Looking Down on the Suburbs: The Economics of Urban Sprawl

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US sprawl during the 20th century

US cities sprawled after World War 2

- Rapid expansion in land area, population density decline (Kim, 2007)
- Allowed by higher incomes and transportation improvements (Glaeser and Kahn, 2004; Baum-Snow, 2007)
- Also caused by central city decline and *while flight* (Boustan, 2010; Barr et al., 2018)

Sprawl stabilized after mid-1970s

- During 1976-92, US cities expanded in space, but did not become any sparser (Burchfield et al., 2006)
  $\rightarrow$ Measured using high-res land use satellite data
- Large differences across metro areas which remained stable in time

What happened since then?

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This paper: Sprawl has been (Unequally) reversing since the mid-1980s

Successful cities are gradually becoming denser and attracting population to central areas

- In late 1980s, successful cities converted land significantly faster than stagnant cities
- Gradually, fast growing cities have transitioned to more compact urban development...
- And big cities have attracted population to central areas
  - → This is driving a divergence in the characteristics of urban spaces

I show this by building a novel high resolution panel of land use, buildings and population

- For 9 billion cells covering the United States, in 1985-2023
- Created by combining historical Landsat-derived data with:
  - → Building polygons for today
  - → Population data at block group level

Hypothesis: Partly driven because of the recovery of central city amenities in big cities

- → Currently working on structural model to measure this
- → But also role of productivity divergences and land use regulations

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Outline

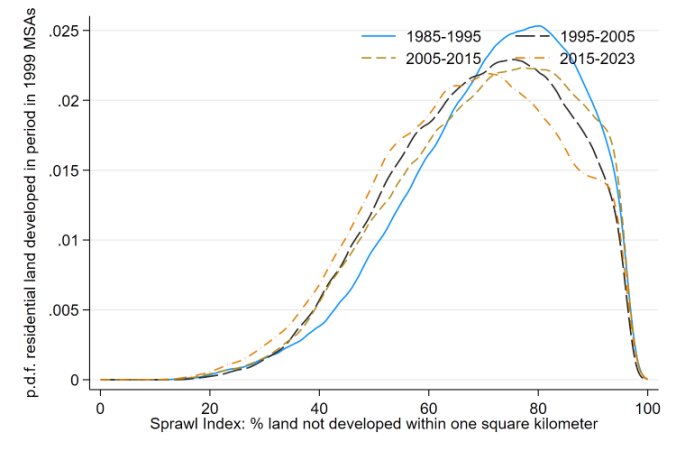
Trends in urban development

Constructing a high resolution panel of land use and buildings

Why is this happening?

Successful cities have been driving an (Unequal) increase in urban compactness

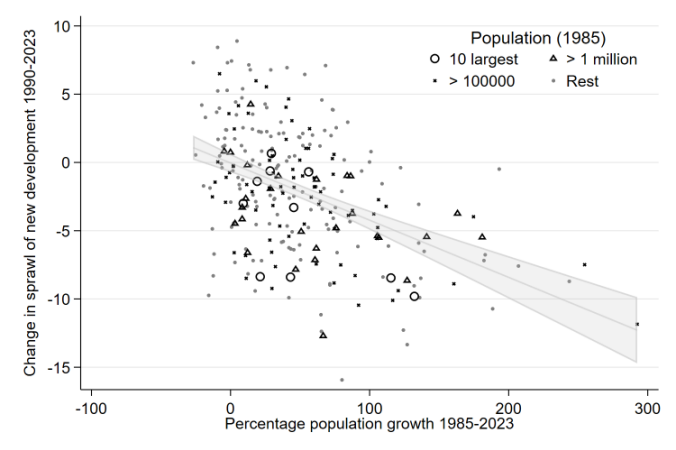
Average building constructed in 1985-90 surrounded by 72.92% open space, 69.81% in 2020-23



p.d.f. of sprawl of new urban development, at the building level, in 10 year windows. Note the gradual increase in compactness overall, excepting the years after the financial crisis

Successful cities have been driving an (Unequal) increase in urban compactness

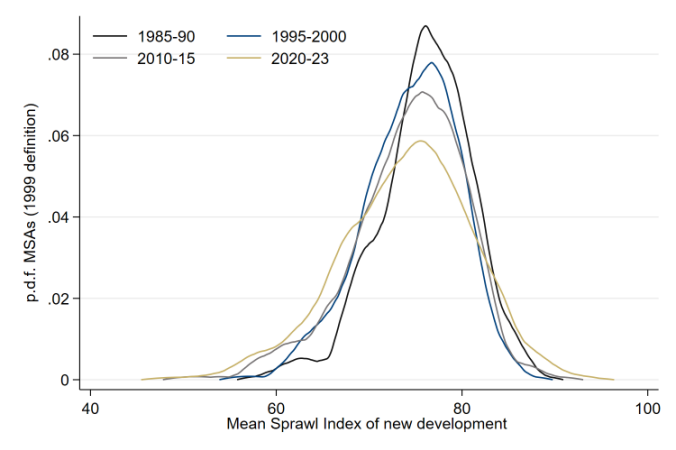
Driven by cities that have grown faster in population



Change in average sprawl of new development by MSA, as a function of population growth. On average, cities that have grown more in population have become differentially denser.

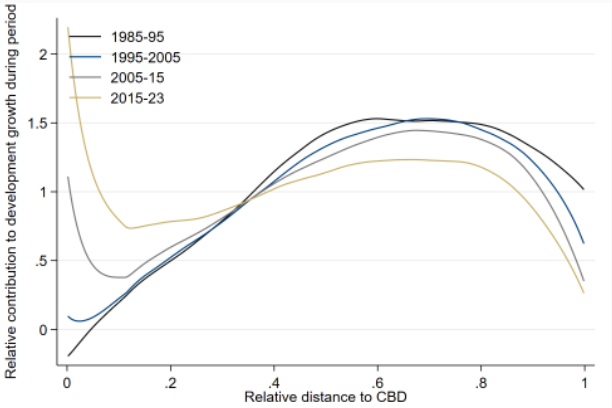
Successful cities have been driving an (Unequal) increase in urban compactness

Dispersion in the compactness of new development gradually increased across metro areas



p.d.f. of average sprawl of new urban development at the metro area level, in 5 year windows. Metro areas according to the 1999 Metropolitan Statistical Area definition (n = 275). Note the gradual increase in the spread of this measure, across metro areas. Variance of the distribution doubled over the period.

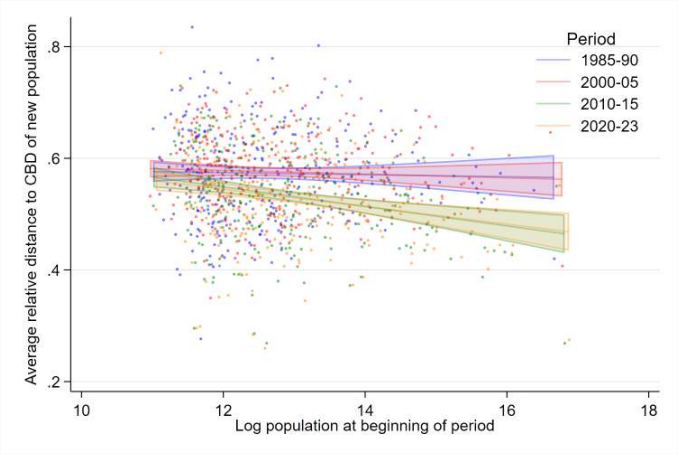
Population growth (But not land conversion) is shifting to city centers



Relative contribution to population growth of locations at different relative distances to the CBD, by decade. Horizontal axis represents relative distance to the city center at the end of the period. Average new inhabitant moved to $54th$ percentile of distance to their city center in 1985-95, $49th$ percentile in 2015-23

Not for urban development

This is driven by larger cities



p.d.f. of relative distance to the city center of new population, by decade. Population growth keeps shifting towards city centers.

New development still in the outskirts

Urban land conversion slowed down after the housing bubble

US built-up or paved land grew $\approx 1\%$ annually in 1985-90, $\approx 0.7\%$ in 2010-23

$\rightarrow$ After exploding during housing bubble: Peak of $\approx 2.10\%$ in 2000-2005 period

Year	United States	All metro areas	Most populated 30 MSAs in 1985
1985-1990	1.01	1.08	1.08
1990-1995	1.07	1.11	1.05
1995-2000	1.74	1.80	1.62
2000-2005	2.10	2.19	2.01
2005-2010	1.31	1.29	1.07
2010-2015	0.61	0.59	0.48
2015-2020	0.76	0.78	0.64
2020-2023	0.73	0.74	0.62

Table 1: Annual rate of growth of paved or built-up land, in 5 year periods. Metro areas according to the 1999 Metropolitan Statistical Area definitions

Urban land conversion slowed down after the housing bubble

Across metro areas, distribution of growth rates compressed

→ Almost no destruction, since buildings depreciate very slowly (Glaeser and Gyourko, 2005)

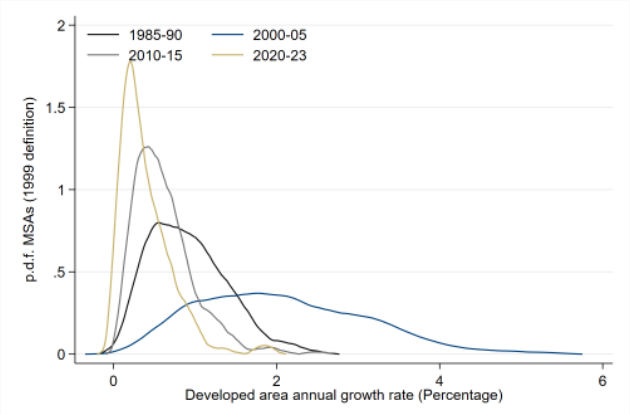


Figure 1: Annual rate of growth of paved or built-up land, in 5 year periods, p.d.f at metro area level. Metro areas according to the 1999 Metropolitan Statistical Area definitions. Note how the distribution gets compressed after the housing crisis.

Urban land conversion slowed down after the housing bubble

Decrease driven by cities that grow fast in population

→ Decrease in elasticity of land conversion to population growth

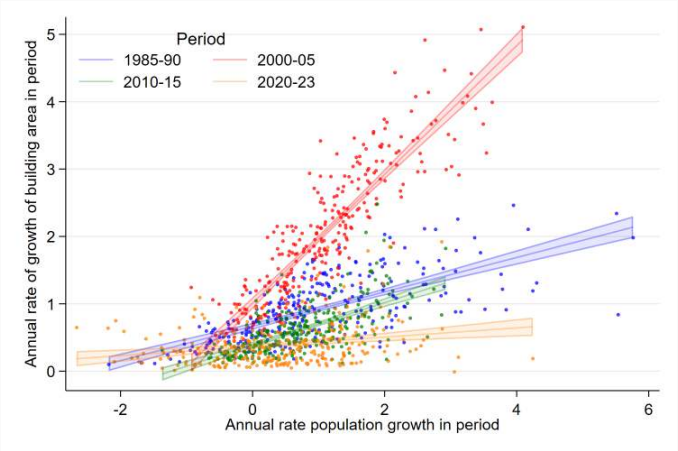


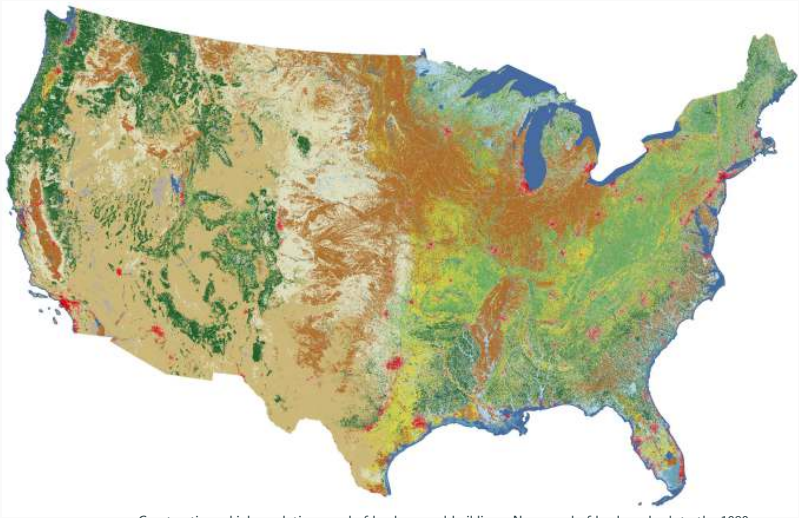
Figure 1: Scatterplot of annual rate of growth of urban land as a function of annual rate of growth of population, by five-year period.

Outline

Annual NLCD 2023: Land use 1985-2023 (United States Geological Survey, 2024)

High resolution dataset in raster format derived from Landsat Thematic Mapper imagery

- **Land cover**, % area developed for 30x30 meter cells across the conterminous United States



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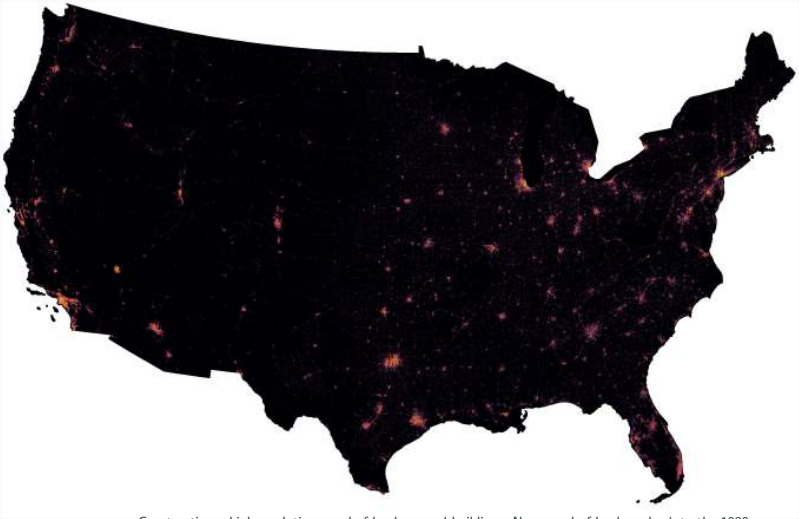
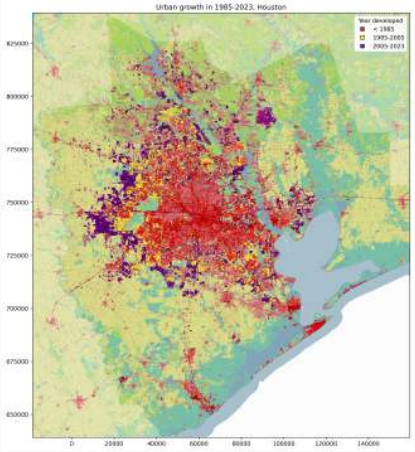
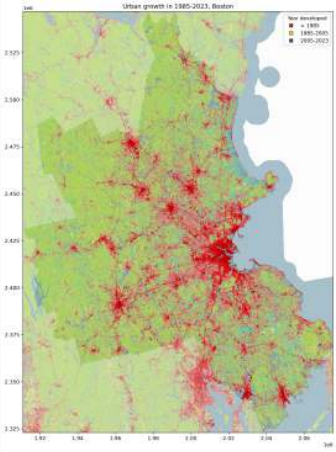


Annual NLCD 2023: Land use 1985-2023 (United States Geological Survey, 2024)

Expanded back to 1980s due to advances in processing of Landsat time series (Tollerud et al., 2023)



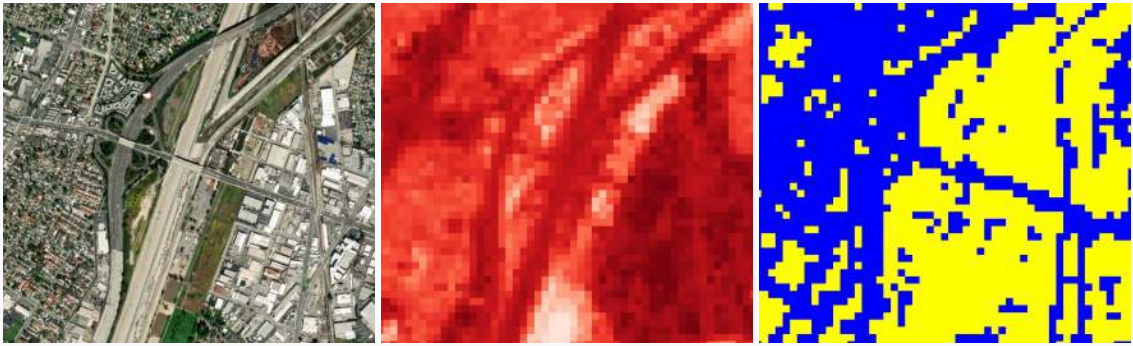
(a) Houston, TX



(b) Boston, MA

A tale of two cities. Development that was present before 1985 in red. New development 1985-2005 in yellow. New development 2005-2023 in purple.

Caveat: Does not distinguish well between buildings and pavement



(a) Visible light **(b)** Imperviousness percentage **(c)** Impervious descriptor

Example of how the NLCD is good at detecting artificial surfaces, but bad at distinguishing buildings from other paved surfaces. In panel (c) blue represents roads, yellow buildings. An entire residential area is classified as primarily road, while the river/canal is classified as primarily buildings.

Solution: Cross-section of building polygons in 2024

Overture Foundation buildings data, $\sim$ 180 million building polygons

$\rightarrow$ From very high resolution satellite imagery obtained today

(a) Visible light **(b)** Building polygons

Solution: Cross-section of building polygons in 2024

Overture Foundation buildings data, $\sim$ 180 million building polygons

$\rightarrow$ Rasterize to format of NLCD $\rightarrow$ % of 30x30m cell covered by buildings

(a) Visible light **(b)** Rasterized building polygons

I use the NLCD Percentage Imperviousness layer to date the construction of buildings

Example: New development in outskirts of Houston, 2015 to 2023

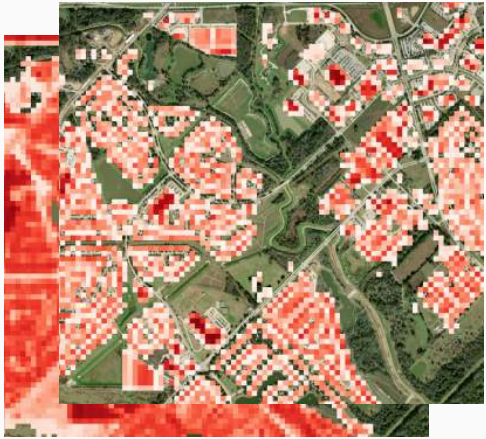
(a) 2015, Esri World Imagery

(b) 2023, Esri World Imagery

I use the NLCD Percentage Imperviousness layer to date the construction of buildings

I have the NLCD panel for both periods, rasterized footprints for 2023

(a) 2015, NLCD percentage imperviousness



(b) 2023: Both

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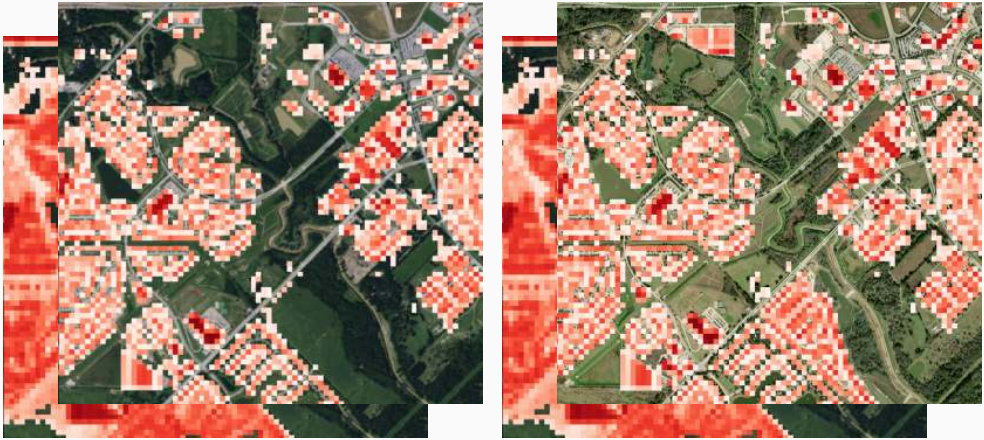
I impute the building footprints in 2015 by using the 2015 NLCD



(a) 2015, Both

(b) 2023: Both

Create high resolution population data: Census data + panel of footprints

I impute block-group level Census population data to panel of buildings

(a) Building footprints in NY, 1985

(b) Population in NY, 1985

Create high resolution population data: Census data + panel of footprints

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(a) Building footprints in NY, 2023

(b) Population in NY, 2023

Urban compactness: Sprawl Index from Burchfield et al. (2006)

$\forall$ cells containing a building, $\forall$ years in the data, draw a circle of one square kilometer area:

$\rightarrow$ Sprawl index of building is percentage of land that remains undeveloped in that area

(a) Location with 50% sprawl

(b) Location with 40% sprawl

Outline

Patterns of land are a market outcome

Recent work emphasizes housing supply responses in both intensive and extensive margins

→ Murphy (2018) and Baum-Snow and Han (2023)

- Locations with higher demand for housing should be less sprawling
- But obviously, local supply responses vary due to many reasons (Regulation, labor costs, geography...)

Both the spatial patterns of demand and supply have changed due to:

- Big cities becoming more amenity-rich, especially for high skill people
- Big cities have become more productive, especially for high skill people
- (Some) high amenity, high productivity cities have become heavily regulated

The trends I find in this paper are an equilibrium byproduct of this

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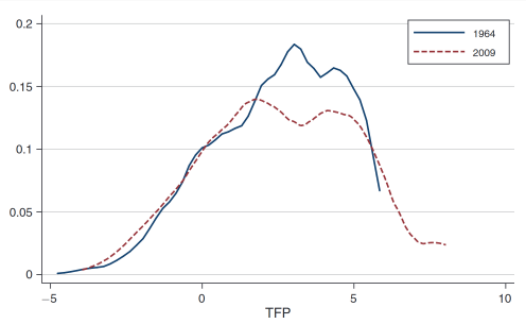
Labor productivity is diverging across cities (Particularly for high skill people)

→ Baum-Snow and Pavan (2013), Diamond (2016), Ganong and Shoag (2017), Hsieh and Moretti (2019), Lee and Lin (2018), and Couture, Gaubert, et al. (2024)

→ Could explain differences across metro areas, but not why the population is centralizing

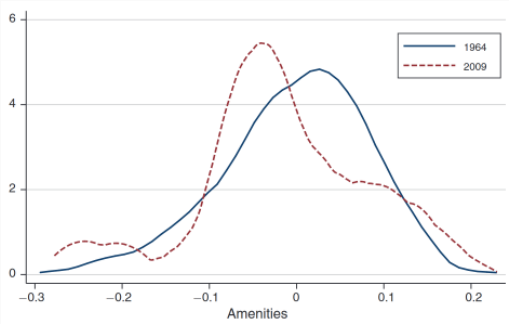


Distribution of TPF across 220 metro areas in 1964 and 2009 (Source: Hsieh and Moretti, 2019)

Urban revival: Big central city amenities are increasingly attracting high skill households

→ Diamond (2016), Baum-Snow and Hartley (2020), Couture and Handbury (2020), and Couture, Gaubert, et al. (2024)

- Elasticity of non-work related trips to distance higher than work trips (Miyauchi et al., 2021)
  → Could explain centralization of population in fast-growing cities



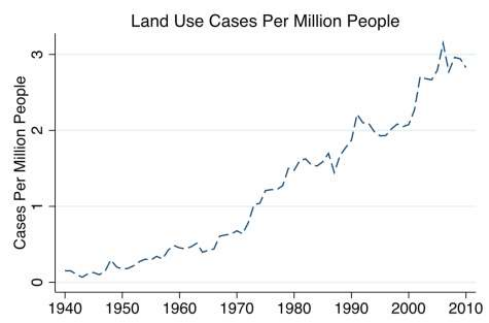
Distribution of endogenous amenities (As measured in their model) across 220 metro areas in 1964 and 2009 (Source: Hsieh and Moretti, 2019)

Increasingly restrictive land use regulations in high demand coastal areas

→ Glaeser, Gyourko, and Saks (2005), Ganong and Shoag (2017), Lee and Lin (2018), Hsieh and Moretti (2019), Baum-Snow and Han (2023), and Orlando and Redfearn (2024)

→ Much variation within cities (Gyourko et al., 2008; Glaeser and Ward, 2009; Bartik et al., 2023)

→ Likely having a dampening effect since they push population away to lower demand cities



Trend in land use court cases in state courts per million people (Source: Ganong and Shoag, 2017)

Decomposing impact of work accessibility, local amenities, and housing supply elasticities

What is the role of these factors in driving the trends in the data?

- Labor productivity is diverging across cities (Particularly for high skill people)
- Urban revival: Big central city amenities are increasingly attracting high skill households
- Increasingly restrictive land use regulations in high demand coastal areas

I need to develop a model with these ingredients

- Distinguish demand due to workplace accessibility from demand due to urban revival/gentrification
- Measure distortionary role of diverging land use regulations

Quantitative Spatial Model in the family of Ahlfeldt et al. (2015)?

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Quantitative Spatial Model in the family of Ahlfeldt et al. (2015)?

A quantitative spatial model with heterogeneous housing supply

Ahlfeldt et al. (2015)'s model: a spatial model with discretized spatial units (eg.Census Tracts)

- Households make residential, workplace choices over tracts
  - $\rightarrow$ Flows assumed to follow a gravity equation
- Each tract has a local market for labor and residential/commercial floorspace
- There is a market for a homogeneous consumption good
- All markets are perfectly competitive

Tracts differ in fundamentals and outcomes:

- Exogenous component to local productivity and amenities
  - $\rightarrow$ For this application, also differences across local developer sectors
- Outcomes: population, workers, flows, salaries, prices, **development outcomes**
- A spillovers component (Due to density or composition) of productivity and amenities

This is great, but there are identification challenges!

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Identification problem: I want to identify both amenities AND heterogeneous housing supply

These models are estimated recursively...

1. Gravity equation + commuter flows identify wages
2. Wages and land prices identify local productivity
3. A measure of "Resident Market Access" (RMA) identifies residential amenities
   → Expected wage living at tract, discounted by commuting costs
4. Population and employment distribution: decompose productivity and amenities
   → into exogenous fundamentals and spillover effects
5. **Land market clearing determines floorspace supply**

And variation across tracts is identified by...

$1, 2$ Zero profit condition in tradeable sector

$3, 4$ Exogenous shock to RMA across tracts

5 **Usually no variation in local housing supply fundamentals (Here is my identification problem)**

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Conclusion

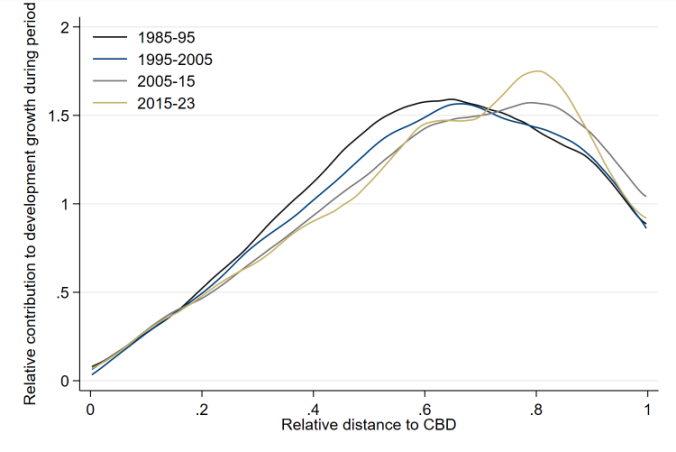
I use a novel panel of land use to show that the US is densifying again

- Decreasing land conversion
- More compact development
- Population moving to centers of big cities

I propose a quantitative urban model to understand the reasons why

Thanks for your attention!!!

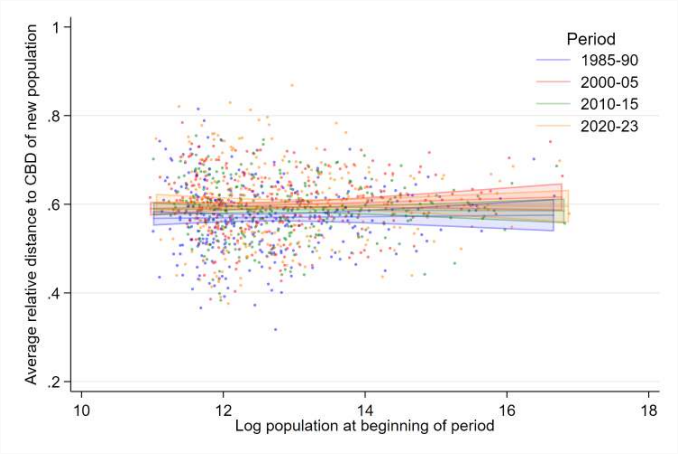
New urban development has not shifted from the outskirts



Relative contribution to new development of locations at different relative distances to the CBD, by decade. New buildings are built primarily in the outskirts, and the distribution has shifted slightly to the outskirts. Average new urban development: located at $62th$ percentile in 1985-95, $63rd$ in 2015-23

Back

Land conversion has not become more central for larger cities



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