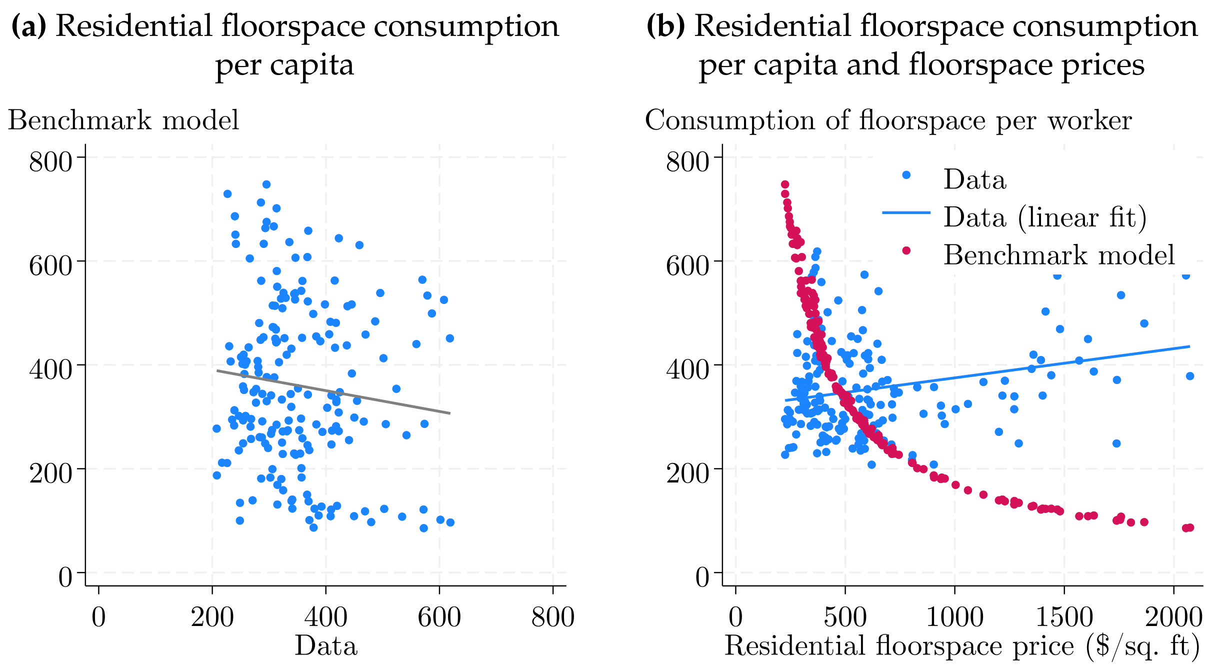
Individual incomes are only identifiable up to a constant, which I can calibrate using the total spending on housing in NYC, equal to $\beta$ times the total income of residents of the city. I can then identify the total income of residents in each location, and given the prices $\boldsymbol{R_R}$ of floorspace, I can recover the average amount of floorspace consumed by person in each location $\tilde{\boldsymbol{H}}$.

In Appendix Figure E.1, I compare this structural residual with $\boldsymbol{H}$, the average amount of floorspace per capita observed in the data. There is little correlation between $\tilde{\boldsymbol{H}}$ and $\boldsymbol{H}$. Furthermore, the structural residual $\tilde{\boldsymbol{H}}$ is much more dispersed than the floorspace consumptions observed in the data. In the upscale SoHo-Tribeca neighborhood of Manhattan, the benchmark model predicts a housing consumption of 86 sq. ft per capita, about six times lower than the average consumption of 572 sq. ft observed in the data. Conversely, in the Hunts Point neighborhood in the Bronx, where about a third of the residents live below the poverty line, the benchmark model predicts an average floorspace consumption of 663 sq. ft, more than twice the 293 sq. ft observed in the data.

These examples help understand why the benchmark model fails to accurately predict floorspace consumption in the context of NYC. In Appendix Figure E.1(b), I plot $\boldsymbol{H}$ and $\tilde{\boldsymbol{H}}$ as a function of residential floorspace prices $\boldsymbol{R_R}$. In the benchmark model, despite locations' heterogeneous access to high-wage workplaces, the average income of residents is relatively homogeneous across locations. Hence, agents' consumption of floorspace is approximately inversely proportional to residential prices. As there is wide variation in rents across neighborhoods, the consumption of floorspace varies greatly from one area to another.

In reality, per capita housing consumption is relatively homogeneous across neighborhoods and, if anything, tends to increase with residential prices. These patterns can be rationalized

**Figure E.1:** Benchmark model fit




*Notes*: This figure evaluates model fit for the benchmark model presented in Appendix Section E.1, where agents have homogeneous skill levels and homothetic preferences. In this model, the amount of residential floorspace per capita in each neighborhood is a structural residual. In panel (a), I compare this structural residual with the amount of residential floorspace observed in the data. In panel (b), I plot both variables against the price of residential floorspace.

by strongly heterogeneous skill levels and housing being a necessity good.[45] This will lead the rich to locate in expensive, high-amenity neighborhoods while poorer households will sort to cheaper, low-amenity neighborhoods. These assumptions allow the model of Section 4.2 to match the housing consumption levels I observe in the data.

## E.2 Additional model results

In this section, I derive a set of theoretical implications of the model described in Section 4.2 that allow its calibration.

**Workers' choices.** Given the timing of the idiosyncratic shocks $z_n^H$ and $z_m^W$, I can solve for workers' decisions through backward induction. Consider a worker of type $\theta$ who chose home location $n$. Upon drawing shock $z_m^W$, they choose a work location $m$ to maximize their utility. Choosing to work in location $m$ will yield them an income $I_{nm\theta} = w_m s(\theta)(1 + \mathcal{T})$, a utility level

$$U_{nm\theta} \propto B_n z_n^H z_m^W u_{nm\theta} = B_n z_n^H z_m^W \max\left\{ \frac{I_{nm\theta} - R_{Rn}\underline{H}_n}{d_{nm} R_{Rn}^{\beta}}, 0 \right\}, \tag{E.3}$$

[45] A model with two types of workers, e.g., college-educated vs. non-college-educated (as in Tsivanidis, 2019) fails to match the observed consumption patterns in NYC. Indeed, residents in the most expensive neighborhoods of NYC spend, on average, almost ten times more on housing than those in the cheapest neighborhoods of the city. A two-type model cannot explain these wide differences across neighborhoods. This is why I introduce a wider range of types, which captures the considerable heterogeneity in New Yorkers' earnings capacity.

and a housing spending

$$R_{Rn}H_{nmo} = R_{Rn}\underline{H}_n + \beta(I_{nm\theta} - R_{Rn}\underline{H}_n). \tag{E.4}$$

Workers will only commute to locations with a wage high enough to provide them with an income larger than $R_{Rn}\underline{H}_n$, and within that set of locations, the probability that they choose location $m$ is given by:

$$p_{m|n,\theta} = \frac{u_{nm\theta}^{\varepsilon^W}}{\sum_s u_{ns\theta}^{\varepsilon^W}}. \tag{E.5}$$

A worker of type $\theta$ choosing to live in location $n$ receives the following expected utility level before drawing $z_m^W$:

$$U_{n\theta} \propto B_n z_n^H u_{n\theta} = B_n z_{no}^H \left( \sum_m u_{nm\theta}^{\varepsilon^W} \right)^{1/\varepsilon^W}. \tag{E.6}$$

If a worker of type $\theta$ cannot afford $R_{Rn}\underline{H}_n$ no matter its chosen work location $m$, their expected utility $U_{n\theta}$ in that location will be equal to zero. The probability that a worker of type $\theta$ will choose to live in location $n$ is given by:

$$p_{n|\theta} = \frac{(B_n u_{n\theta})^{\varepsilon^H}}{\sum_s (B_n u_{n\theta})^{\varepsilon^H}}. \tag{E.7}$$

**Welfare.** Before drawing their idiosyncratic shocks, the expected utility of a worker of type $\theta$ is given by

$$U_\theta = \left( \sum_n \left( B_n \left( \sum_m u_{nm\theta}^{\varepsilon^W} \right)^{1/\varepsilon^W} \right)^{\varepsilon^H} \right)^{1/\varepsilon^H}. \tag{E.8}$$

Welfare gains are computed using equivalent variation. Specifically, if a worker of type $\theta$ and skill level $s(\theta)$ achieves expected utility $U_\theta^0$ in the initial equilibrium and expected utility $U_\theta^{\text{cf}}$ in the counterfactual equilibrium, then the welfare gain of this worker is given by $\Delta W_\theta = s^{\text{cf}}/s(\theta)$, where $s^{\text{cf}}$ is the skill level required in the initial equilibrium to reach an expected utility of $U_\theta^{\text{cf}}$.

The welfare effects reported in the paper (e.g., in Figure 7) correspond to the weighted average of the utility gains across worker types, $\Delta W = \int_\theta \Delta W_\theta \, \mathrm{d}F_{\text{initial}}(\theta)$, where $F_{\text{initial}}$ is the initial distribution of worker types.

The number of workers of type $\theta$ in the city, $L_\theta$, is governed by the migration elasticity $\varepsilon_M$, with $\mathrm{d}\log(L_\theta) = \varepsilon_M \, \mathrm{d}\log(\Delta W_\theta)$.

## E.3 Calibration procedure

**Worker types.** To calibrate the distribution of skill levels, I rely on the ACS. I assume that $s(\theta)$ is distributed as a Lognormal$(0, 1.2)$ truncated at the 10th percentile. This allows me to match the observed income distribution in the ACS after excluding households with an annual income below \$12,000. To facilitate computation, I approximate this continuous distribution of skill levels with 100 discrete types.

I also rely on the ACS to calibrate $\beta$. The richest households in the NYC metropolitan area spend about 10% of their income on housing, and I therefore calibrate $\beta$ to 0.1.

**Preferences for work locations.** In the absence of subsistence levels for housing $\underline{H}_n$, the probability that a worker living in $n$ will choose to work in $m$ is

$$p_{m|n} = \frac{(w_m/d_{nm})^{\varepsilon^W}}{\sum_s (w_s/d_{ns})^{\varepsilon^W}}, \tag{E.9}$$

and the share of workers $\pi_{nm}$ commuting between $n$ and $m$ is related to travel times between these locations through the following gravity equation, as in Ahlfeldt et al. (2015):

$$\log \pi_{nm} = -\nu\tau_{nm} + \vartheta_n + \varsigma_m, \tag{E.10}$$

where $\nu = \kappa\varepsilon^W$. This equation can be estimated using data on commuting flows from LODES and commuting times from Google Maps. To account for the sparsity of the commuting flows matrix, I follow Dingel and Tintelnot (2020) and estimate equation (E.10) through PPML. I find a commuting elasticity $\nu$ approximately equal to 0.044. Assuming that the commuting cost parameter $\kappa$ equals 0.01 as in Ahlfeldt et al. (2015), I set $\varepsilon^W$ to 4.4.

The presence of subsistence levels $\underline{H}_n$ distorts agents' choices of work locations and makes equation (E.10) no longer hold. However, this distortion induced by non-homothetic preferences is minimal. After calibrating $\varepsilon^W$ to 4.4 and other parameters using the procedure laid out below, I can predict commuting flows $\tilde{\pi}_{nm}$ between locations. Estimating equation (E.10) using $\tilde{\pi}_{nm}$ instead of $\pi_{nm}$ yields an estimated coefficient of 0.0441, instead of the 0.044 that would be estimated when the subsistence levels $\underline{H}_n$ are set to zero. This justifies estimating $\nu$ using equation (E.10) despite it not strictly holding in the model.

**Preferences for home locations.** Then, I calibrate the dispersion of idiosyncratic preferences for home locations $\varepsilon^H$, the subsistence levels of housing $\underline{\boldsymbol{H}}$, amenity levels $\boldsymbol{B}$, and wages $\boldsymbol{w}$. To facilitate estimation, I introduce $\tilde{\boldsymbol{w}} = \boldsymbol{w}/\left(\prod w_m\right)^{1/S}$, a normalized vector of wages such that the geometric mean of $\tilde{\boldsymbol{w}}$ is one, and an income normalization parameter $\mathcal{I}$ such that the income of a worker of type $\theta$ working in location $m$ is $I_{nm\theta} = \mathcal{I} \cdot s(\theta)\tilde{w}_m$. To calibrate these parameters, I use the following iterative procedure:

1. Start with an initial guess for the parameters $\varepsilon^H$, $\underline{\boldsymbol{H}}$, $\boldsymbol{B}$, $\tilde{\boldsymbol{w}}$, and $\mathcal{I}$, as well as for the distribution of types among the residents of each location.

2. The guessed parameters imply a distribution of work locations through equation (E.5). Increasing the wage in a location increases the number of people working there. I update $\tilde{\boldsymbol{w}}$ until I match the number of jobs in each location reported by LODES, keeping the geometric mean of $\tilde{\boldsymbol{w}}$ normalized to one.

3. The guessed parameters imply a distribution of home locations through equation (E.7). Increasing the amenity level in a location increases the number of people living there. I update $\boldsymbol{B}$ until I match the number of residents in each location reported by LODES. $\boldsymbol{B}$ is only identified up to a constant, and I therefore normalize its geometric mean to one.

4. The guessed parameters imply a total spending on housing in each neighborhood through equation (E.4). Increasing the subsistence housing level $\underline{H}$ in a location increases the

housing spending in that location. I update $\underline{\boldsymbol{H}}$ until the total expenditure on housing in each neighborhood $\boldsymbol{R_R} \circ \boldsymbol{H_R}$ in the data is matched. At each update of $\underline{\boldsymbol{H}}$, I update the guess of the distribution of types in each location using equation (E.7), as well as the guess of wages and amenities by going through steps (2) and (3).

5. The guessed parameters imply a distribution of the share of income spent on housing $r_R H/I$. Increasing the income normalization parameter $\mathcal{I}$ decreases the average share of income spent on housing. I update $\mathcal{I}$ until the average worker spends 33% of their income on housing, which corresponds to the average spending on housing observed in the ACS. At each update of $\mathcal{I}$, I iterate through steps (2)–(4) to concurrently update wages, amenities, and subsistence levels.

6. The guessed parameters imply a distribution of the average income level in each neighborhood. Increasing $\varepsilon^H$ decreases the heterogeneity in workers' idiosyncratic preferences for home locations, leads to a stronger sorting of high-skill workers to high-amenity locations, and increases the dispersion of neighborhoods' average income. I update $\varepsilon^H$ until the standard deviation of neighborhoods' (log) average per capita income matches that observed in the ACS (of 0.51). For each update of $\varepsilon^H$, I iterate through steps (2)–(5) to concurrently update wages, amenities, subsistence levels, and the income normalization parameter.

7. Once the parameters $\varepsilon^H, \underline{\boldsymbol{H}}, \boldsymbol{B}, \tilde{\boldsymbol{w}}$, and $\mathcal{I}$ are calibrated, I can compute the total income of workers $I_{\text{total}}$. That income is the sum of total wage income $I_{\text{wages}}$ and total income from rents, $I_{\text{rents}} = \sum_n (R_{Rn} H_{Rn} + R_{Cn} H_{Cn})$, which is observable in the data. I can recover $\mathcal{T} = I_{\text{rents}}/I_{\text{wages}} = I_{\text{rents}}/(I_{\text{total}} - I_{\text{rents}})$. Knowing $\mathcal{T}$ then allows me to recover the vector of (non-normalized) wages, as $w_m = (\mathcal{I}\tilde{w}_m)/(1+\mathcal{T})$.

**Productivities and floorspace shares.** Once wages and other parameters describing workers' preferences have been calibrated, I can compute the effective labor supply $\boldsymbol{L_C^{\text{eff}}}$ provided in each location and infer the importance $\boldsymbol{\alpha}$ of floorspace in production through the share of floorspace in firms' costs in each location:

$$\alpha_m = \frac{R_{Cm} H_{Cm}}{R_{Cm} H_{Cm} + w_m L_{Cm}^{\text{eff}}}. \tag{E.11}$$

Finally, the productivity of each location can be inferred as

$$A_m = \frac{w_m}{1-\alpha_m} \left( \frac{L_{Cm}^{\text{eff}}}{H_{Cm}} \right)^{\alpha_m}. \tag{E.12}$$

**Spillover parameters and location fundamentals.** After recovering the endogenous productivities $\boldsymbol{A}$ and amenities $\boldsymbol{B}$, I calibrate the spillover parameters $\boldsymbol{\gamma}$ to match the measured demand elasticities $\boldsymbol{\varepsilon}$. This allows me to recover fundamental productivities as $\bar{A}_m = A_m/(\tilde{L}_{Rm}^{\gamma_{RC}} \tilde{L}_{Cm}^{\gamma_{CC}})$ and fundamental amenities as $\bar{B}_n = B_n/(\tilde{L}_{Rn}^{\gamma_{RR}} \tilde{L}_{Cn}^{\gamma_{CR}})$. Specifically, I use the following calibration procedure:

1. Guess a vector of spillover parameters $\boldsymbol{\gamma}$ and compute the fundamental productivities and amenities it implies.

2. Using the procedure described in Appendix Section F.1, compute the price effects of increasing the amount of residential floorspace in each neighborhood $n$, and infer local demand elasticities $\varepsilon^{\text{sim}}_{RR,n} = \mathrm{d}\log(R_{Rn})/\mathrm{d}\log(H_{Rn})$ and $\varepsilon^{\text{sim}}_{RC,n} = \mathrm{d}\log(R_{Cn})/\mathrm{d}\log(H_{Rn})$. Compute the average local demand elasticities $\varepsilon^{\text{sim}}_{RR}$ and $\varepsilon^{\text{sim}}_{RC}$ by averaging values of $\varepsilon^{\text{sim}}_{RR,n}$ and $\varepsilon^{\text{sim}}_{RC,n}$ over all neighborhoods $n$ in which the large construction events included in the event study of Figure 6 took place. Symmetrically, by computing the price effects of increasing the amount of commercial floorspace in each neighborhood, find $\varepsilon^{\text{sim}}_{CR}$ and $\varepsilon^{\text{sim}}_{CC}$.

3. If the vector $\boldsymbol{\varepsilon}^{\text{sim}}$ does not match the estimated $\boldsymbol{\varepsilon}$, return to step (1) using a new guess for $\boldsymbol{\gamma}$.

**Outside location.** I estimate the demand model using NYC's partition into 188 Neighborhood Tabulation Areas (NTAs), corresponding to historical neighborhoods of the city (e.g., Chinatown, Hamilton Heights). NYC defines seven additional NTAs that correspond to parks, cemeteries, airports, and Rikers Island—these neighborhoods and the parcels within them are excluded from estimation. I add to the model an outside location corresponding to the rest of the metropolitan area, which workers in the model can commute to and from. LODES indicates the number of workers living and working in this additional location, but I do not have data on the supply or price of floorspace there. I set the initial amount of residential (resp., commercial) floorspace in the outside location such that the amount of floorspace per worker (resp., per job) is at the same level as in NYC's outer boroughs. Furthermore, I set the price of floorspace in this outside location to the average price of residential floorspace in the city's outer boroughs. In counterfactual simulations, I assume the supply of floorspace in the outer location grows at the same rate as within the boundaries of NYC.

## E.4 Welfare changes decomposition

To understand where the welfare gains from relaxing zoning stem from, I express the equivalent variation $\Delta W_\theta$ (the percentage increase in income that would be needed in the initial equilibrium to reach the utility level attained in a counterfactual) as a function of housing costs $\boldsymbol{R_R}$, wages $\boldsymbol{w}$, amenities $\boldsymbol{B}$, rental income $I_{\text{rents}}$, and commuting times $\boldsymbol{\tau}$.

For a worker of type $\theta$, the total welfare change between the status quo scenario and the no-zoning scenario (reported in Figure 9) is given by

$$\Delta W_\theta^{\text{NZ-SQ}} = \Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{NZ}}, I^{\text{NZ}}_{\text{rents}}, \boldsymbol{\tau}^{\text{NZ}}) - \Delta W_\theta(\boldsymbol{R_R}^{\text{SQ}}, \boldsymbol{w}^{\text{SQ}}, \boldsymbol{B}^{\text{SQ}}, I^{\text{SQ}}_{\text{rents}}, \boldsymbol{\tau}^{\text{SQ}}),$$

Where variables with an NZ superscript refer to 2060 values for the no-zoning scenario, and those with an SQ superscript refer to 2060 values for the status quo scenario. This welfare change can be decomposed as:

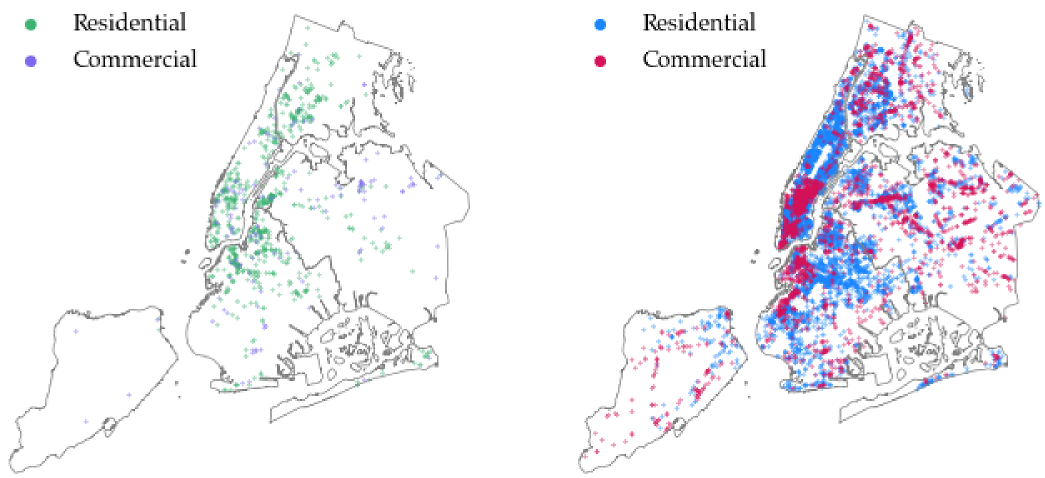
$$\begin{aligned}
\Delta W_\theta^{\text{NZ-SQ}} = & \underbrace{\Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{SQ}}, \boldsymbol{B}^{\text{SQ}}, I_{\text{rents}}^{\text{SQ}}, \boldsymbol{\tau}^{\text{SQ}}) - \Delta W_\theta(\boldsymbol{R_R}^{\text{SQ}}, \boldsymbol{w}^{\text{SQ}}, \boldsymbol{B}^{\text{SQ}}, I_{\text{rents}}^{\text{SQ}}, \boldsymbol{\tau}^{\text{SQ}})}_{\text{Effect of lower housing costs}} \\
& + \underbrace{\Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{SQ}}, I_{\text{rents}}^{\text{SQ}}, \boldsymbol{\tau}^{\text{SQ}}) - \Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{SQ}}, \boldsymbol{B}^{\text{SQ}}, I_{\text{rents}}^{\text{SQ}}, \boldsymbol{\tau}^{\text{SQ}})}_{\text{Effect of higher wages}} \\
& + \underbrace{\Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{NZ}}, I_{\text{rents}}^{\text{SQ}}, \boldsymbol{\tau}^{\text{SQ}}) - \Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{SQ}}, I_{\text{rents}}^{\text{SQ}}, \boldsymbol{\tau}^{\text{SQ}})}_{\text{Effect of higher amenities}} \\
& + \underbrace{\Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{NZ}}, I_{\text{rents}}^{\text{NZ}}, \boldsymbol{\tau}^{\text{SQ}}) - \Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{NZ}}, I_{\text{rents}}^{\text{SQ}}, \boldsymbol{\tau}^{\text{SQ}})}_{\text{Effect of higher rental income}} \\
& + \underbrace{\Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{NZ}}, I_{\text{rents}}^{\text{NZ}}, \boldsymbol{\tau}^{\text{NZ}}) - \Delta W_\theta(\boldsymbol{R_R}^{\text{NZ}}, \boldsymbol{w}^{\text{NZ}}, \boldsymbol{B}^{\text{NZ}}, I_{\text{rents}}^{\text{NZ}}, \boldsymbol{\tau}^{\text{SQ}})}_{\text{Effect of higher commuting times}}.
\end{aligned}$$

Appendix Figure G.15 presents the result of this decomposition exercise.

## E.5 Estimation of spillover parameters: Additional results

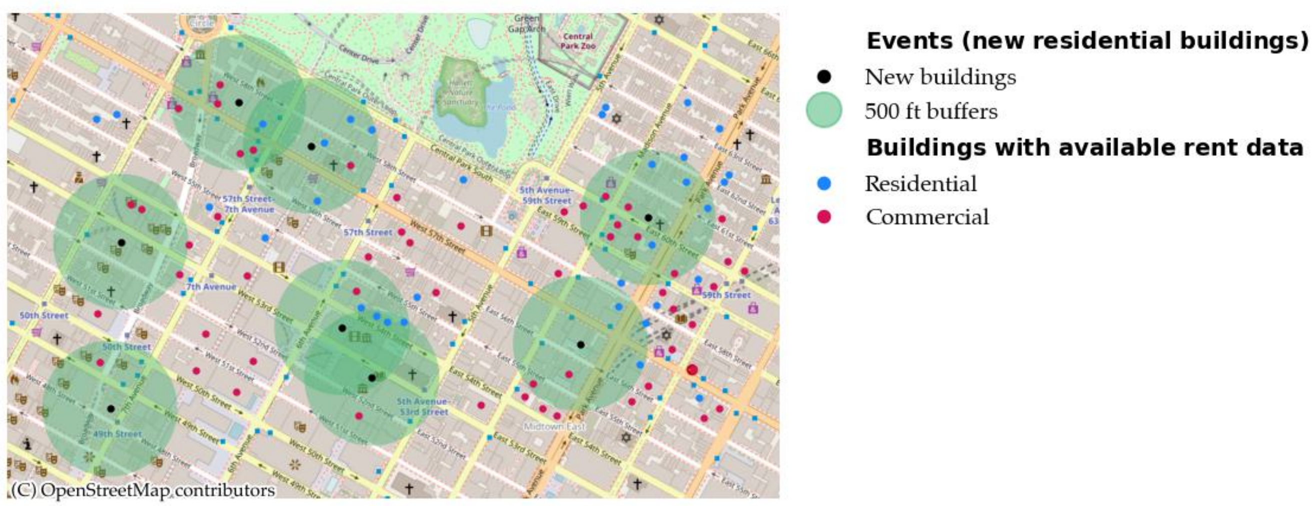
**Figure E.2:** Location of large construction events and buildings with rent data

**(a)** Construction events **(b)** Buildings with rent data




*Notes*: Panel (a) shows the locations of the large new construction events leveraged in the event studies of Figure 6. Panel (b) shows the locations of buildings for which rent data is available over 2004–2021 and that are not rent-stabilized.

**Figure E.3:** Examples of residential construction events and associated buffers

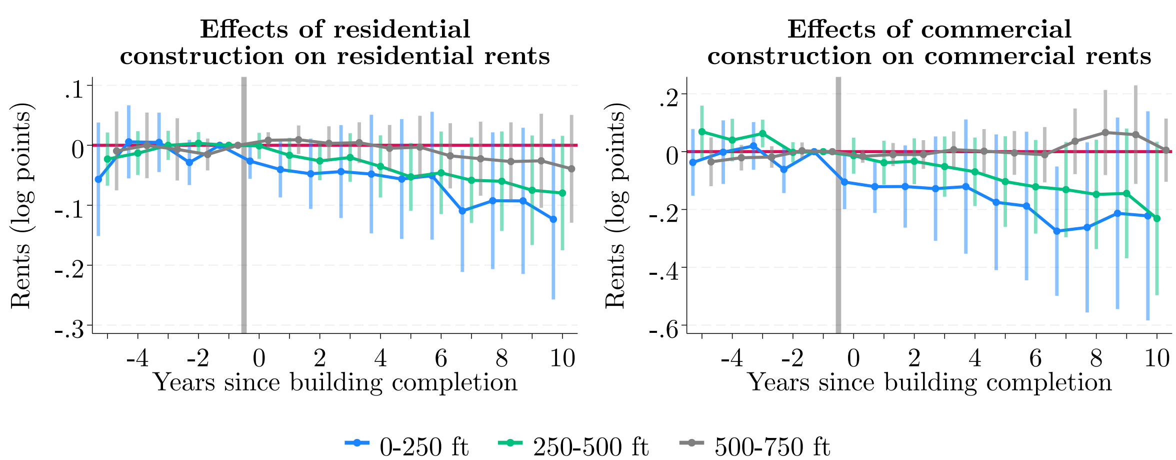



*Notes*: This figure illustrates the methodology underlying the event studies of Figure 6 in a section of Midtown Manhattan. The black dots correspond to the large residential construction projects used as events. The green disks correspond to 500 ft buffers around new buildings. The blue (resp., red) dots correspond to residential (resp., commercial) buildings for which we have data on rents from NOPVs. Rent-stabilized buildings are excluded. In dense areas of the city like the one pictured here, some of the 500 ft buffers used in event studies overlap. Appendix Figure E.4 shows the sensitivity of the event study results to including these overlapping events.

**Figure E.4:** Robustness to including overlapping buffers

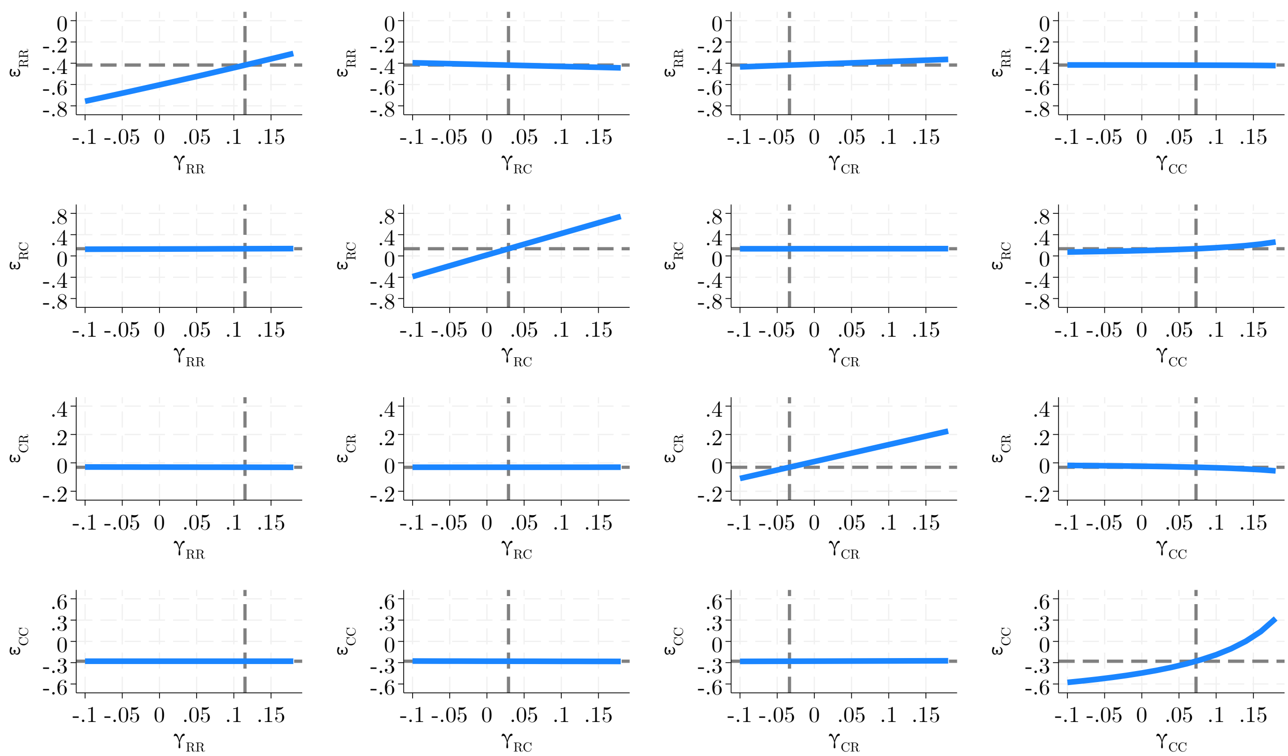

*Notes*: This figure shows the estimates of Figure 6 (in blue) as well as analog estimates when including in the set of new building events those located within 500 ft of another event (in green).

**Figure E.5:** Spatial decay of price effects




*Notes*: The left (resp., right) panel shows the effects of new residential (resp., commercial) construction on residential (resp., commercial) rents, measured at different distances from the studied event. In blue, I show effects on rents measured within 250 ft of the new building; in green, I show effects on rents measured between 250 and 500 ft of the new building; and in gray, I show effects on rents measured between 500 and 750 ft of the new building.

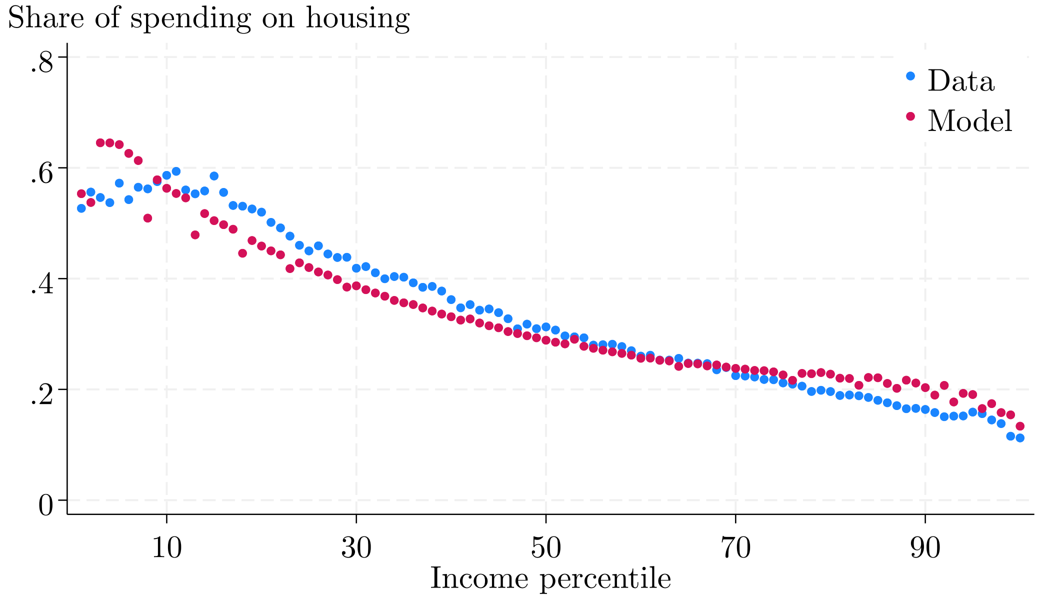
**Figure E.6:** Sensitivity of reduced-form elasticities to spillover parameters




*Notes*: This figure shows how, in the model, the reduced-form parameters $\varepsilon_{RR}, \varepsilon_{RC}, \varepsilon_{CR}$, and $\varepsilon_{CC}$, describing the elasticity of residential/commercial rents in a neighborhood to the supply of residential/commercial floorspace there, vary with the spillover parameters $\gamma_{RR}, \gamma_{RC}, \gamma_{CR}$, and $\gamma_{CC}$, which determine how amenity/productivity levels in a neighborhood vary with the density of workers/jobs there. In each panel, I show how an $\varepsilon$ parameter varies with the values of a $\gamma$ parameter, keeping the values of the other spillover parameters at their baseline value (indicated by the vertical dashed lines). The values of the $\varepsilon$ parameters estimated in Figure 6 are denoted by the horizontal dashed lines.

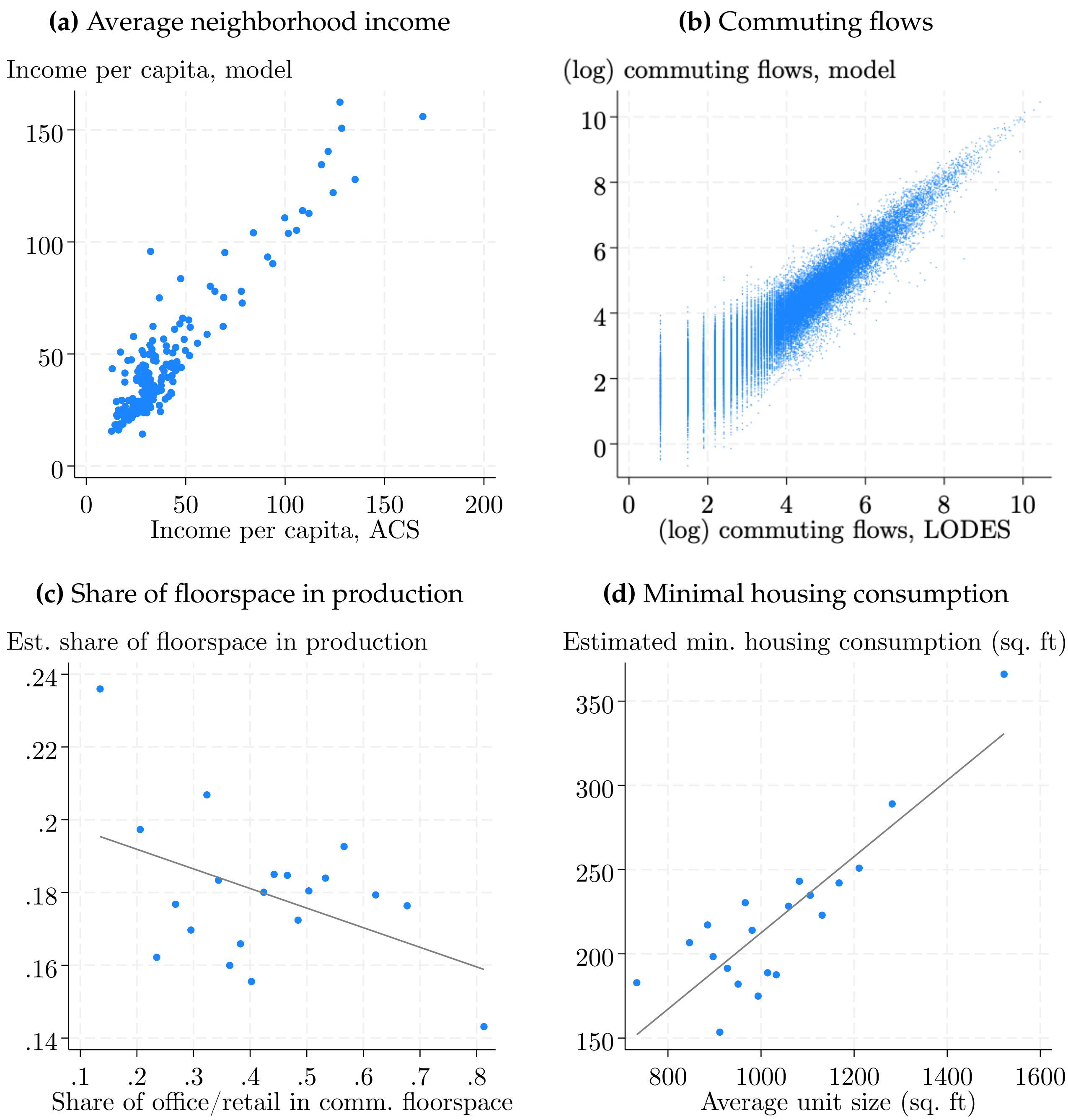
## E.6 Parameter estimates and model fit

**Figure E.7:** Engel curve for housing




*Notes*: This figure shows the share of income spent on housing at different percentiles of the income distribution, in the model and the NYC metropolitan area sample of the 2019 5-year ACS.

**Figure E.8:** Demand model fit




*Notes*: Panel (a) compares the average neighborhood income in the model with that in the ACS. Panel (b) compares commuting flows in the model with those reported in LODES. Panel (c) compares the estimated share of floorspace in production in each neighborhood ($\alpha$ in the model) with the share of commercial floorspace that is used for office or retail uses (as opposed to garage, storage, factory, or other commercial uses), reported in the PLUTO dataset. Panel (d) compares the estimated minimal amount of housing consumption in each neighborhood ($\underline{H}$ in the model) with the average size of residential units reported in the PLUTO dataset.

**Table E.1:** Correlation between model-derived amenities and survey-reported neighborhood satisfaction levels

| **Amenity** | **Correlation between share of satisfied residents and** $B$ |
|---|---|
| Neighborhood cleanliness | 0.47 |
| Control of street noise | 0.07 |
| Household garbage pick-up | 0.33 |
| Recycling services | 0.34 |
| Snow removal | 0.77 |
| Rat control | 0.36 |
| Bike safety | 0.25 |
| Pedestrian safety | 0.53 |
| Street maintenance | 0.53 |
| Parking enforcement | 0.74 |
| Storm water drainage and sewer maintenance | 0.57 |
| Availability of healthcare services | 0.52 |
| Availability of cultural activities | 0.60 |
| Neighborhood parks | 0.86 |
| Fire protection services | 0.75 |
| Emergency medical services | 0.73 |
| Neighborhood public safety | 0.66 |
| Bus services | 0.66 |
| Subway services | 0.71 |
| Public services | 0.63 |

*Notes*: This table compares calibrated amenities $\boldsymbol{B}$ with residents' satisfaction with 20 neighborhood characteristics, as measured in the 2017 Resident Survey conducted by the Citizens Budget Commission. I consider residents satisfied with an amenity if they rate it as "good" or "excellent" in their neighborhood. Survey results are available at the Community District level, a coarser geography than the Neighborhood Tabulation Areas used in the model. Therefore, I aggregate model-derived amenities $B$ at the Community District level to compare them with survey results.

# F Computational Details

In this section, I describe the algorithm used to compute a dynamic equilibrium of the model. In Appendix F.1, I start by describing how I find an equilibrium of the demand model for any set of floorspace supplies. This algorithm is used to find an equilibrium path of floorspace supplies and prices, using a procedure described in Appendix F.2. Finally, Appendix F.3 discusses the issue of multiple equilibria.

## F.1 Finding an equilibrium of the demand model

In counterfactual simulations, I need to characterize static equilibrium in each period. I.e., given values of $\boldsymbol{H_R}$ and $\boldsymbol{H_C}$ (the quantities of floorspace that vary from year to year), I need to compute equilibrium values of $\{L, \mathbf{L_R}, \mathbf{L_C}, \boldsymbol{R_R}, \boldsymbol{R_C}, \boldsymbol{\tau}, \mathbf{w}, \mathcal{T}\}$. To do so, I use the following procedure:

1. Start with a guess for the equilibrium objects $\{L, \mathbf{L_R}, \mathbf{L_C}, \boldsymbol{R_R}, \boldsymbol{R_C}, \mathbf{w}, \mathcal{T}\}$.
2. Compute the travel time matrix $\boldsymbol{\tau}$, with $\tau_{nm} = \tau_{nm}^{2019} \left( \frac{\mathcal{L}}{\mathcal{L}^{2019}} \right)^{\varepsilon_C}$, where $\mathcal{L} = \sum_\theta L(\theta)$ is the total number of workers in the city in the counterfactual, $\mathcal{L}^{2019}$ is the total number of workers in the city in the initial equilibrium, $\tau_{nm}^{2019}$ is the observed travel time between $n$ and $m$, and $\varepsilon_C$ is the congestion elasticity.
3. Compute the density of workers $\tilde{L}_{Rn}$ and jobs $\tilde{L}_{Cn}$ in each neighborhood using $L_{Rn}$, $L_{Cn}$, and $K_n$ (the land area of neighborhood $n$). Compute the implied productivity levels $A_m = \bar{A}_m \tilde{L}_{Rm}^{\gamma_{\text{RC}}} \tilde{L}_{Cm}^{\gamma_{\text{CC}}}$ and amenity levels $B_n = \bar{B}_n \tilde{L}_{Rn}^{\gamma_{\text{RR}}} \tilde{L}_{Cn}^{\gamma_{\text{CR}}}$.
4. For each type $\theta$, compute the distribution of workers' home locations using equation (E.7). Update the total number of workers in each location $\boldsymbol{L_R}$ accordingly.
5. Evaluate commuting flows using equation (E.5). Update accordingly the total number of jobs in each location, $\boldsymbol{L_C}$. Compute the number of effective units of labor supplied in each location as $L_{Cm}^{\text{eff}} = \sum_\theta \sum_n \left[ L(\theta) p_{n|\theta} p_{m|n,\theta} \right] s(\theta)$. Then, compute the aggregate demand for commercial floorspace $\boldsymbol{H_C^d}$, with $H_{Cm}^d = L_{Cm}^{\text{eff}} \left( \frac{w_m}{(1-\alpha_m) A_m} \right)^{1/\alpha_m}$.
6. Using the distribution of types in each location and commuting probabilities, compute the income distribution of workers in each location, and, using equation (E.4), the total amount spent on housing in each location. Dividing this total spending by rent levels $\boldsymbol{R_R}$, compute the aggregate demand for residential floorspace $\boldsymbol{H_R^d}$.
7. Update the vector of wages $\boldsymbol{w}$, with $w_m = (1-\alpha_m) A_m \left( \frac{H_{Cm}}{L_{Cm}^{\text{eff}}} \right)^{\alpha_m}$.
8. Update the vector of commercial floorspace prices $\boldsymbol{R_C}$, with $R_{Cm} = \alpha_m A_m \left( \frac{L_{Cm}^{\text{eff}}}{H_{Cm}} \right)^{1-\alpha_m}$.
9. Update the vector of residential floorspace prices $\boldsymbol{R_R}$ by increasing (resp., decreasing) rents if the demand for residential floorspace $\boldsymbol{H_R^d}$ is over (resp., below) its supply $\boldsymbol{H_R}$.
10. Compute the total rental income stream $I_{\text{rents}} = \boldsymbol{H_R} \cdot \boldsymbol{R_R} + \boldsymbol{H_C} \cdot \boldsymbol{R_C}$. Update the non-wage income redistribution parameter $\mathcal{T} = I_{\text{rents}} / I_{\text{wages}}$.

11. If the demand for floorspace ($\boldsymbol{H_R^d}$, $\boldsymbol{H_C^d}$) does not match its supply ($\boldsymbol{H_R}$, $\boldsymbol{H_C}$), return to step (3) with the updated values of $\{\mathbf{L_R}, \mathbf{L_C}, \boldsymbol{R_R}, \boldsymbol{R_C}, \mathbf{w}, \mathcal{T}\}$.

12. Compute workers' expected utility using equation (E.8). Comparing it with the 2019 expected utilities, compute welfare changes $\Delta W_\theta$ for each type $\theta$. Compute a new population distribution $L^{\text{new}}(\theta) = \frac{1}{2}\left[L^{2019}(\theta)\exp\left(\varepsilon_M \log(\Delta W_\theta)\right) + L(\theta)\right]$, where $L^{2019}(\theta)$ is the 2019 population distribution. If $L^{\text{new}}(\theta)$ and $L(\theta)$ coincide, then $\{L, \mathbf{L_R}, \mathbf{L_C}, \boldsymbol{R_R}, \boldsymbol{R_C}, \mathbf{w}, \mathcal{T}\}$ is an equilibrium. Else, return to step (2) using $L^{\text{new}}$ as a new value for $L$.

## F.2 Dynamic equilibrium

To find an equilibrium path of the evolution of the city, I use the following procedure:

1. Start with an initial guess for the paths of prices $(\boldsymbol{P_R}, \boldsymbol{P_C})$ and average FAR levels in each neighborhood.

2. For each parcel:

   (a) Compute the value of the existing structure, per sq. ft of land, for each year.

   (b) Compute the expected profits from redevelopment (excluding fixed costs) in each year, using equations (D.9) and (D.10).

   (c) Compute the fixed costs of redevelopment in each year, given by equation (6), and the expected profits from redevelopment, inclusive of fixed costs.

   (d) Compute for each year the option value of redeveloping in the future, using equation (D.11).

   (e) Compute redevelopment probabilities in each year using equation (D.12).

   (f) Compute expected built FARs conditional on redevelopment using equation (D.6).

   (g) Given redevelopment probabilities and expected built FARs for each year, compute the expected FAR of the parcel over time, as well as its expected supply of quality-adjusted floorspace.

3. Aggregating over parcels, find the expected supply of (quality-adjusted) residential and commercial floorspace in each neighborhood and year, as well as the average FAR of buildings, which enters the expression for fixed costs in equation (6).

4. For each year, solve for the static equilibrium using the procedure of Appendix F.1. In particular, recover the path of rents in each neighborhood. Compute prices as the discounted sum of rents.

5. If the recovered path of prices coincides with the initial guess, the computed allocation is a dynamic equilibrium of the model. Otherwise, return to step (2) using a new guess for the paths of prices, and the result of step (3) for the evolution of average FARs across neighborhoods.

## F.3 Multiple equilibria

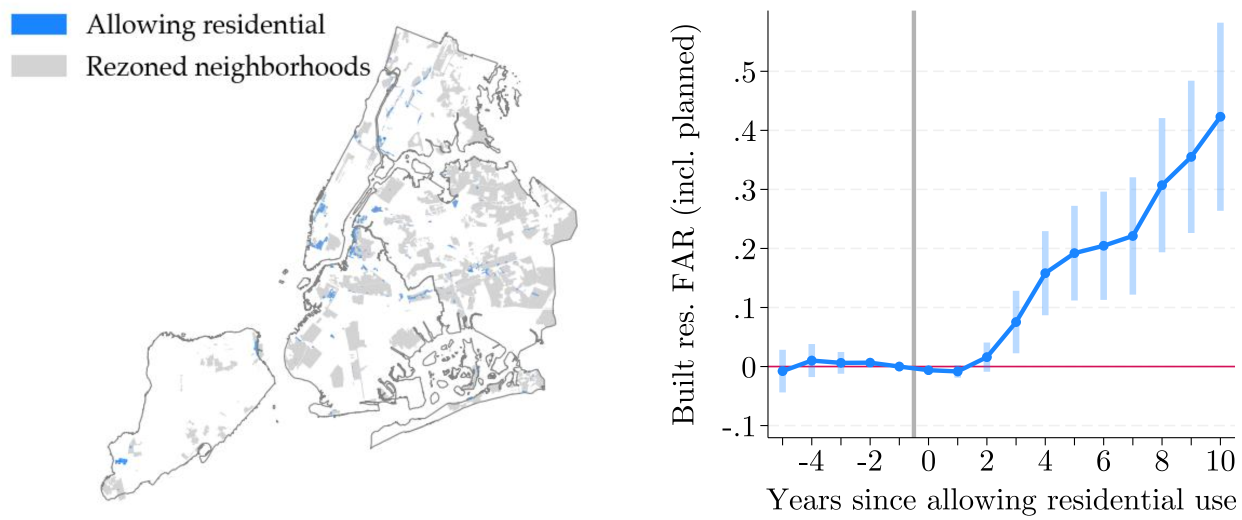
The presence of agglomeration externalities raises the potential issue of multiple equilibria. In each time period, there could be multiple population distributions and rent levels that constitute an equilibrium. Furthermore, even if the static demand model solved each period always had unique equilibria, several paths of prices and development could potentially be sustained in equilibrium. For instance, if developers expect high future prices in a neighborhood, they will build more there, attracting more economic activity. With strong agglomeration forces, this can indeed lead to high prices. Conversely, under more pessimistic expectations, prices and development might remain at a lower equilibrium level.

To investigate the importance of multiple equilibria in my model, I follow Bayer and Timmins (2005) and Almagro, Chyn and Stuart (2024) and compute equilibrium allocations using various starting values for the solving algorithm. Specifically, I initialize the solver with extreme values, which increases the likelihood of discovering multiple equilibria. Using this procedure, I do not find evidence of multiple equilibria, either in the static demand model solved each period or in the dynamic model.

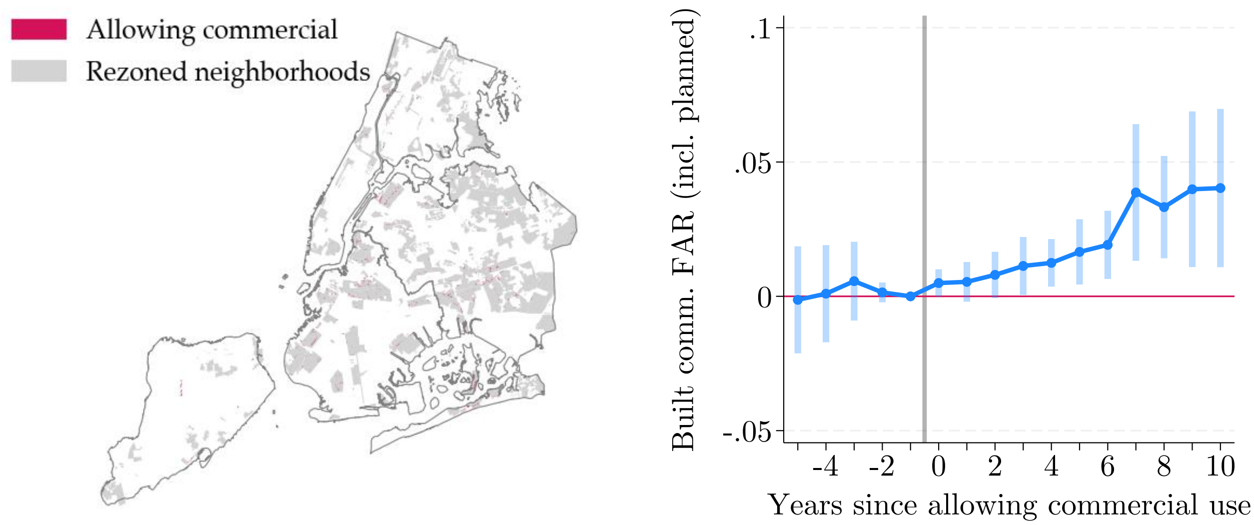
# G Additional Results

**Figure G.1:** Effects of rezonings allowing previously disallowed land uses

**(a)** Allowing residential uses

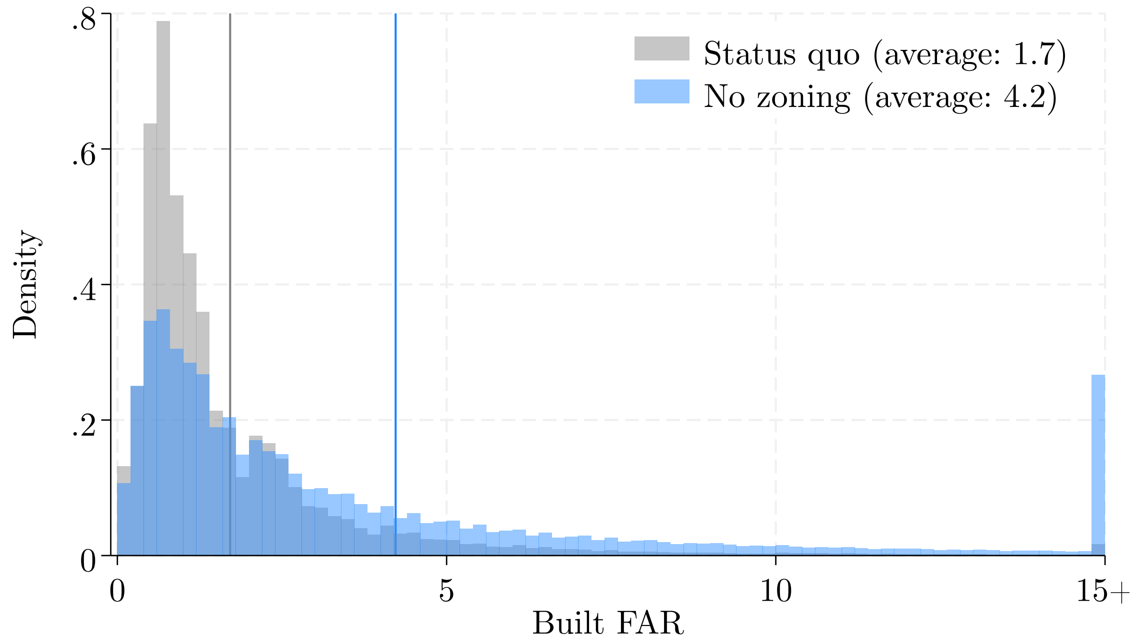



**(b)** Allowing commercial uses



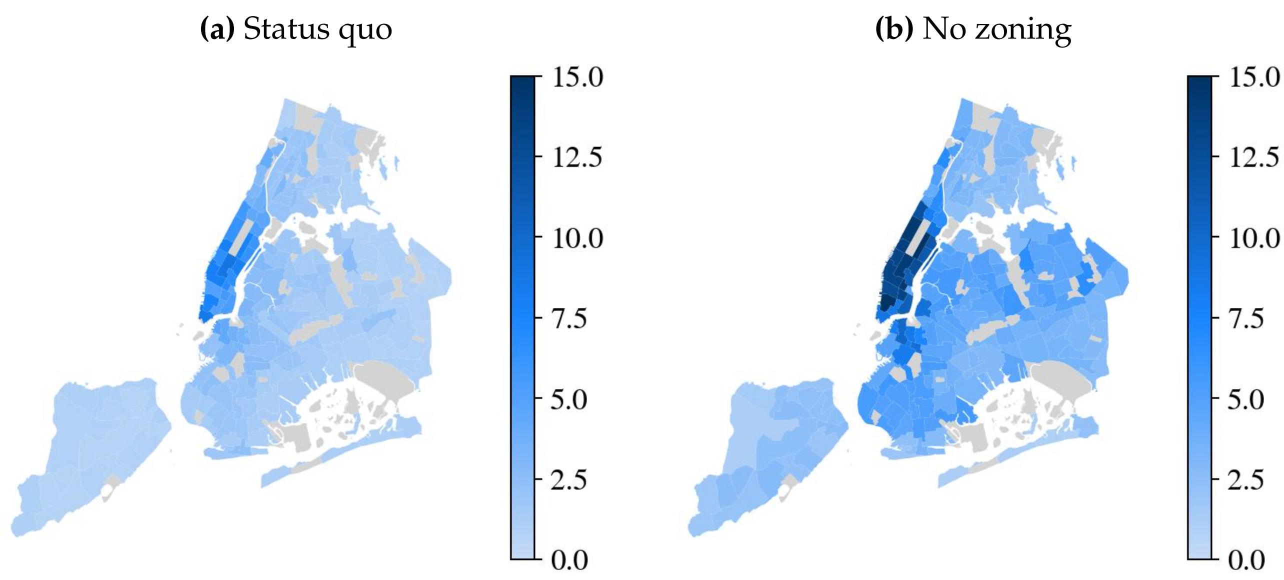

*Notes*: This figure shows the effects of rezonings allowing a previously disallowed use. The estimation sample comprises parcels within large rezonings for which allowed uses changed. Panel (a) (resp., b) focuses on parcels for which a rezoning allowed a previously disallowed residential (resp. commercial) use. The parcels in the estimation sample are mapped on the left panels, along with the large rezonings that took place in NYC between 2004 and 2022. The right panels show the effect of rezoning on the built residential and commercial FAR (including the planned floorspace of buildings under construction). Treatment effects are computed using the procedure of de Chaisemartin and d'Haultfœuille (2020), observations are weighted by parcel size, and standard errors are clustered at the city block level.

**Figure G.2:** FAR distribution of new buildings



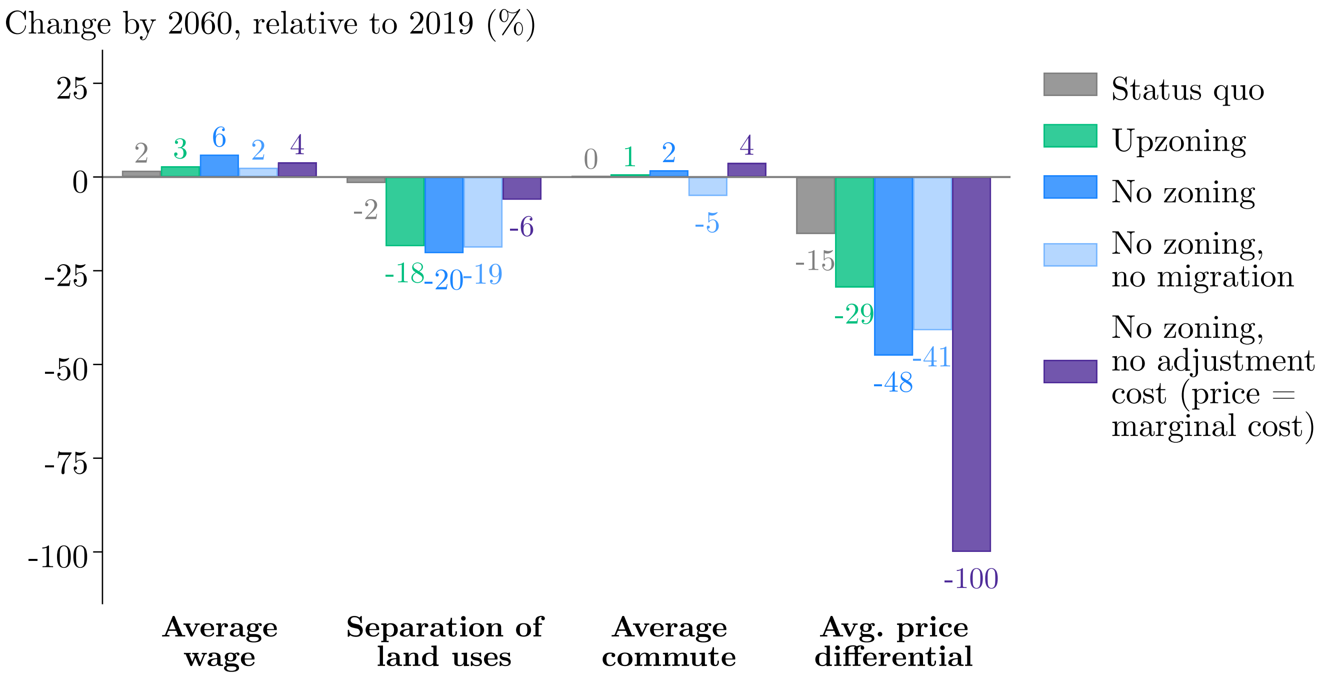

*Notes:* This figure plots the predicted distribution of the FAR of buildings constructed between 2020 and 2060 under status quo zoning and in the no-zoning scenario. The vertical lines represent the average FAR of new buildings in both scenarios.

**Figure G.3:** Average FAR of new buildings, by neighborhood




*Notes:* This figure maps the average FAR of structures built between 2020 and 2060 in the status quo scenario (panel a) and the no-zoning one (panel b).

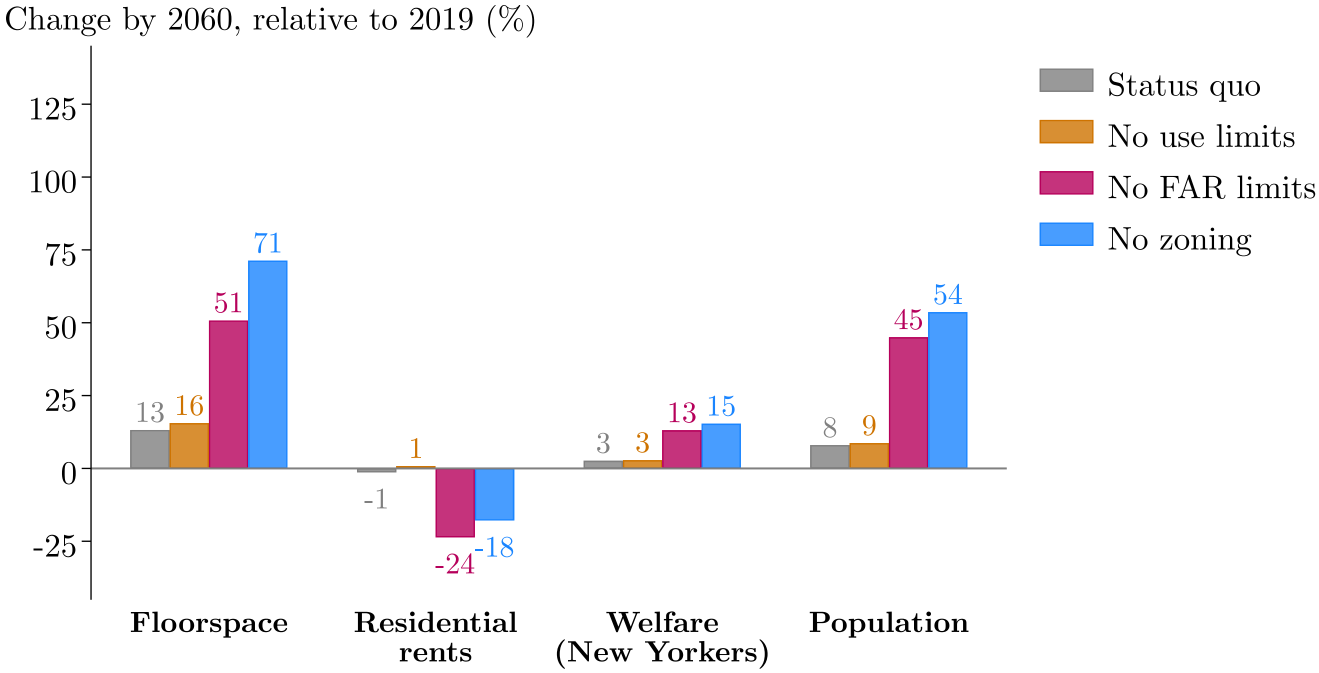
**Figure G.4:** Effects of relaxing zoning, additional outcomes



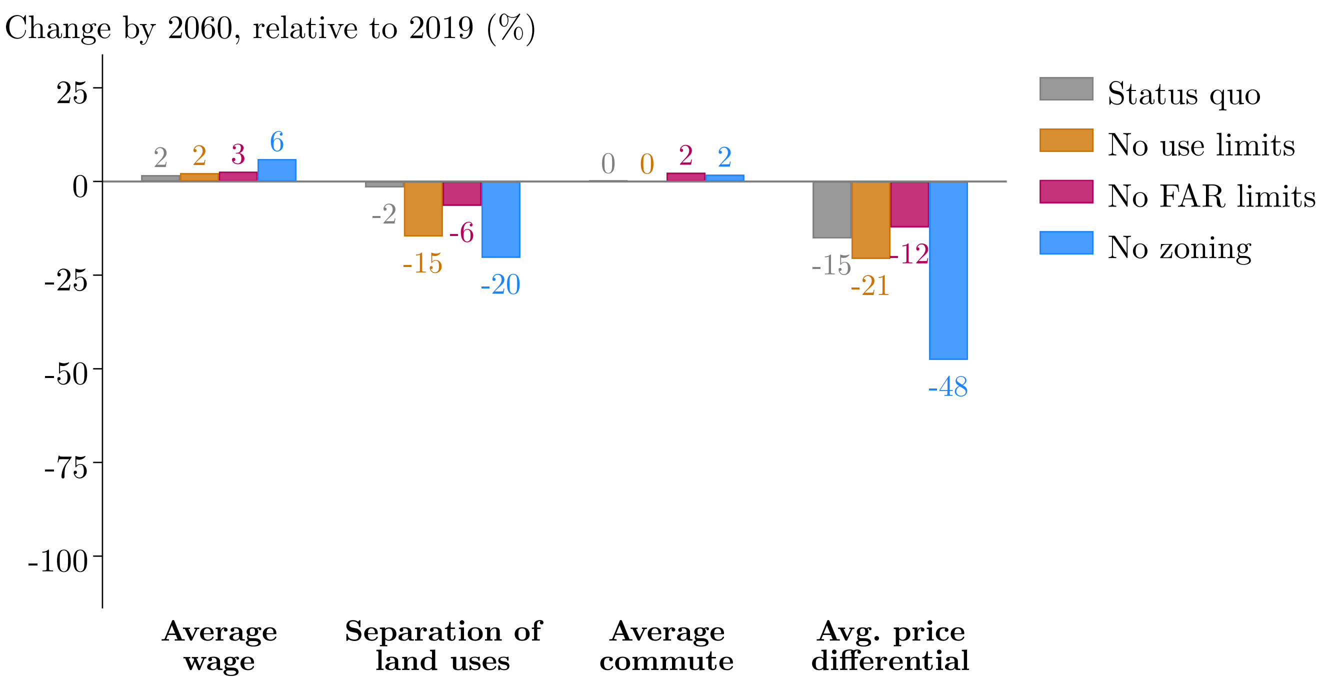

*Notes*: This figure shows changes in average wages, the separation of land uses, average commuting times, and the average residential–commercial price differential between 2019 and 2060 in the different counterfactuals described in Figure 7. The separation of land uses is measured through a dissimilarity index, as $S = 0.5 \times \sum_n |(H_{Rn}/H_R) - (H_{Cn}/H_F)|$, where $H_{Rn}$ (resp., $H_{Cn}$) is the amount of residential (resp., commercial) floorspace in neighborhood $n$, and $H_R$ (resp., $H_C$) is the total amount of residential (resp., commercial) floorspace in the city. Price differentials are measured as the average absolute difference between the price of residential floorspace and that of commercial floorspace, weighted by the amount of floorspace in each neighborhood.

**Figure G.5:** Effects of relaxing use vs. FAR limits

**(a)** Main outcomes

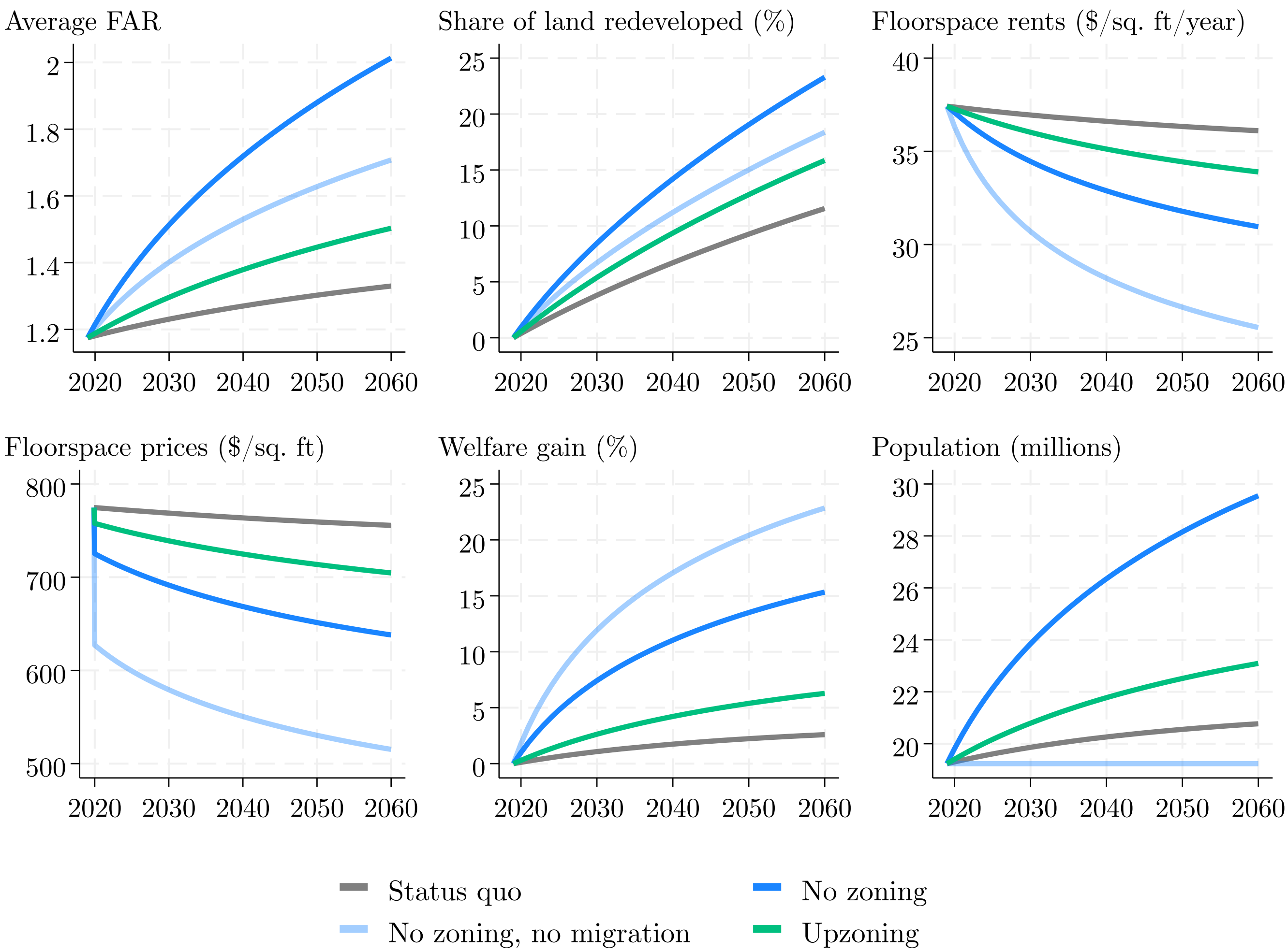



**(b)** Additional outcomes



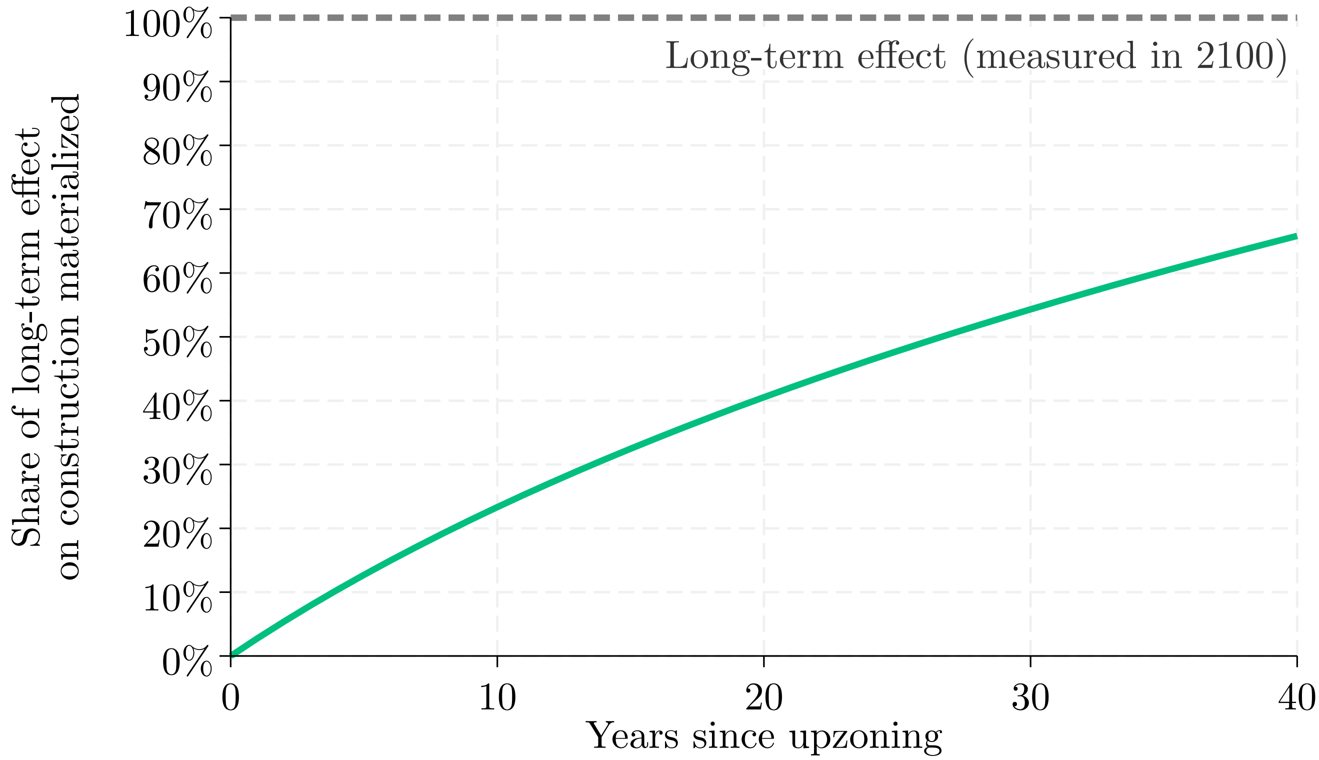

*Notes*: This figure shows changes in the outcomes studied in Figure 7 and Appendix Figure G.4 between 2019 and 2060 across four different counterfactuals. In the status quo counterfactual, zoning limits remain at their 2019 level. In the "no use limits" counterfactual, I allow residential and commercial uses on each parcel, keeping the maximum allowed FAR fixed. In the "no FAR limits" counterfactual, I remove FAR limits, but use limits remain at their 2019 level. In the "no zoning" counterfactual, I remove both use and FAR limits. In all counterfactuals, I keep zoning regulations at their 2019 levels for parcels protected (as landmarks or part of historic districts) or in flood zones.

**Figure G.6:** Transition paths



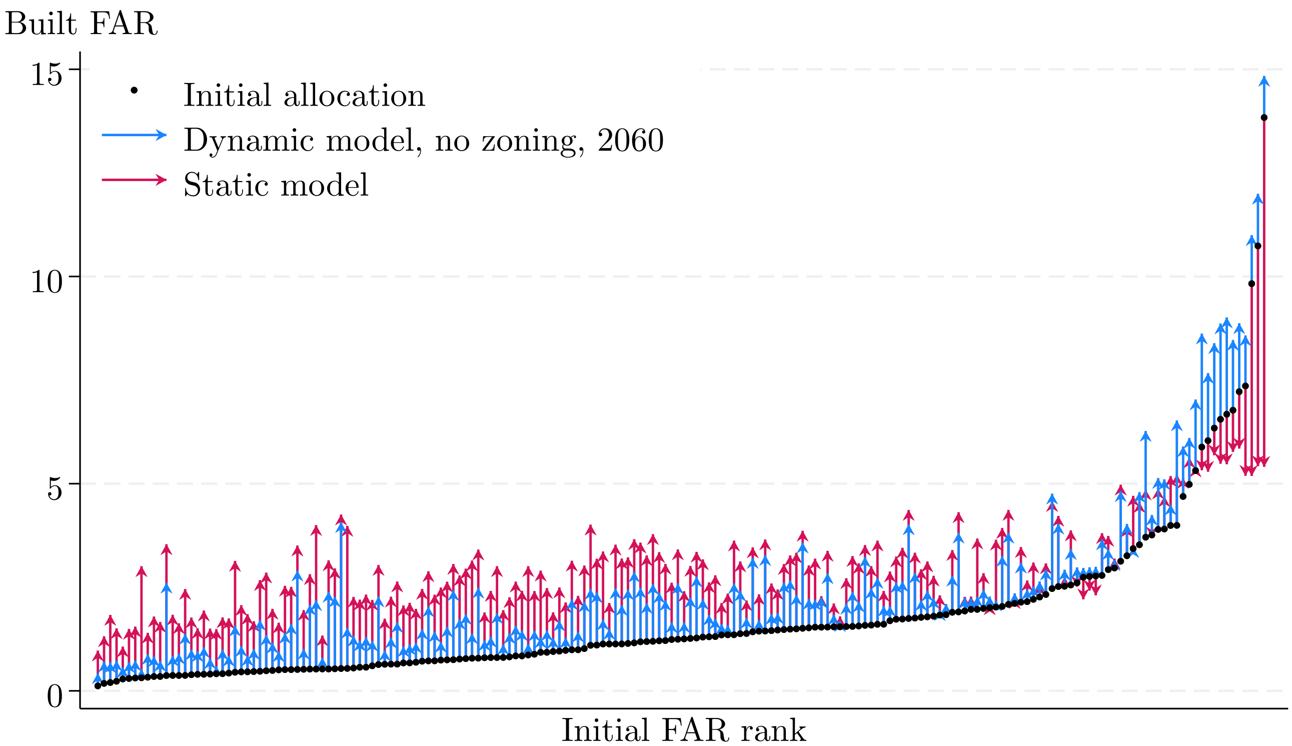

*Notes*: This figure shows how key variables evolve along the transition path. Floorspace prices (resp., rents) correspond to the average floorspace price (resp., rent) across neighborhoods, weighted by floorspace quantities. Population corresponds to the population in the NYC metropolitan area.

**Figure G.7:** Effects of upzoning materialize slowly over time




*Notes*: The figure reports, for each year following the enactment of upzoning, the fraction of the long-term construction response that has materialized. Here, the long-term effect of upzoning is measured in 2100, 81 years after the policy change. The upzoning considered here is described in Appendix Figure C.7.

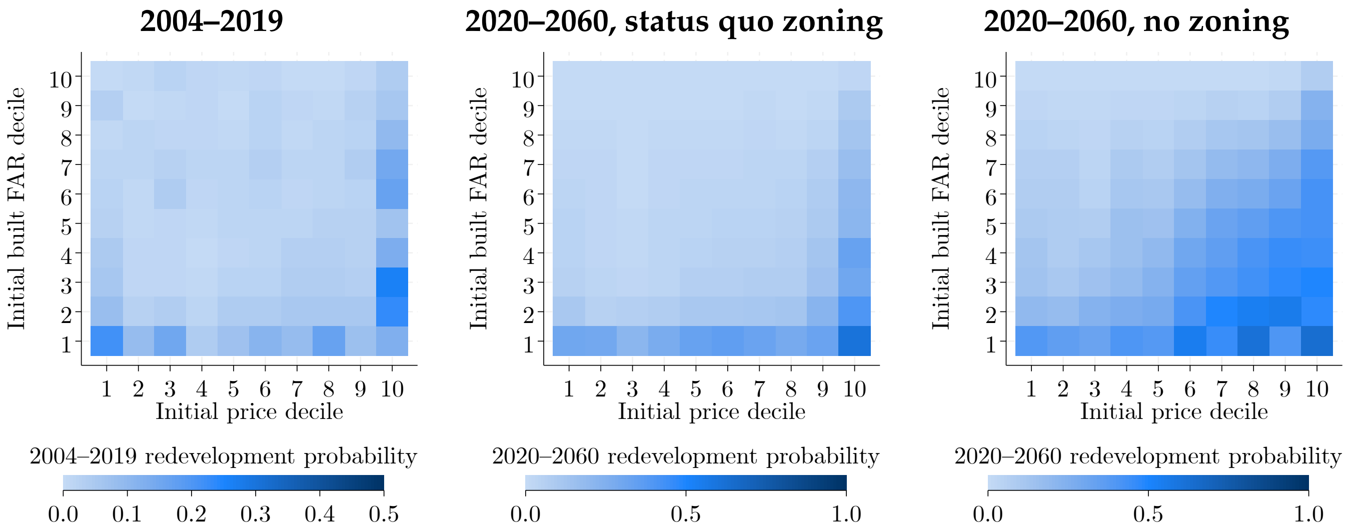
**Figure G.8:** Effects of removing zoning, computed using a dynamic vs. static approach



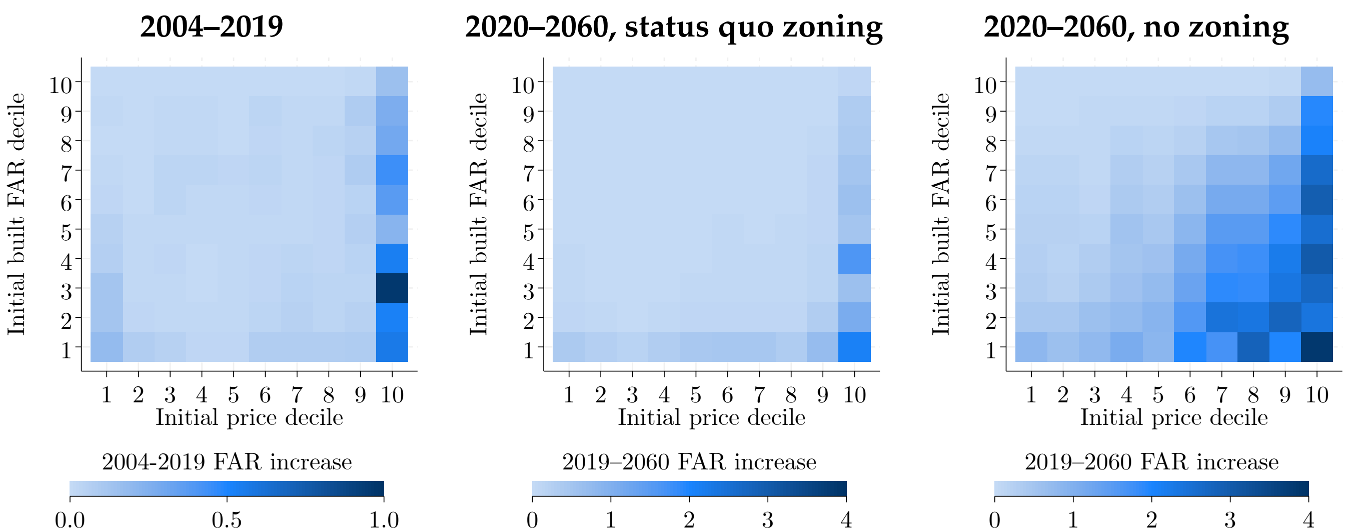

*Notes*: This figure shows the evolution of neighborhoods' FAR if zoning were removed, computed using two approaches. In blue, I show predictions of the dynamic model presented in this paper. In red, I show predictions of a model without zoning or adjustment costs, where the price of floorspace is equalized with its marginal construction cost in each neighborhood.

**Figure G.9:** Redevelopment activity, split by price and density levels

**(a)** Redevelopment probabilities

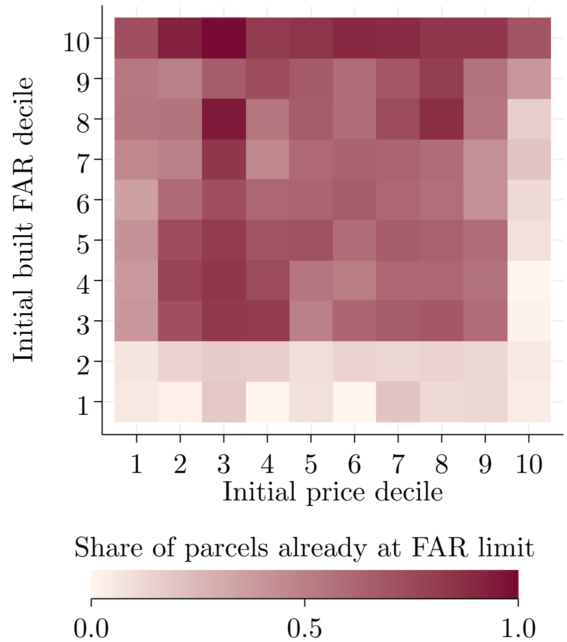



**(b)** FAR increases




*Notes*: This figure plots redevelopment activity for different deciles of floorspace prices and built FAR. Panel (a) shows redevelopment probabilities and panel (b) plots increases in built FAR. In each panel, I plot observed redevelopment activity over 2004–2019, predicted redevelopment activity over 2020–2060 if zoning stayed at its 2019 level, and predicted redevelopment activity over 2020–2060 if zoning were removed.

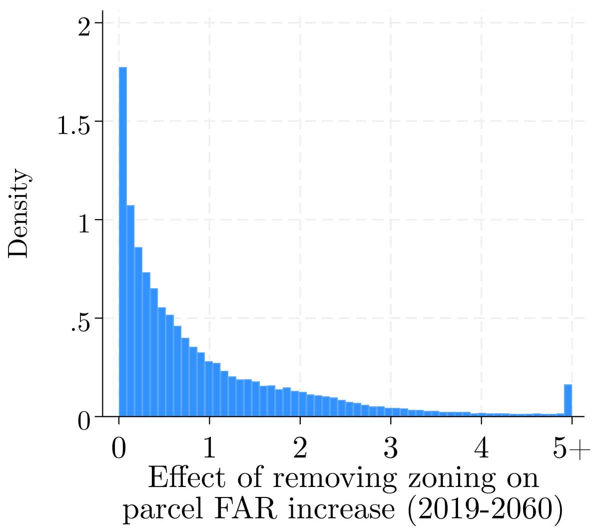
**Figure G.10:** Share of parcels with a built FAR at or above the zoning limit, split by price and density levels



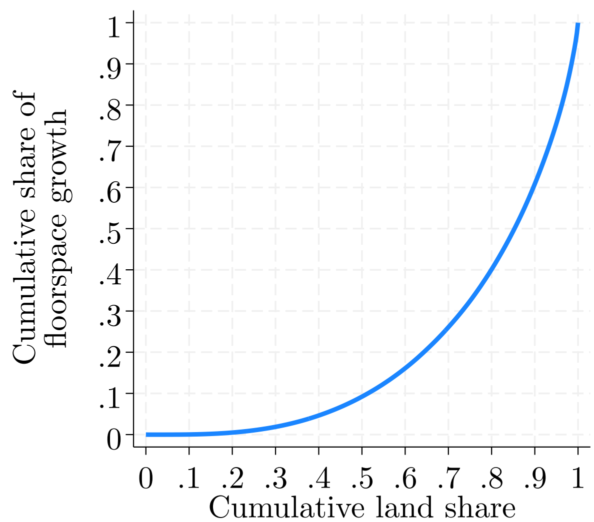

*Notes*: This figure plots the share of parcels with a built FAR over 80% of the maximum allowed FAR for different deciles of floorspace prices and built FAR.

**Figure G.11:** Concentrated effects of removing zoning on floorspace growth

**(a)** Parcel-level distribution of FAR increases



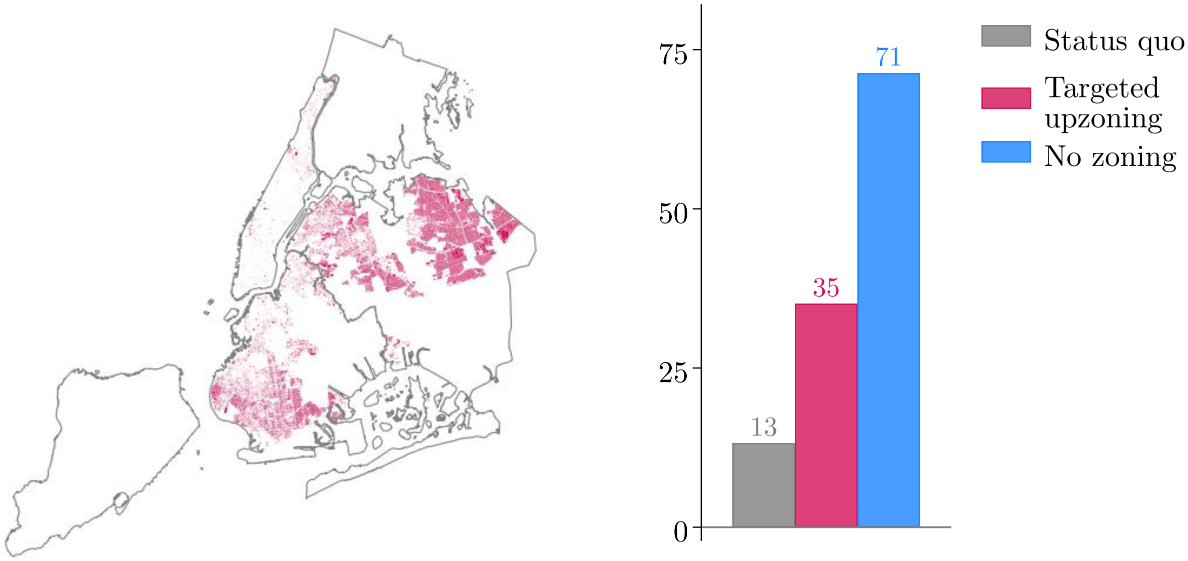

**(b)** Spatial concentration of floorspace growth




*Notes*: This figure illustrates the spatial concentration of the effects of removing zoning on floorspace growth. Panel (a) shows the parcel-level distribution of expected FAR increases between 2019 and 2060, relative to the status quo. Panel (b) ranks parcels by their predicted FAR gains from removing zoning and plots the cumulative share of floorspace growth against the cumulative share of land. For example, 39% of the additional floorspace built by removing zoning is concentrated on 10% of the city's land. Both panels restrict the sample to parcels affected by zoning changes in the counterfactual, excluding those landmarked, in historic districts, or in flood zones.

**Figure G.12:** Targeted upzoning

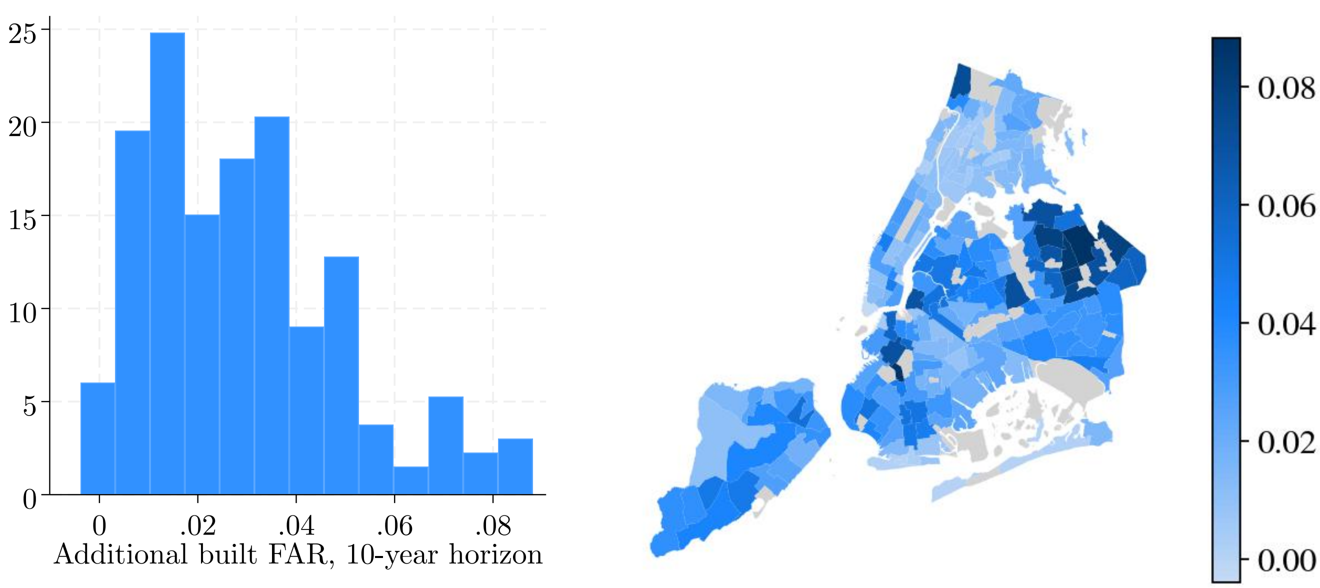
**(a)** Upzoned parcels **(b)** Floorspace growth, 2019–2060




*Notes*: This figure shows counterfactual results for a targeted upzoning policy that removes FAR limits on parcels with built FARs below the 60th percentile, in neighborhoods with floorspace prices above the 60th percentile, and that are not landmarked or in a historic district or flood zone. Panel (a) shows the location of the upzoned parcels. They account for 14% of NYC's developable land. Panel (b) shows the growth of floorspace between 2019 and 2060 in this counterfactual, as well as in the status quo and no-zoning counterfactuals of Figure 7.

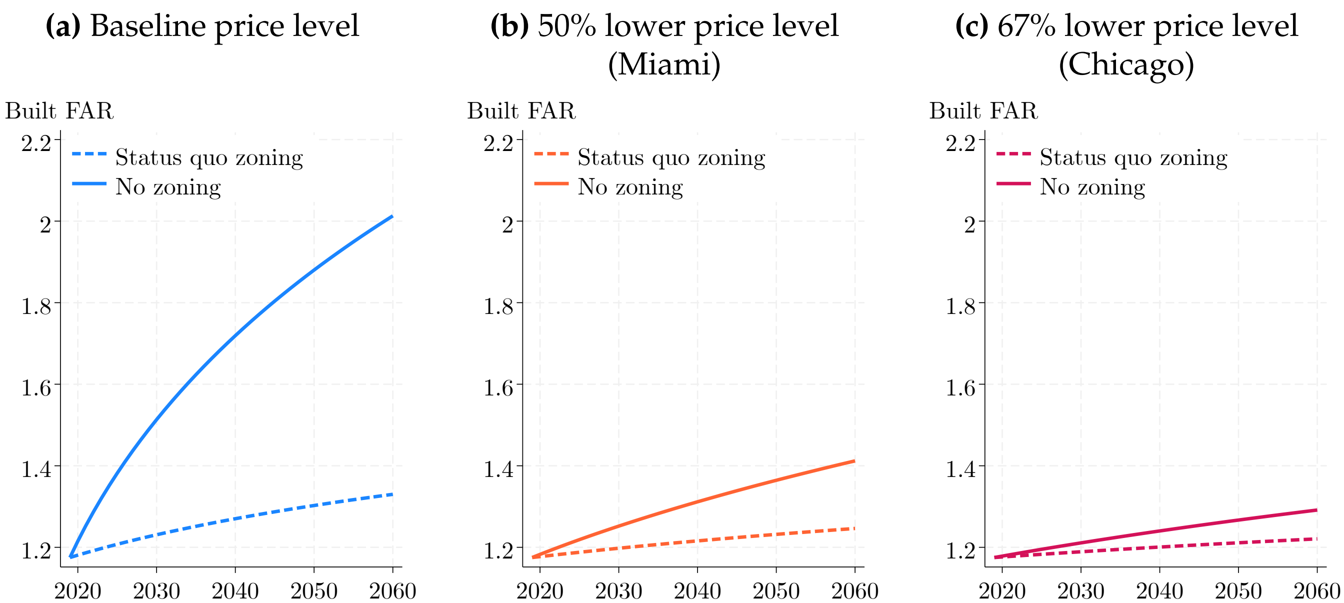
**Figure G.13:** Effects of a uniform 1 FAR point upzoning on built FAR (10-year horizon)

**(a)** Heterogeneity in neighborhoods' growth **(b)** Spatial distribution



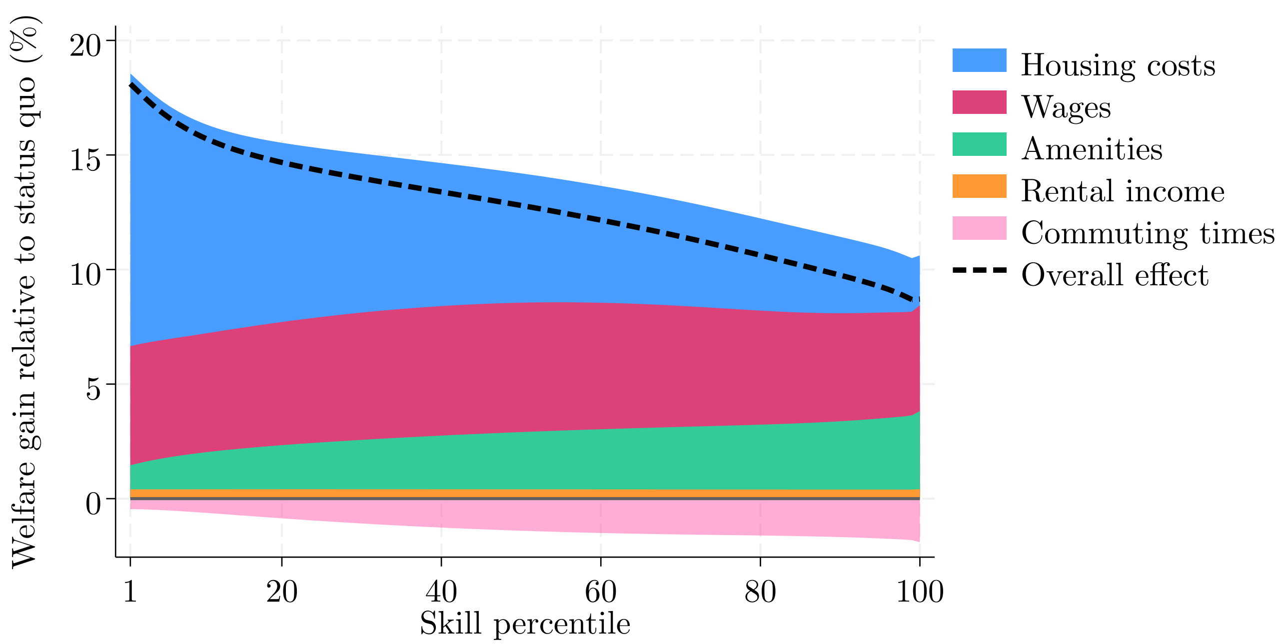

*Notes*: This figure shows the effect of uniformly upzoning NYC by one FAR point on the growth of different neighborhoods over a 10-year horizon.

**Figure G.14:** Effects of removing zoning on built FAR at different aggregate price levels



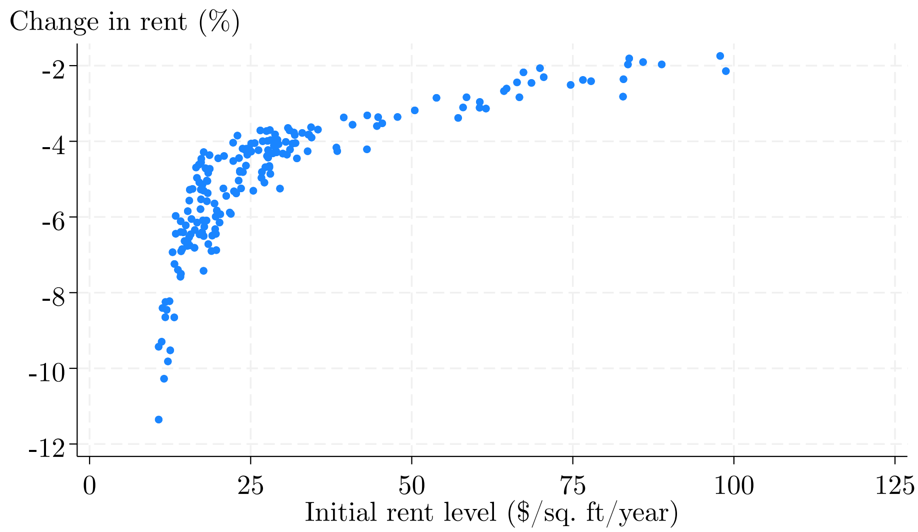

*Notes*: Panel (a) shows the evolution of the amount of floorspace in NYC under the baseline scenario, where productivity and amenity levels remain at their 2019 values in the future. In panels (b) and (c), I consider a scenario where the city is hit in 2020 with permanent productivity and amenity shocks that uniformly reduce floorspace prices (by 50% and 67%, respectively), placing them at levels comparable to those in Miami and Chicago, respectively. In all panels, I show results for the status quo zoning scenario and the no-zoning scenario.

**Figure G.15:** Decomposition of the welfare gains of removing zoning




*Notes*: This figure decomposes the welfare gains from removing zoning shown in Figure 9(a) into five effects: lower housing costs, higher wages, higher amenities, changes in the rental income $I_{\text{rents}}$, and increases in commuting times. Appendix E.4 outlines the procedure used to obtain this decomposition.

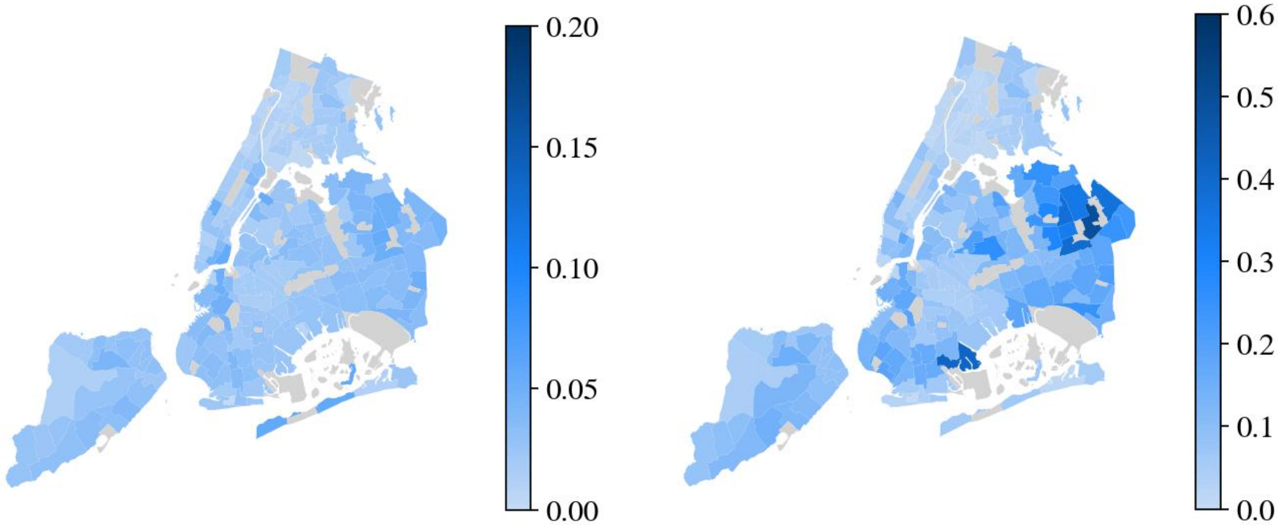
**Figure G.16:** Effects of a 10% increase in the city's floorspace on rents




*Notes*: This figure plots the effects of uniformly increasing the city's floorspace by 10% on rents. Each dot corresponds to a neighborhood.

**Figure G.17:** Exposure to redevelopment

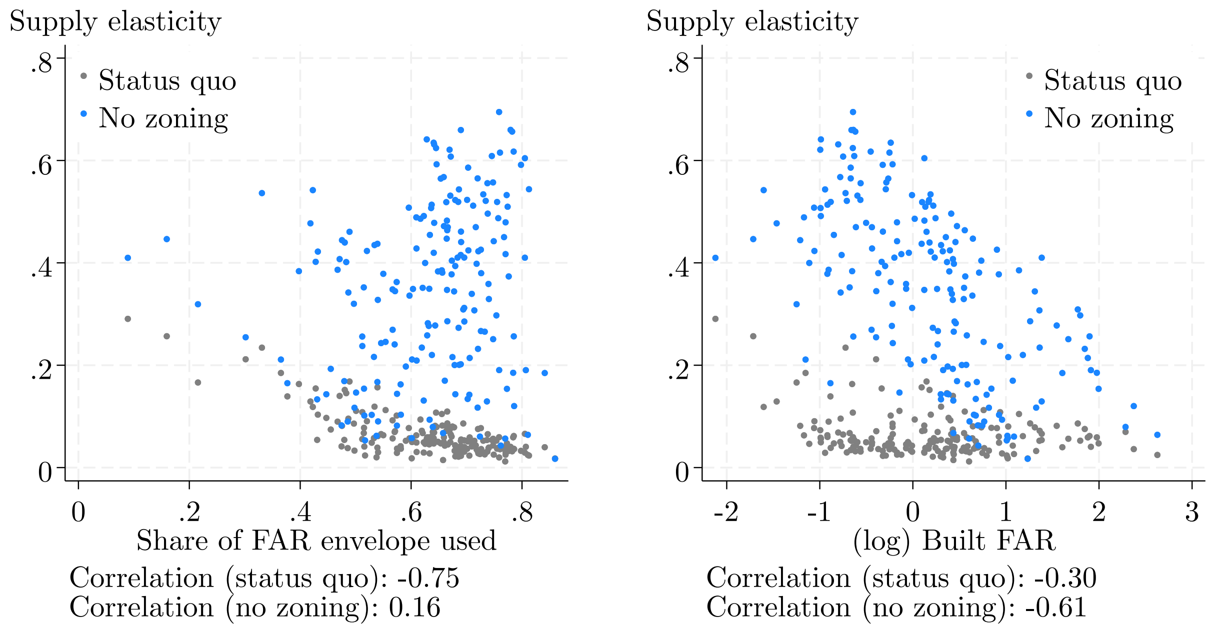
**(a)** Status quo zoning **(b)** No zoning




*Notes*: This figure maps, for each neighborhood, the share of residential floorspace in each neighborhood that is redeveloped between 2020 and 2060 in the status quo zoning counterfactual (panel a) and the no-zoning counterfactual (panel b).

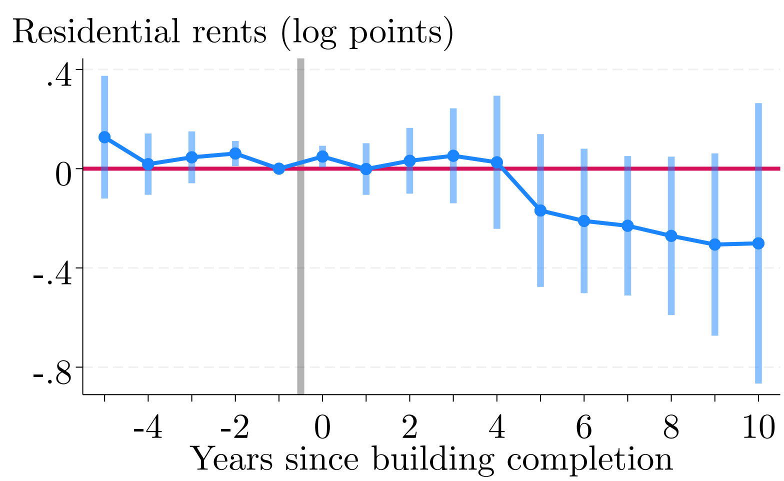
**Figure G.18:** Correlates of neighborhood-level supply elasticities

**(a)** Zoning constraints **(b)** Built FAR




*Notes*: This figure shows the correlation between neighborhood-level supply elasticities (measured at a 40-year horizon) and two of their most important determinants: the share of the FAR envelope that is already used (panel a) and preexisting density levels (panel b). Results are shown both under current zoning regulations and in the no-zoning counterfactual. The FAR envelope corresponds to the maximum amount of floorspace that could potentially be built according to the zoning code. When computing the share of the FAR envelope that is already used, I exclude from each parcel floorspace that exceeds the FAR limit.

**Figure G.19:** Effects of industrial construction on residential rents




*Notes*: This figure shows the results of an exercise similar to that of Figure 6, estimating the effect of building a new large industrial building (a factory, garage, or warehouse) on the rents of preexisting nearby residential buildings.