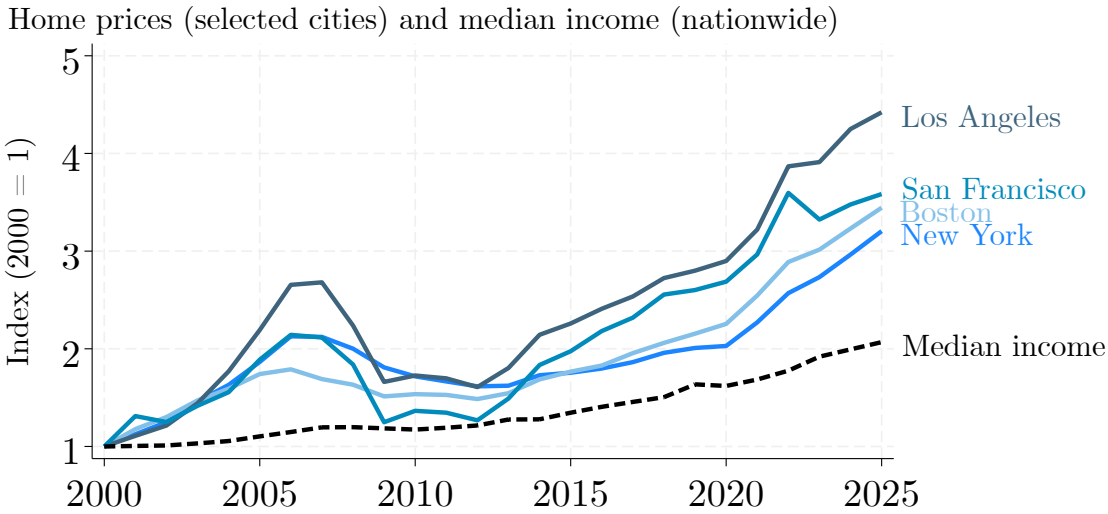
Zoning and the Dynamics of Urban Redevelopment

Vincent Rollet

MIT

Home prices have skyrocketed in many large cities



Strict zoning is often denounced as a culprit

Zoning: Regulations restricting characteristics of new buildings.

- **Density limits** (e.g., height limits).
- **Use limits** (e.g., residential only).

- Some deregulation (**upzoning**) happening in many cities (Chicago, Cambridge, Minneapolis, Berkeley, Denver, Seattle, Austin, NYC, Portland, Raleigh, San Diego...)

Technological constraints matter too

- In urban cores, vacant land is scarce.
- Change comes from **redevelopment**.
  → Demolishing and replacing old buildings.
- Increasingly how cities grow (Frolking et al., 2024).
- Requires paying large **fixed costs**.

How do zoning and the existing building stock influence urban development?

- First paper to build a **parcel-level land use and zoning panel** for a city.
  → Track all parcels and development events in NYC over 2004–2022.
- **Dynamic spatial equilibrium model** of urban change.
  → **Supply**: Behavior of forward-looking developers given prices and regulation.
  → **Demand**: Spatial equilibrium model predicts how development affects prices.

Policy application: What would be the effects of relaxing zoning?

- **Quasi-experimental evidence** from recent zoning changes.
- Model accurately predicts effects of past upzonings.
- Use model to predict the **effects of relaxing zoning** on **construction** and **prices**.

Findings

- Zoning strongly hinders construction, and relaxing zoning yields **large welfare gains**.
- But **adjustment** to policy change is **slow**, **take-up of upzoning is limited**.
  - → Only 1/4 of long-term gains in first decade.
  - → Allowing 5 new units yields only 1 built over 40 years.
  - → Mechanism: Large **fixed costs** of redevelopment that rise steeply with height.
- **Consequences**: Relaxing zoning most effective where **prices are high**/**density is low**.
- Affordability **gains geographically spread out** due to migration.

Contribution

City structure and evolution Burgess (1925), Hoyt (1939), Alonso (1964), Mills (1967), Muth (1969), Ogawa & Fujita (1980), Lucas & Rossi-Hansberg (2002), Ahlfeldt, Redding, Sturm & Wolf (2015), Allen, Arkolakis, & Li (2015), Heblich, Redding, & Sturm (2020), Gechter and Tsivanidis (2023), Hsiao (2024)

→ Instead of long-run static equilibria, focus on **redevelopment** and **transition path**.

→ New granular **data** allows to show new **facts** and build a new **model** of urban change.

Land use regulation Glaeser, Gyourko and Saks (2005), Ganong and Shoag (2017), Glaeser and Gyourko (2018), Hsieh and Moretti (2019), Ospital (2022), Anagol, Ferreira & Rexer (2024), Peng (2023)

→ Evaluation of the **effects of relaxing zoning** (reduced-form + credible extrapolation).

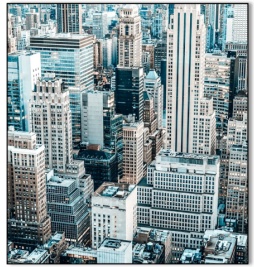
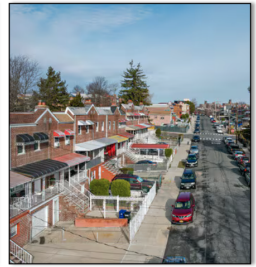
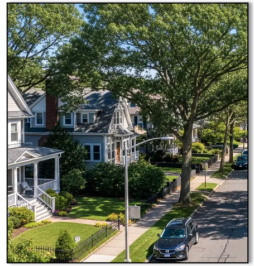
Roadmap

1. Data and context
2. Empirical evidence on redevelopment and zoning
3. Dynamic model of urban change
4. Model estimation and validation
5. Implications for zoning policy

Data and context

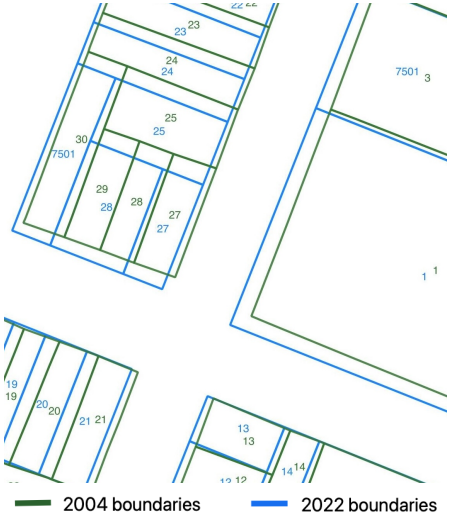
NYC as a case study

- Largest US city (8.5 million inhabitants).
- Wide variation in density and prices.
- Housing affordability crisis.
- Active policy debate.
- Need to gather data on:
  1. Floorspace quantities.
  2. Floorspace prices.
  3. Zoning.


Floorspace quantities: Parcel-level land use

- I use **cadastral maps** to:
  - → Partition NYC in time-consistent parcels.
  - → Link land parcels to buildings over time.
- Developed a polygon conflation algorithm.
  - → 5,700 manual adjustments for a perfect match.
- Track universe of parcels over 2004–2022.
  - → 833,000 parcels in total.
- **Building characteristics**:
  - → Property tax records (scraping, FOIA requests).
  - → StreetEasy (scraped data on 1.6 million units).



Floorspace quantities: Redevelopment events

- Isolate 22,000 **redevelopment events**.
  - → Buildings constructed since 2004.
- **Building permits**
- **Certificates of Occupancy**
  - → Construction ends.
  - → Scraped and digitized 250,000 documents.

Floorspace quantities: Redevelopment timelines

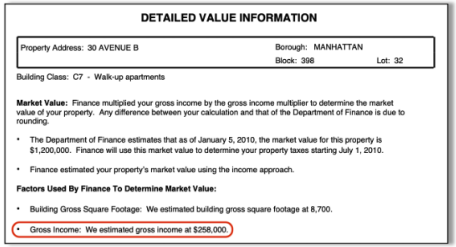
2014 — 2015 — 2017 →

Building permit issued

Certificate of Occupancy issued

Floorspace prices

- **Sales prices** from real estate transactions over 2003-2022 (1.2 million observations).
  → From NYC Department of Finance.
- Yearly **rent** measures for 73,000 buildings.
  → Scraped 600,000 tax documents.
- Digitized historical sales data from the Real Estate Board of New York.
  → 63,000 sales over 1950–1985.



DETAILED VALUE INFORMATION

Property Address: 30 AVENUE B
Borough: MANHATTAN
Block: 398 Lot: 32

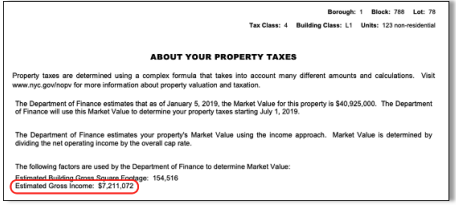
Building Class: C7 - Walk-up apartments

Market Value: Finance multiplied your gross income by the gross income multiplier to determine the market value of your property. Any difference between your calculation and that of the Department of Finance is due to rounding.

- The Department of Finance estimates that as of January 5, 2010, the market value for this property is $1,200,000. Finance will use this market value to determine your property taxes starting July 1, 2010.
- Finance estimated your property's market value using the income approach.

Factors Used By Finance To Determine Market Value:

- Building Gross Square Footage: We estimated building gross square footage at 8,700.
- Gross Income: We estimated gross income at $258,000.



Borough: 1 **Block:** 788 **Lot:** 78
Tax Class: 4 **Building Class:** L1 **Units:** 123 non-residential

ABOUT YOUR PROPERTY TAXES

Property taxes are determined using a complex formula that takes into account many different amounts and calculations. Visit www.nyc.gov/nopv for more information about property valuation and taxation.

The Department of Finance estimates that as of January 5, 2019, the Market Value for this property is $40,925,000. The Department of Finance will use this Market Value to determine your property taxes starting July 1, 2019.

The Department of Finance estimates your property's Market Value using the income approach. Market Value is determined by dividing the net operating income by the overall cap rate.

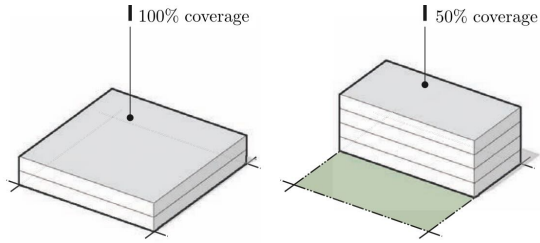
The following factors are used by the Department of Finance to determine Market Value:
Estimated Building Gross Square Footage: 154,516
Estimated Gross Income: $7,211,072

Zoning

- I match my land use panel with zoning regulations for each year.
- Zoning limits the **size** and **use** (residential vs. commercial) of new buildings.
- Main zoning instrument in NYC: limits on the **Floor Area Ratio** (FAR).

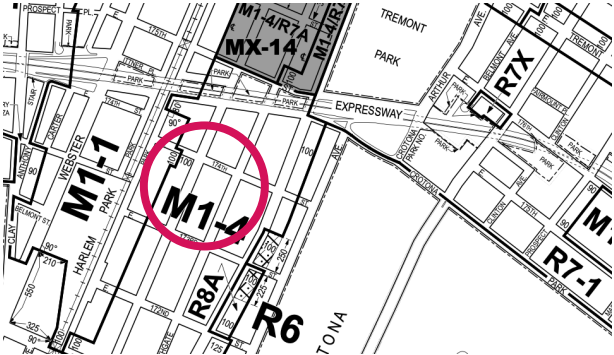
$$\textbf{FAR} = \frac{\text{sq. ft of floorspace}}{\text{sq. ft of land}}$$

Buildings with a FAR of 2



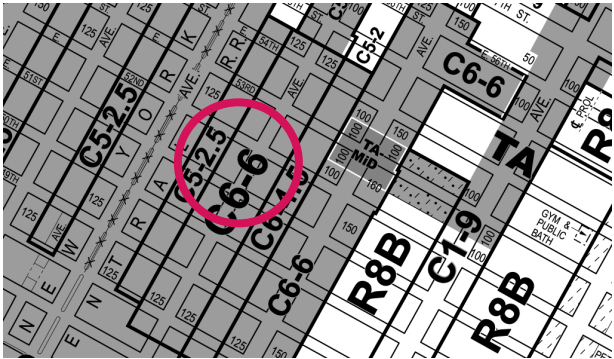
Zone R1-2

- **Residential** allowed up to 0.5 FAR points.
- **Commercial** not allowed.



Zone M1-4

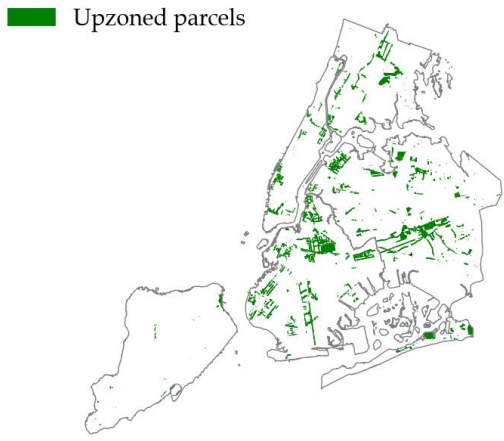
- **Residential** not allowed.
- **Commercial** allowed up to 2 FAR points.



Zone C6-6

- **Residential** allowed up to 10 FAR points.
- **Commercial** allowed up to 15 FAR points.

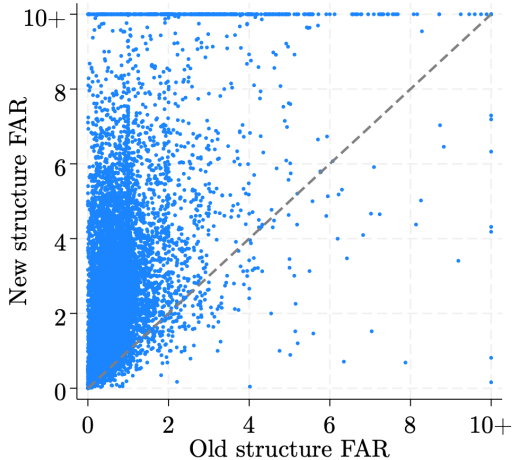
- Zoning ordinance adopted in 1961.
  - → Promoted "towers in the park."
  - → Separated residential/commercial uses.
  - → Goal was to limit negative externalities.
- Strong persistence over time.
- Several areas upzoned in past decades.
  - → Allows to evaluate the effects of upzoning.
- Focus on large planner-initiated changes.
  - → Many veto players.
  - → Exact changes and timing unclear when upzoning discussions begin.
  - → Leveraged in reduced-form.



Empirical evidence

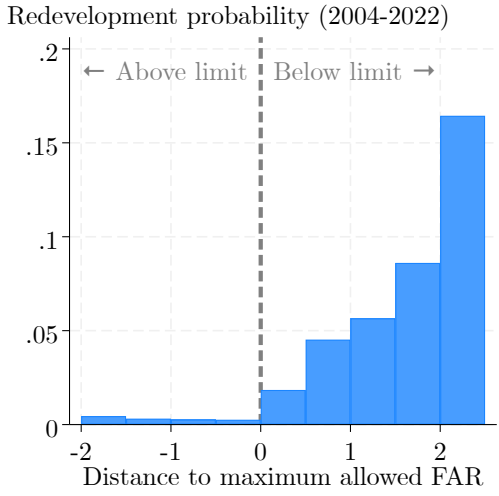
Redevelopment means densification

- New buildings 3.4 times larger than the ones they replace (on average).
- Suggests large redevelopment **fixed costs**.



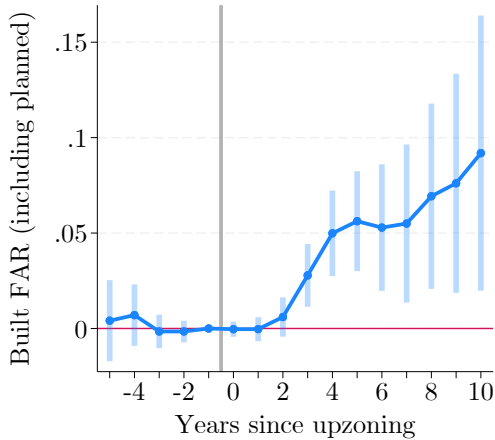
Redevelopment mostly happens when upward growth is allowed

- Buildings at/over the zoning limit are seldom redeveloped.



The effects of upzoning on built FAR materialize slowly

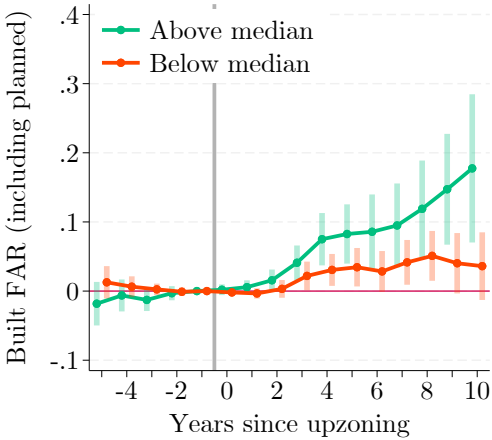
- Compare parcels upzoned earlier vs. later.
  → Identifying assumption: Exogenous timing.
  (de Chaisemartin & d'Haultfœuille, 2020)
- Upzoning increases allowed FAR by ≈ 1.
- $\approx$ 10% of increase used after a decade.



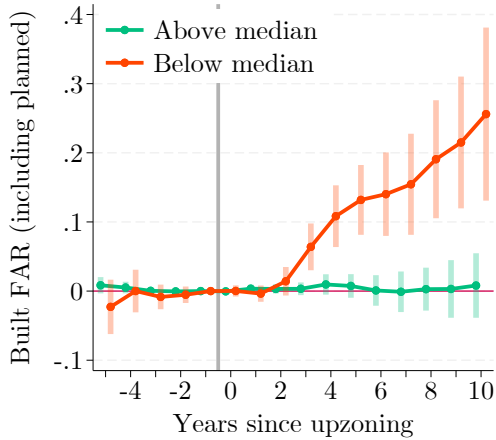
The effects of upzoning vary widely

Effects concentrate in high-price neighborhoods and underbuilt parcels

Heterogeneity by baseline neighborhood floorspace prices

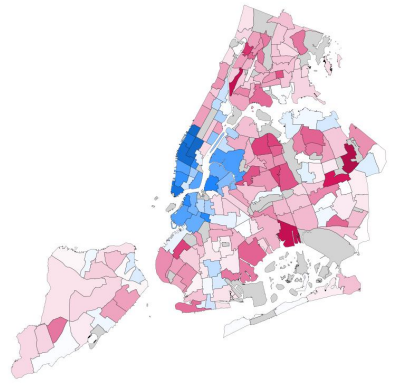


Heterogeneity by baseline built FAR (within neighborhood)

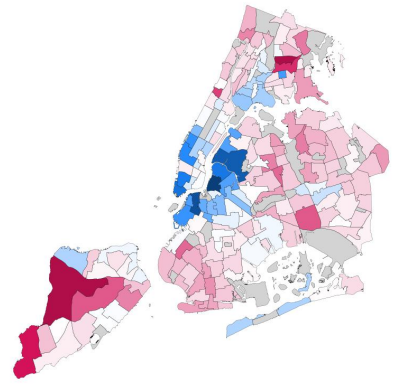


Redevelopment reallocates land to its most profitable use

Commercial-residential price diff. ($/sq. ft)

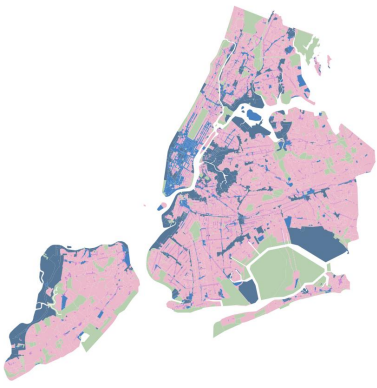


2004-2022 change in commercial share (pp)

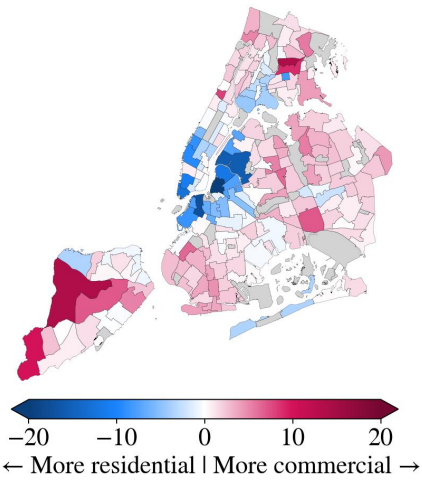


Zoning constrains the reallocation of land uses

Zoning map



2004-2022 change in commercial share (pp)



Remaining questions

1. **Extrapolation**:
   - → Upzoned neighborhoods were selected: what would happen if we upzoned **elsewhere**?
   - → The upzonings were limited in scope: what would happen if we upzoned **more**?
   - → Effects take time to materialize: how large are they in the **long run**?

2. What are the effects of allowing more construction on **prices**?

→ Answer these questions with a **model of urban change** incorporating:

- Dynamic transition path.
- Fixed costs of redevelopment increasing with old building FAR.
- Use (residential/commercial) and bulk (FAR) zoning constraints.
- Externalities associated with different land uses.

→ Use reduced-form analysis of upzoning for **model validation**.

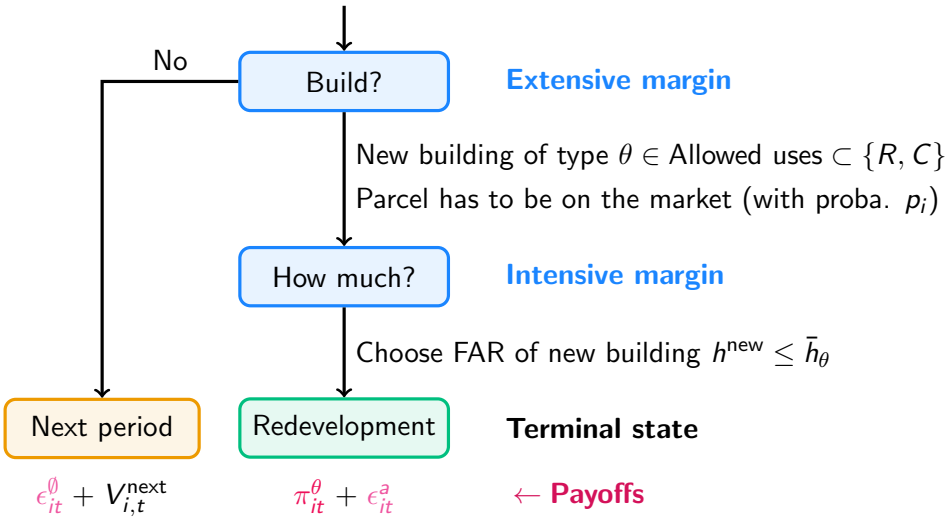
A dynamic model of urban change

Supply of floorspace

Dynamic behavior of developers given prices and regulation

Developer choices

Developers are atomistic and perfectly foresighted. They make decisions each year:



Developer profit function

$$\pi_{it}^{\theta} = \max_{h^{\text{new}} \leq \bar{h}_{\theta it}} \left[\underbrace{P_{\theta it}^{\text{new}}(h^{\text{new}}) - P_{it}^{\text{old}}}_{\text{Change in property value}} - \underbrace{[VC_{it}(h_{it}^{\text{new}}) + FC_{it}]}_{\text{Cost of redevelopment}} \right]$$

- As buildings age, P_{it}^{old} decreases, redevelopment becomes more profitable.
- Variable costs (VC): construction costs, increase with size of new building.
- Fixed costs (FC): eviction, demolition, permitting, etc.
  $\rightarrow$ Vary by building (e.g., larger for bigger buildings in dense neighborhoods).

Demand for floorspace

Evolution of prices given developers' choices

Demand for floorspace

- Neighborhoods endowed with commercial and residential floorspace.
- Workers rent housing H, choose home and work locations (n, m) each period:

$$\max_{n,m,H,C} \underbrace{B_{nt}}_{\text{amenities}} \cdot \underbrace{(H - \underline{H}_{nt})^{\beta}}_{\text{housing}} \cdot \underbrace{C^{1-\beta}}_{\text{other cons.}} \cdot \underbrace{d_{nmt}^{-1}}_{\text{commuting}} \cdot \underbrace{z_{nt}^{H} z_{mt}^{W}}_{\substack{\text{idiosyncratic} \\ \text{preferences for} \\ \text{home/work locations}}}$$

$$\text{s.t. } C + R_{nt} H \leq \text{Income}_t$$

→ Labor income $= s \cdot w_{mt}$, skill s lognormally distributed.
→ Income from rented floorspace redistributed proportionally to labor income.

- **Key extension**: Subsistence level of housing and realistic distribution of worker skills.
  → Essential to rationalize consumed quantities of housing.

Amenities and productivities

- Firms consume commercial floorspace:

$$Y_{jt} = A_{mt} \cdot \underbrace{H_{Fmt}^{\alpha_m}}_{\substack{\text{Commercial} \\ \text{floorspace}}} \cdot \underbrace{L_{Fmt}^{1-\alpha_m}}_{\text{Labor}}$$

- Amenities (B) and productivities (A) vary with density of residents (L_R) and jobs (L_F).

$$B_{nt} = \bar{B}_{nt} L_{Rnt}^{\gamma^{RR}} L_{Fnt}^{\gamma^{CR}} \qquad A_{mt} = \bar{A}_{mt} L_{Rmt}^{\gamma^{RC}} L_{Fmt}^{\gamma^{CC}}$$

  → γ are the agglomeration elasticities (could be positive or negative).

- City population and congestion increase with expected utility.

Dynamic spatial equilibrium

An equilibrium is a path of

→ Local floorspace supplies, rents, and prices;
→ Population and job distributions;
→ Local productivities, amenities, wages;
→ Commuting costs;

Such that:

1. Developers maximize profits.
2. Workers maximize utility, firms maximize profits.
3. Productivities, amenities, and commuting costs adjust (agglomeration/congestion).
4. Floorspace markets clear.
5. Prices are the discounted sum of rents.

Model estimation and validation

Supply-side parameters

Prices

- Value of a building:

$$P_{\theta it} = \underbrace{\rho^{\theta}_{nt}}_{\text{Location premium}} \times \underbrace{Q(\mathbf{x}_{it})}_{\text{Building quality}} \times \underbrace{h_{it}}_{\text{Building size}}$$

  → Estimated through a hedonic regression on the sales data.
  → Focus on buildings at/above FAR limit (option value of redevelopment ≈ 0).
  → Quality proxied using rich building characteristics in $\mathbf{x}_{it}$ (e.g., age, grade, materials, FAR).

Variable costs estimation

- **Identification approach**: Revealed preferences.
  → Use data on FARs chosen by developers for new buildings + prices/zoning they faced.

- **Challenge**: Zoning induces wedge between price and marginal cost of floorspace.

- **Parametric assumption**: Cobb-Douglas production of floorspace with capital and land.

$$VC_{it}(h_{it}) = \alpha_{bt}^{\theta} h_{it}^{1/\zeta} e^{\eta_{it}}$$

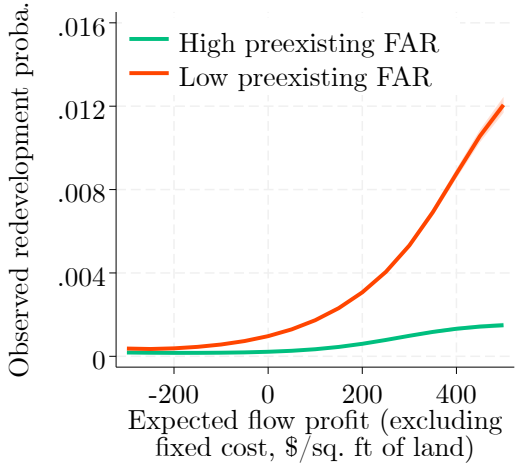
- Developers choose FAR $h \leq \bar{h}$ to max profits: $\max_{h \leq \bar{h}} \{P(h) - VC(h)\}$.
  → Use variation on chosen FAR when below the limit and whether the limit is hit.
  → Recover parameters through **maximum likelihood estimation**.

- I find costs rise steeply with FAR and align with engineering estimates/reported costs.

Fixed costs estimation: Intuition

- **Idea:**
  - → Compute expected profit from redevelopment, excluding fixed costs.
  - → Find fixed costs to best match relationship with redevelopment probability.

- **Parameterization**: fixed costs
  - → Increase with size of old building.
  - → Increase with neighborhood density.
  - → Larger in historic districts.



Fixed costs estimation: Algorithm

- Requires solving the full model.
  - → Option value of redevelopment depends on future path of prices.
  - → This path depends on the collective behavior of developers, which depends on fixed costs.
  - → Assume that developers believe fundamentals and zoning will stay constant after 2019.

- Estimation using **full-solution approach** (extending Rust, 1987).
  - → Inner loop: Estimate developers' value function.
  - → Middle loop: Recover price paths by repeatedly solving the demand model.
  - → Outer loop: Maximum likelihood.

- I find fixed costs increase sharply with existing buildings' FAR.

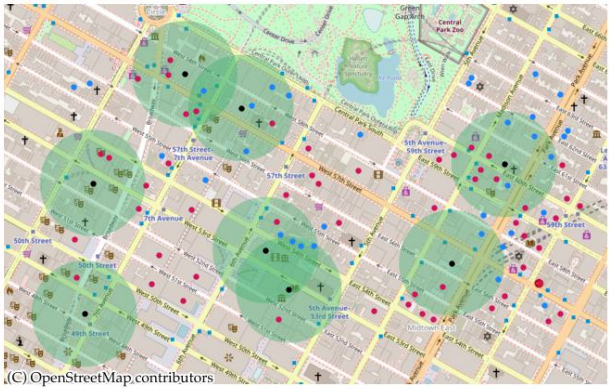
Demand-side parameters

Demand model estimation

- Fundamentals estimated to match commuting flows, rents, and floorspace supplies.
  → Data: LEHD LODES.
- Commuting elasticity estimated using the correlation between commuting flows and commuting times.
  → Data: Google Maps.
- Migration and congestion elasticities calibrated from literature ($\varepsilon_M = 3$, $\varepsilon_M = 0.15$).
- Agglomeration externalities estimated by measuring local demand elasticities.

Price effects of new construction

- Draw 500-ft disks around large construction events (290 residential, 112 commercial).
- Compare the evolution of rents in disks treated earlier vs. later.



Events (new residential buildings)

New buildings

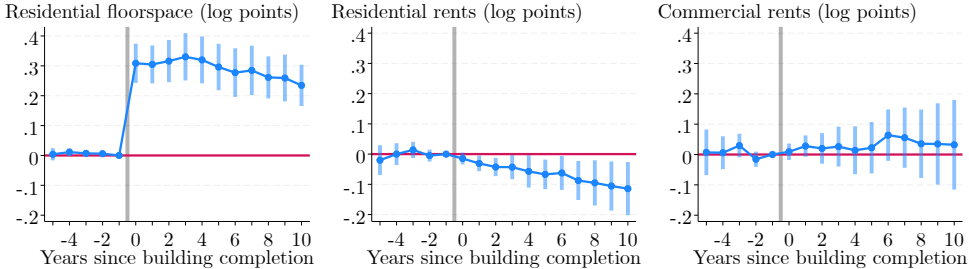
500 ft buffers

Buildings with available rent data

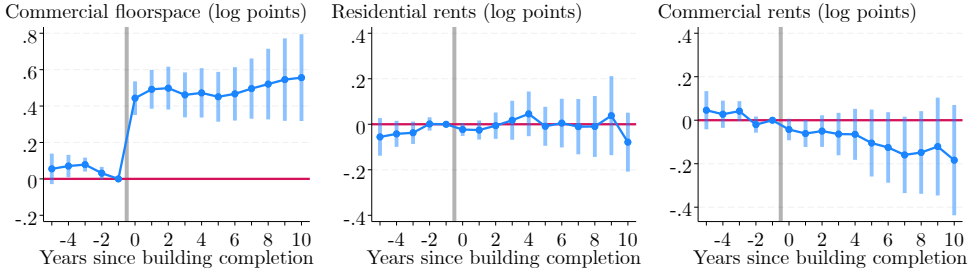
Residential

Commercial

Effects of residential construction



Effects of commercial construction



Price effects of new construction

- Estimate agglomeration parameters via **indirect inference** to match reduced-form.

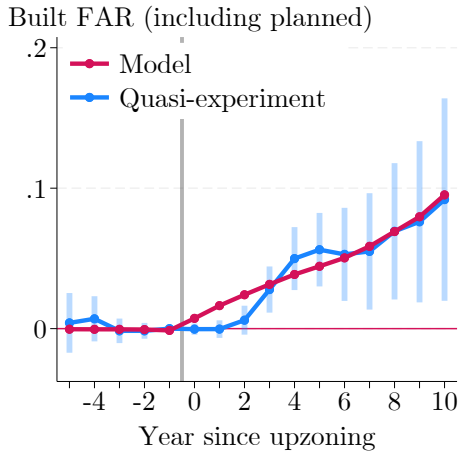
- I find positive agglomeration externalities within uses, limited externalities across uses.
  - → Effect of residents on other residents: $\gamma_{RR} = 0.11$.
  - → Effect of firms on other firms: $\gamma_{CC} = 0.07$.
  - → Corresponding estimates in Ahlfeldt et al. (2015): 0.16 and 0.07.

Model validation

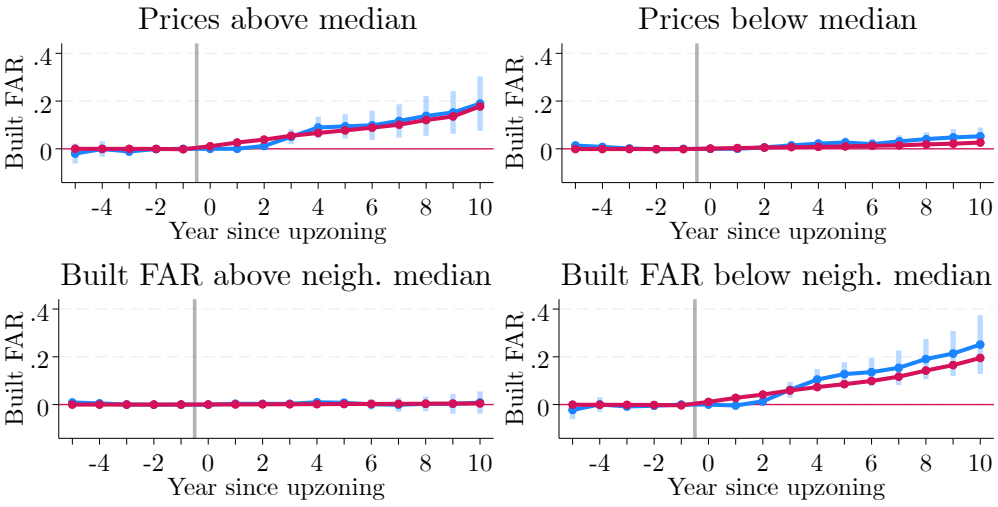
Predicted effect of upzonings

- Model estimation separate from reduced-form.
  → 90% of redevelopment on non-upzoned parcels.

- **Validation exercise**:
  1. Estimate model on non-upzoned parcels.
  2. Predict evolution of upzoned parcels with/without upzoning.
  3. Build model-implied effect of upzoning.
  4. Compare with quasi-experimental estimates.



Model validation: Predicted effect of upzonings



Implications for zoning policy

Main counterfactuals

Simulate the evolution of the city until 2060, keeping fundamentals at their 2019 level.

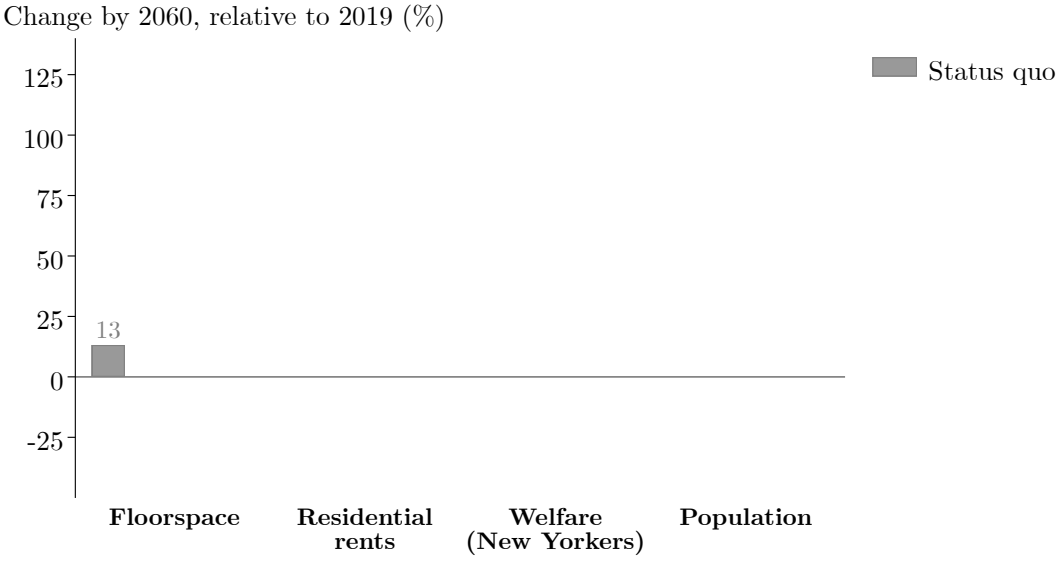
1. **Status quo**: zoning stays as is.
2. **Realistic but ambitious upzoning** around transit stations.
   → **Increases total allowed FAR in NYC by 60%**.
3. **No zoning** (excluding landmarks, historic districts, flood zones).

---

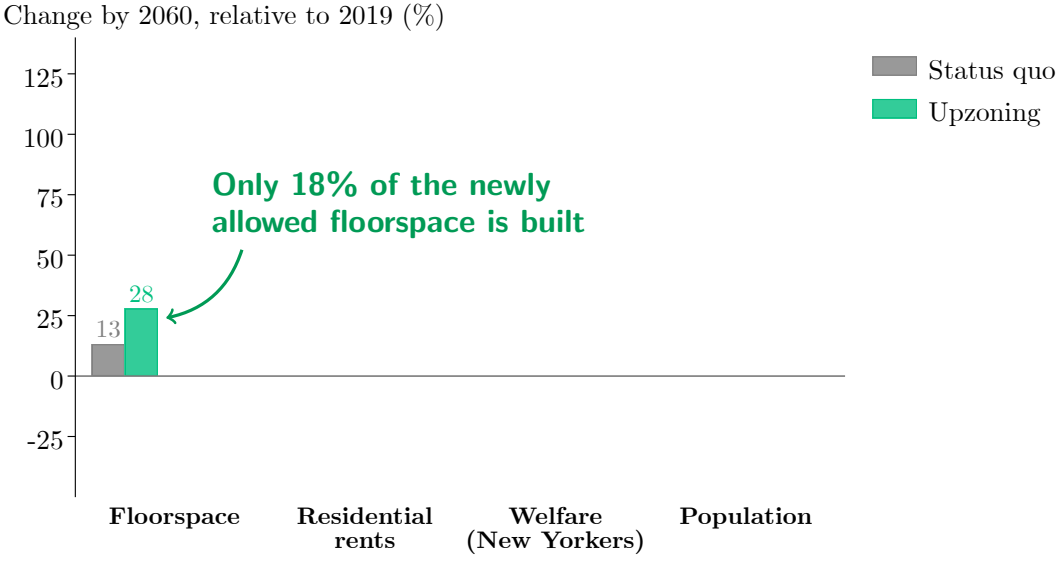
4. **Frictionless benchmark** (no zoning, no adjustment costs, price = marginal cost).

To what extent does zoning constrain NYC's growth?

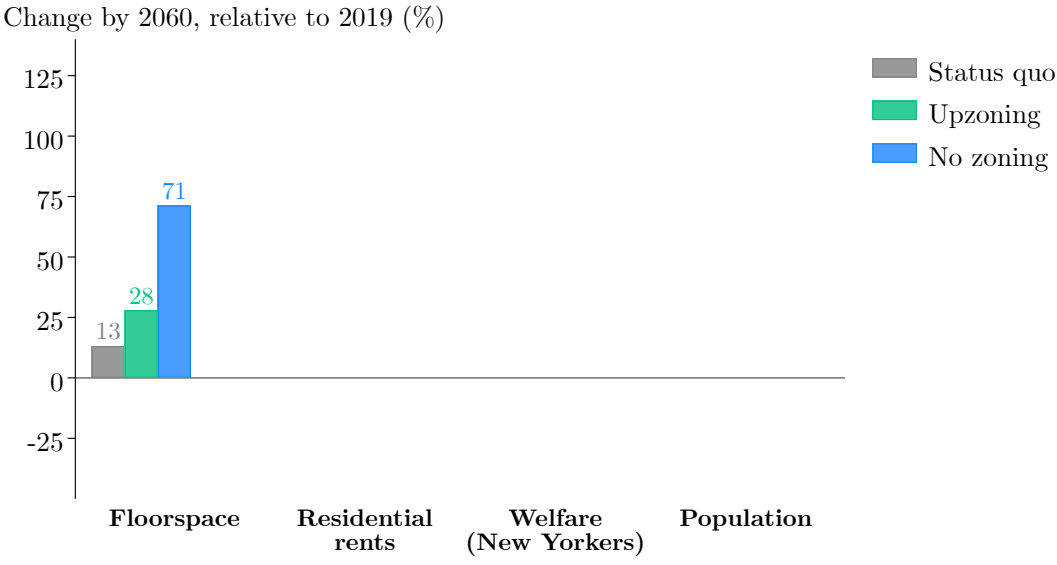
Under current zoning, NYC continues to grow slowly



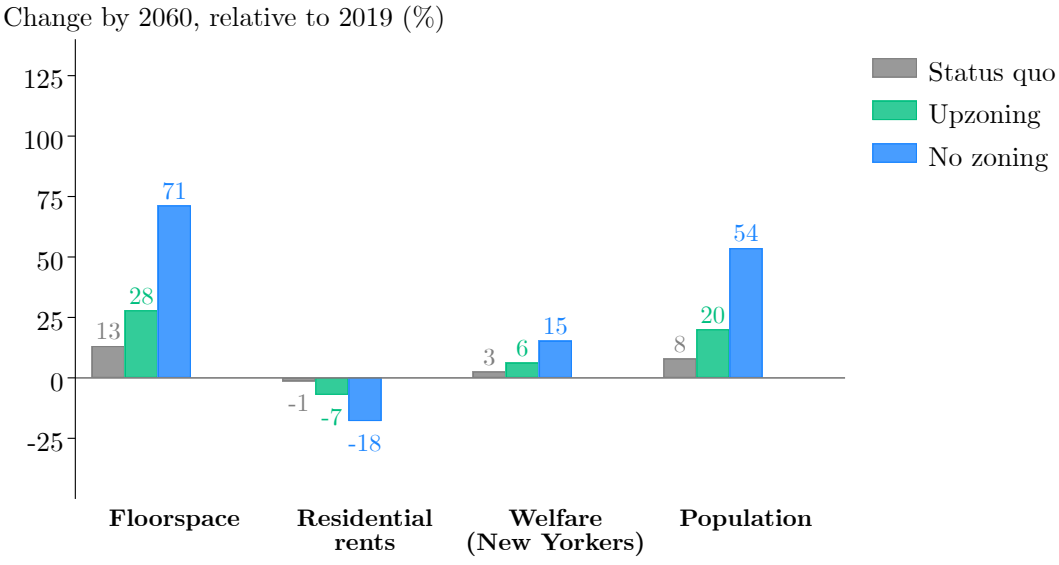
Upzoning increases floorspace by 15pp over 40 years



Completely removing zoning quintuples NYC's growth rate

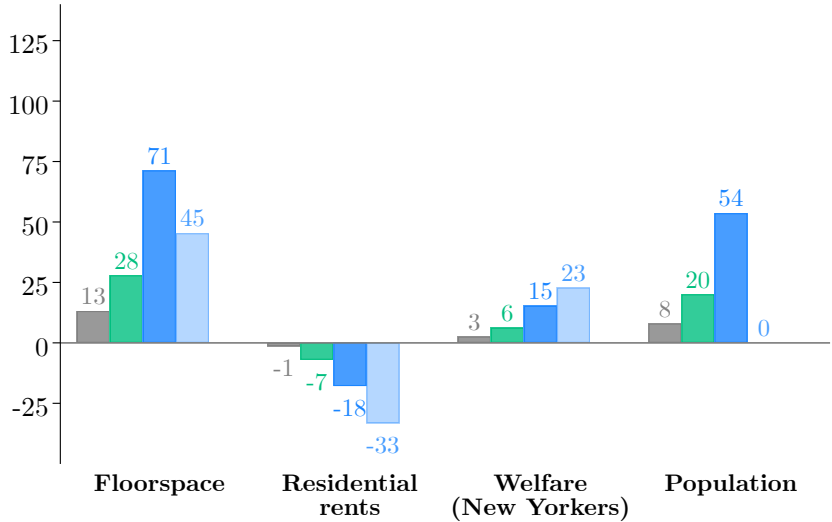


Rent decreases are moderate

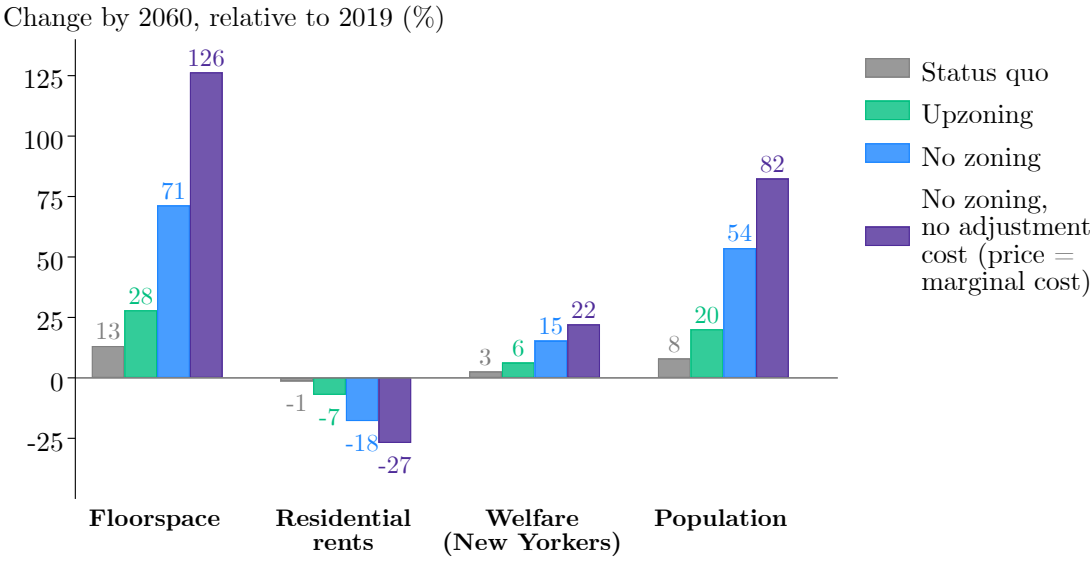


Rent decreases are moderated by migration

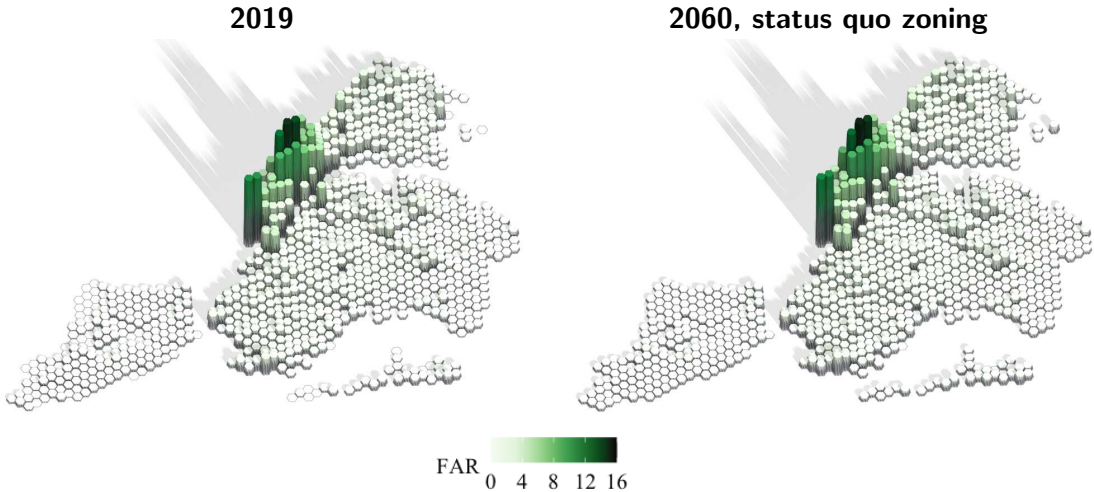
Change by 2060, relative to 2019 (%)



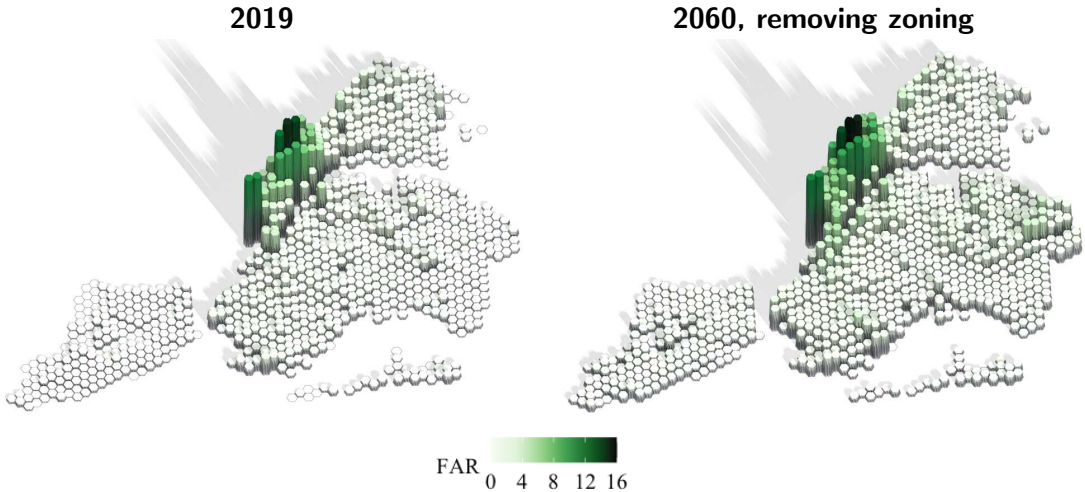
A model ignoring redevelopment greatly overstates effects



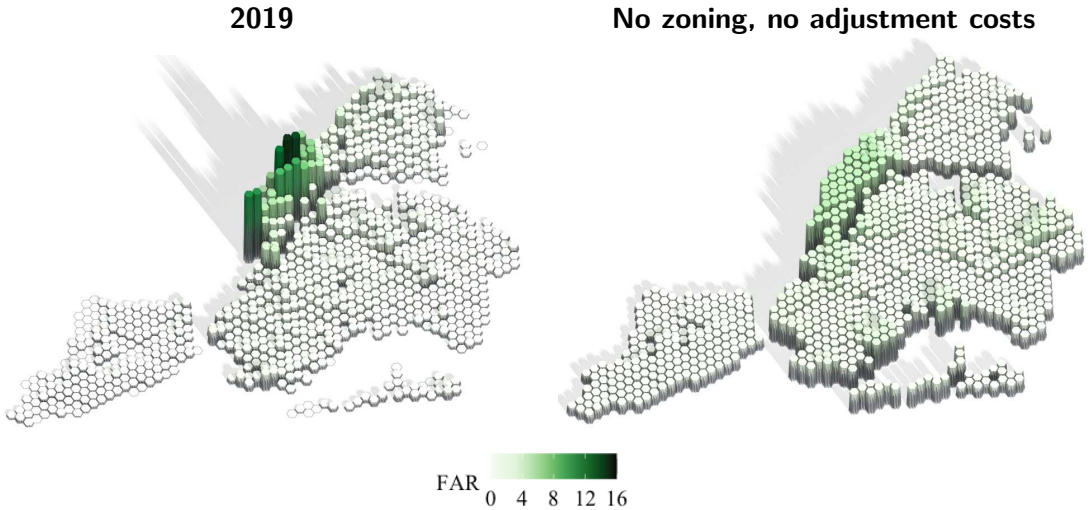
Technological constraints matter for credible counterfactuals



Technological constraints matter for credible counterfactuals

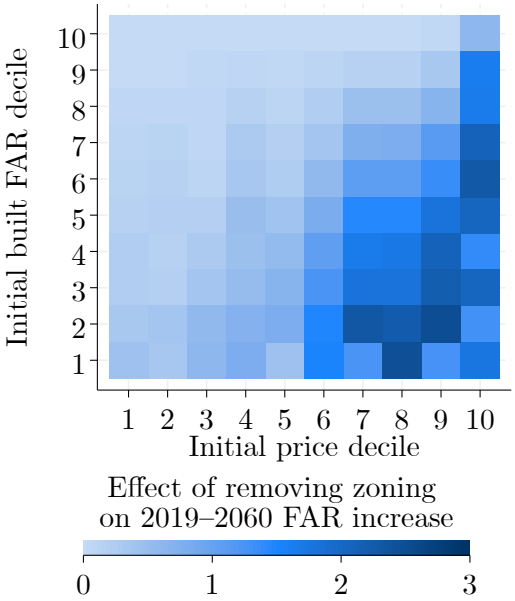


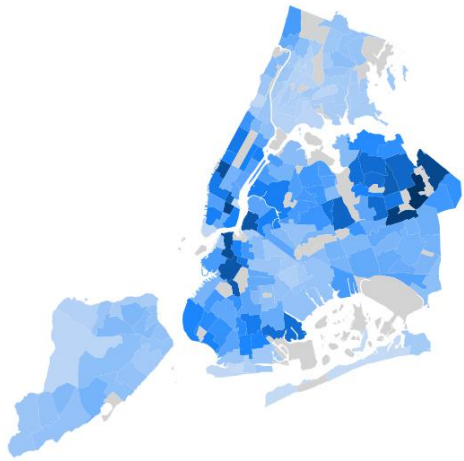
Technological constraints matter for credible counterfactuals



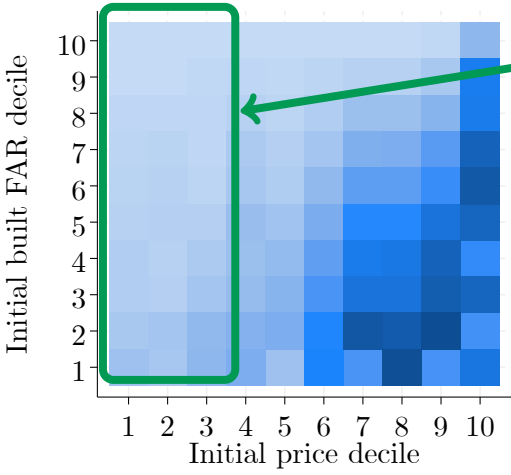
Where is zoning a constraint?

Where does relaxing zoning lead to increased supply?

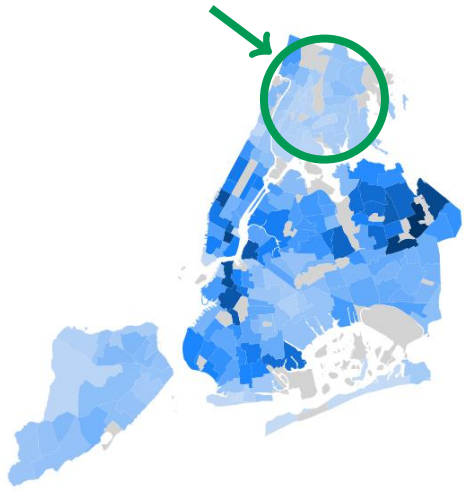




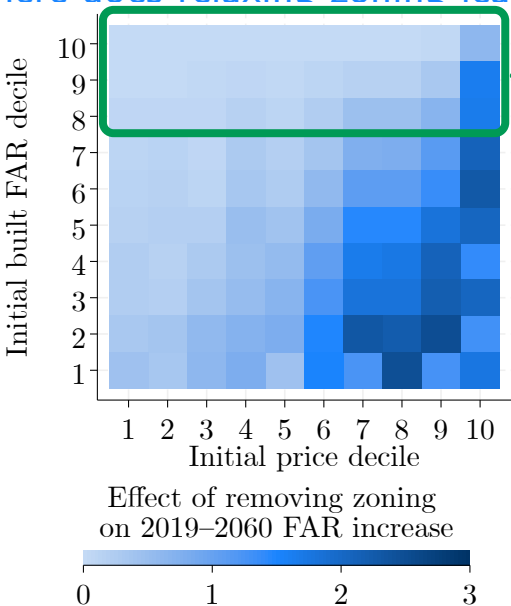
Where does relaxing zoning lead to increased supply?



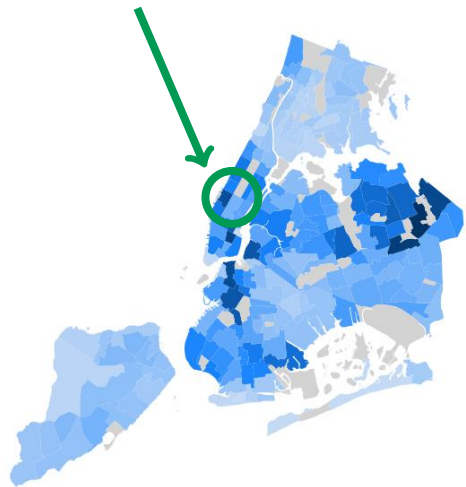
Zoning tends not to be binding when floorspace prices are low.



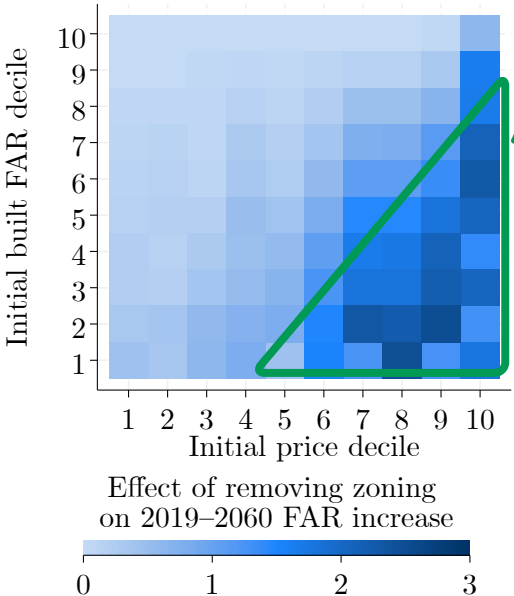
Where does relaxing zoning lead to increased supply?



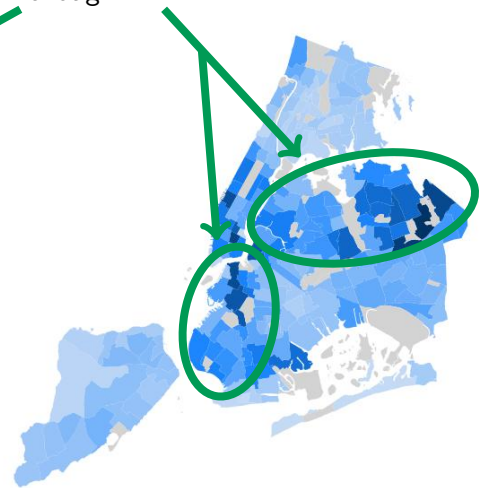
Removing zoning has little effect on parcels with tall buildings.



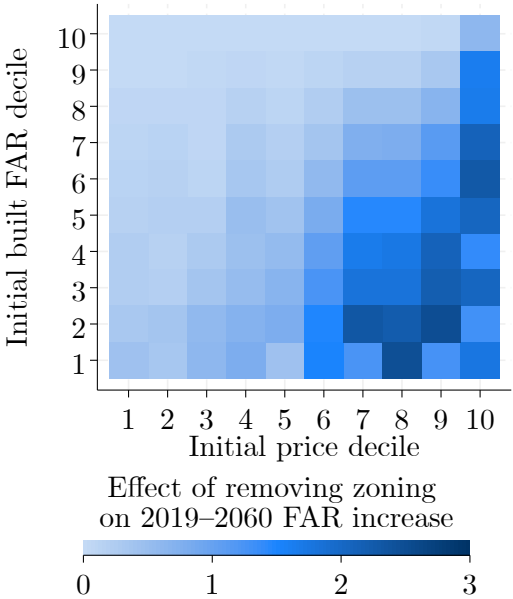
Where does relaxing zoning lead to increased supply?



Upzoning is effective when prices are high enough and density is low enough.



Where does relaxing zoning lead to increased supply?



- Upzonings should be **targeted**.
  - → Upzoning is politically costly.
  - → Can achieve half of the gains of removing zoning by deregulating 12% of the land.
- NYC's planners already do targeting.
- Upzoning would likely have limited effects in inexpensive cities.

Additional results

Additional results

- **Distributional effects**.
  - → Lower-income workers benefit more.

- **Alternative policies** to promote construction and affordability.
  - → Upzoning outperforms reducing construction costs and tax incentives.
  - → Contribution to the literature on the topic: Glaeser and Gyourko (2008), Soltas (2024)...

- **Supply elasticities**.
  - → Compute supply elasticities at a granular level and different time horizons.
  - → Supply elasticities vary widely across neighborhoods. Zoning is their primary determinant.
  - → Contribution to the literature on the topic: Saiz (2010), Baum-Snow and Han (2024)...

Why did NYC's planners impose costly zoning regulations?

Why did NYC's planners impose such costly regulations?

- Zoning creates large welfare losses. Why is it in place?
- When the zoning code was crafted in 1961, restricting construction had limited costs.
  - → Low population growth and land values, floorspace prices close to marginal cost.
  - → Zoning could help curb negative spillovers from manufacturing.
- Much has changed since 1961:
  - → Floorspace prices have skyrocketed, manufacturing activity has plummeted.
- But zoning has been much more persistent than planners anticipated and intended.
  - → Rezoning is vulnerable to obstruction by those with a stake in the status quo.

Conclusion

Conclusion

- **Redevelopment** is key to the economics of densely built areas.
  - → Increases the supply of floorspace and reallocates land to most profitable use.

- This paper provides a framework to analyze this process.
  - → I use it to study the effects of zoning.
  - → Can be applied to other questions (rent control, transit upgrades, remote work, structural transformation, property taxation).

- Large fixed costs of redevelopment.
  - → Even at a 40-year horizon, **take-up of upzoning is limited**.
  - → Upzoning works best when **prices are high/density is low**.

- Gains **take time to materialize** and are **geographically spread out**.
  - → Local reforms might look disappointing despite **large aggregate/long-term gains**.