Agglomeration and Green Commercial Development Within Cities

Evan Perry

MEA Conference

Coe College

March 25, 2022

Preview

Research Question

Can agglomeration economies help explain why some neighborhoods have more green commercial buildings than others?

- Theory: Build a model to describe how firms choose (1) where to locate, and (2) whether or not to occupy a green building
- Evidence: Test the primary hypothesis of the model empirically—that neighborhoods dense with workers have disproportionately more green commercial real estate

Why Green Buildings? Why Their Location?

- Green building: energy-efficiency or sustainability certification that shows it has smaller carbon footprint than otherwise comparable buildings

- 30% of US greenhouse gas emissions are tied to buildings (RFF, 2021)
  - 18% through electricity consumption
  - 12% directly from buildings (heating/cooking)

- Location may be an effective way to target green building incentives towards the firms who are least likely to make energy-efficient upgrades on their own

Agglomeration Economies

Why do firms locate in dense urban areas?

- "benefits that come when firms and people locate near one another together in cities and industrial clusters" (Glaeser, 2010)
- Labor pooling, knowledge spillovers, proximity to inputs
- Some firms experience higher agglomeration economies than others (Gaubert, 2018)
- Benefits are driven by the density (proximity) of workers

Model Overview

Environment City with many neighborhoods that differ only in their # of workers

Agents Firms choose between neighborhoods and green or brown real estate
Developers choose how much green and brown real estate to build

Behavior Profit maximizing, others enter/exit competitively

Equilibrium Agents indifferent between where they are and anywhere else
Labor market and both segments of the real estate market clear

Agents

Firms

- Choices: What neighborhood? Occupy green or brown real estate?
- Tradeoffs: $\uparrow$ Productive Location $\Rightarrow \uparrow$ Wages, $\uparrow$ Rents
- Heterogeneity:
  - Agglomeration economies: Benefits from locating in a dense neighborhood
  - Ecological responsiveness: Benefits from green building
- Assume: High agglomeration benefits more often come with high benefits from green building

Agents

Firms

- Choices: What neighborhood? Occupy green or brown real estate?
- Tradeoffs: $\uparrow$ Productive Location $\Rightarrow \uparrow$ Wages, $\uparrow$ Rents
- Heterogeneity:
  - Agglomeration economies: Benefits from locating in a dense neighborhood
  - Ecological responsiveness: Benefits from green building
- Assume: High agglomeration benefits more often come with high benefits from green building

Developer

- Choices: How much green real estate? How much brown real estate?
- Tradeoffs: Some firms willing to pay more green, but green costs more to build

Figure 1: Example with Two Types of Firms

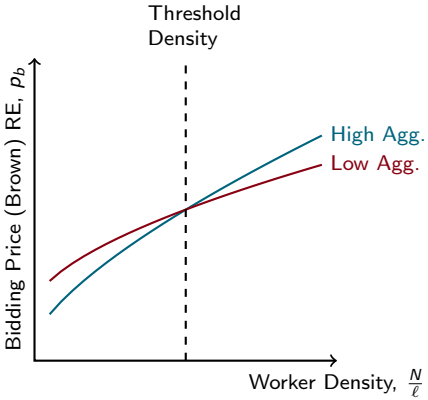


Figure 1: Example with Two Types of Firms

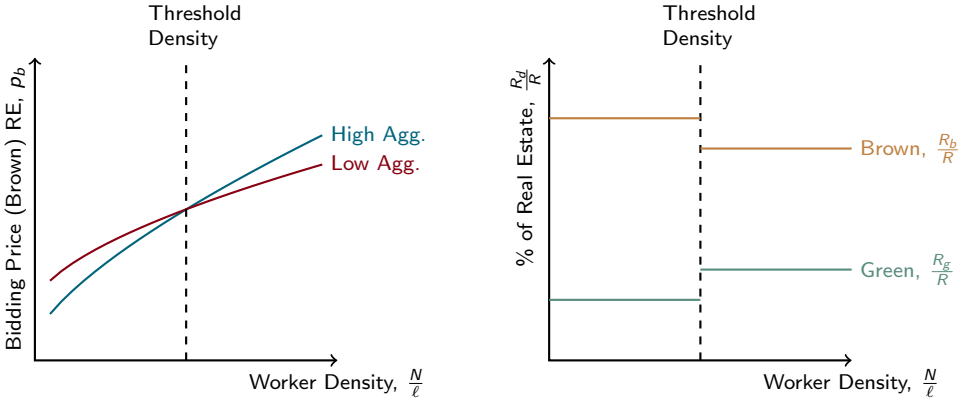
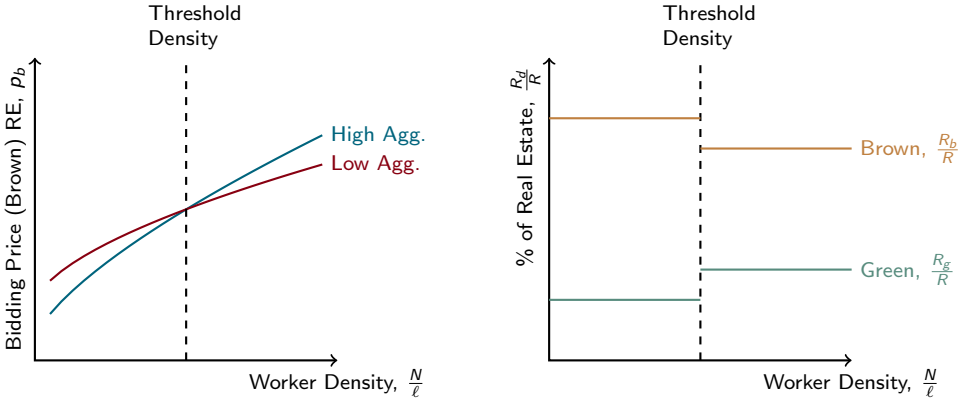


Figure 1: Example with Two Types of Firms



Worker-dense neighborhoods (with high agglomeration benefits) have a higher proportion of green real estate

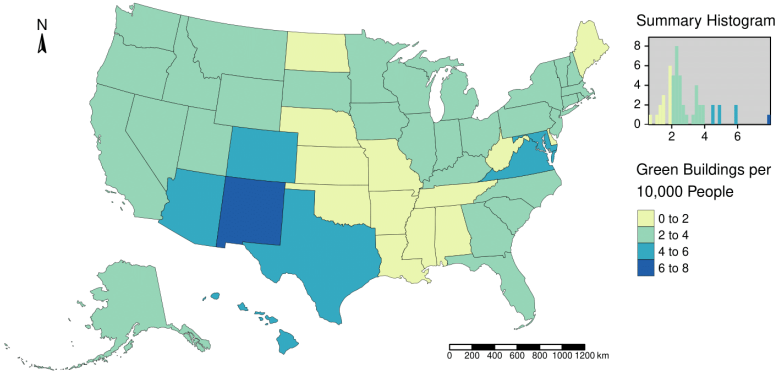
Data Overview

Do worker-dense neighborhoods really have a higher proportion of green real estate?

- Use census tracts (neighborhoods) as unit of analysis

- For each neighborhood, collect data on:
  - Green buildings
  - Workers
  - Demographics

Figure 2: Green Buildings per Capita by State



- Registry of Energy Star Certified Buildings and Plants
- Leadership in Energy and Environmental Design (LEED) Program Database

Neighborhood Data

- Census data from the 2019 American Community Survey (ACS)
- Cellphone data from Safegraph
  - Agglomeration is driven by the density of workers, but how many people are employed in a neighborhood?
  - Safegraph is a private company that collects GPS data on over 20 million cellphones
  - Worker population: the number of devices located in the census tract during conventional working hours (7:30am to 5:30pm, Monday through Friday) more than any other census tract over the previous 45 days

Table 1: Summary Statistics

	Full Sample			≥ 1 Green Building		No Green Buildings	
	Mean	Median	StnDev	Mean	Median	Mean	Median
Green Commercial Real Estate							
Green Comm. Buildings	1	0	3	3	1	0	0
Green Comm. Real Estate (ft^2)	131,266	0	893,299	422,467	96,786	0	0
Cellphone Data							
Worker Population	3,042	2,130	3,135	4,813	3,662	2,243	1,734
Worker Density (workers/mi^2)	6,029	3,069	13,089	8,385	3,965	4,967	2,723
Residents							
Residential Population	4,248	4,040	1,931	4,546	4,334	4,113	3,904
Median Household Income	67,913	60,136	36,238	72,400	64,495	65,894	58,054
Median Age of Residents	38	37	7	37	37	38	37
Proportion White	0.619	0.689	0.265	0.654	0.710	0.603	0.674
Proportion Black	0.191	0.078	0.254	0.156	0.071	0.207	0.082
No. of Observations	35,853			11,140		24,713	

Empirical Model

For Neighborhood i in City k,

$$\log(GRE_{ik}) = \alpha + \beta \log(N_{ik}) + \gamma \mathbf{X}_{ik} + \sum_{k=1}^{K} \left[\delta_k \log\left(\frac{N_{ik}}{\ell_{ik}} \right) c_k \right] + \varepsilon_{ik} \qquad (1)$$

GRE	Green Real Estate (ft.^{2})
N	Worker Population
$\mathbf{X}$	Vector of Neighborhood Covariates
$\frac{N}{\ell}$	Worker Density
c_k	Dummy variable for City k

If the predicted relationships holds, then $\delta_k > 0$.

Table 2: Estimation of Equation (1)

	Log [Green Real Estate (ft^2)]			
	$\geq$ 20 Tracts per City		$\geq$ 40 Tracts per City	
	(1)	(2)	(3)	(4)
Log Worker Population	0.961**	0.941**	0.972**	0.947**
	(0.028)	(0.033)	(0.030)	(0.035)
Log Median Resident Age		−1.500**		−1.552**
		(0.136)		(0.145)
Log Income per Capita		0.898**		0.935**
		(0.073)		(0.077)
Log Worker Density – City	✓	✓	✓	✓
Observations	9,495	8,064	8,550	7,271
R^2	0.191	0.229	0.186	0.227
Adjusted R^2	0.183	0.220	0.180	0.221
Notes:	**Sig. at the 1% level; *Sign. at the 5% level			

Figure 3: Distribution of $\widehat{\delta}$ in Cities with ≥ 20 Tracts

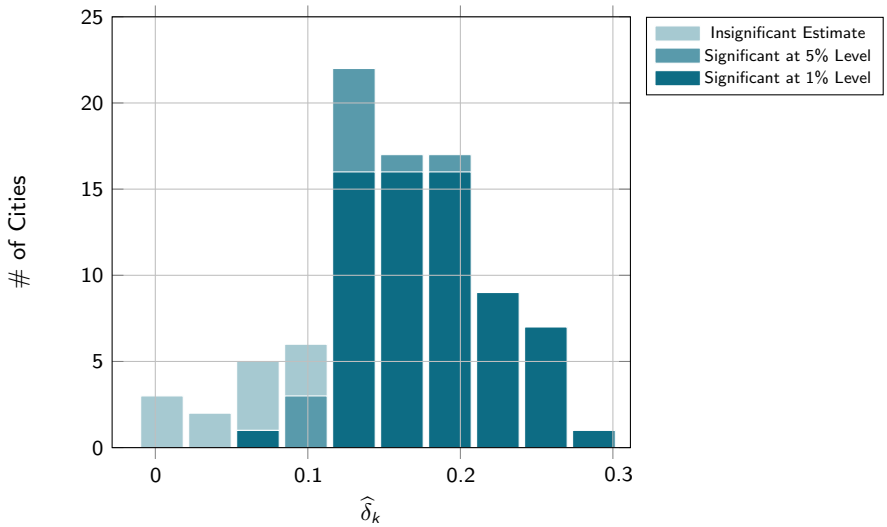
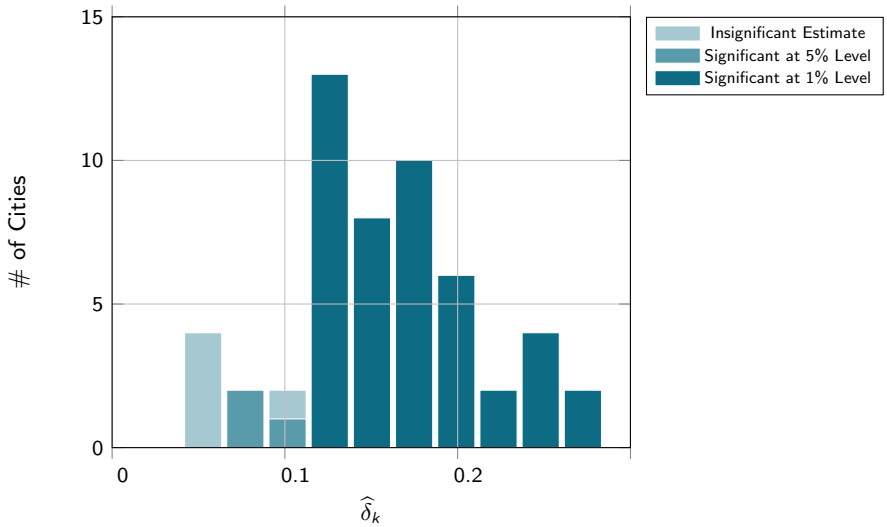


Figure 4: Distribution of $\widehat{\delta}$ in Cities with ≥ 40 Tracts



Takeaways & Policy Implications

- In the model, firms that prefer to "go green" also prefer to locate in worker-dense neighborhoods
- Empirical results fit with this finding: low worker-density neighborhoods have a smaller proportions of green commercial real estate
- Suggests public policy supporting green commercial development locally may be more effective when targeted towards low worker-density areas

References

Allcott, Hunt and Michael Greenstone, "Is there an energy efficiency gap?," *Journal of Economic Perspectives*, 2012, *26* (1), 3–28.

Bansal, Pratima and Kendall Roth, "Why companies go green: A model of ecological responsiveness," *Academy of Management Journal*, 2000, *43* (4), 717–736.

Braun, Thomas and Sven Bienert, "Is green (still) a matter of prime? Stylized facts about the location of commercial green buildings," *Journal of Sustainable Real Estate*, 2015, *7* (1), 160–182.

Eichholtz, Piet, Nils Kok, and John M Quigley, "Ecological responsiveness and corporate real estate," *Business & Society*, 2016, *55* (3), 330–360.

Gaubert, Cecile, "Firm sorting and agglomeration," *American Economic Review*, 2018, *108* (11), 3117–53.

Glaeser, Edward L, *Agglomeration economics*, University of Chicago Press, 2010.

RFF, "US carbon emissions at a glance," *Federal Climate Policy Toolkit*, 2021.

Firm's Problem

$$\max_{L,R,d,N} \{\pi(L,R,d,N)\} = \max_{L,R,d,N} \left\{ \mathcal{A}\ L^{\beta} R^{\gamma} \bar{K}^{1-\beta-\gamma} - WL - p_d R - k_{ij} \right\}$$

- L: Labor
- R: Real Estate
- K: Capital
- W: Market Wage
- p_d: Price of Real Estate with design d
- d: Green or Brown, $d \in \{g, b\}$

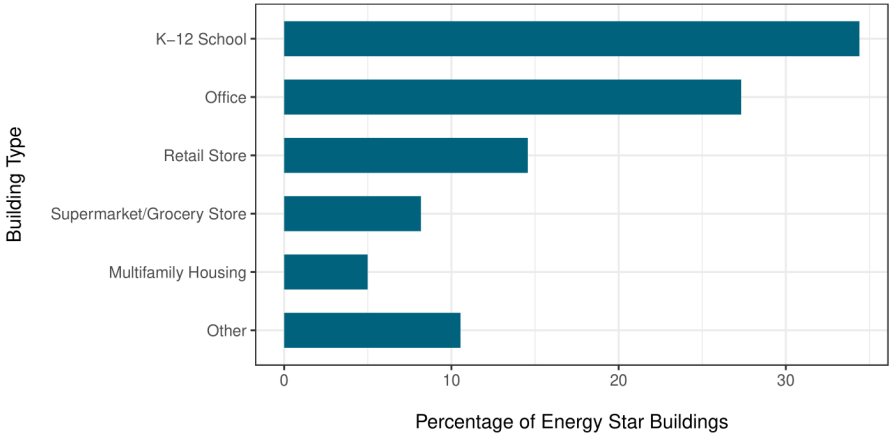
where $\mathcal{A} = A\ \psi(\alpha_i, N)\ \lambda(d, \theta_j)$

Developer's Problem

$$\max_{h_g, h_b, \ell_g, \ell_b} p_g h_g \ell_g - c_g h_g^{\delta} \ell_g + p_b h_b \ell_b - c_b h_b^{\delta} \ell_b - p_\ell \bar{\ell} \quad \text{s.t.} \quad \bar{\ell} = \ell_g + \ell_b$$

- h: Height
- ℓ: Land
- c: Cost parameter
- p: Price of Real Estate

Energy Star Certified Building Classifications



LEED Certified Building Classifications

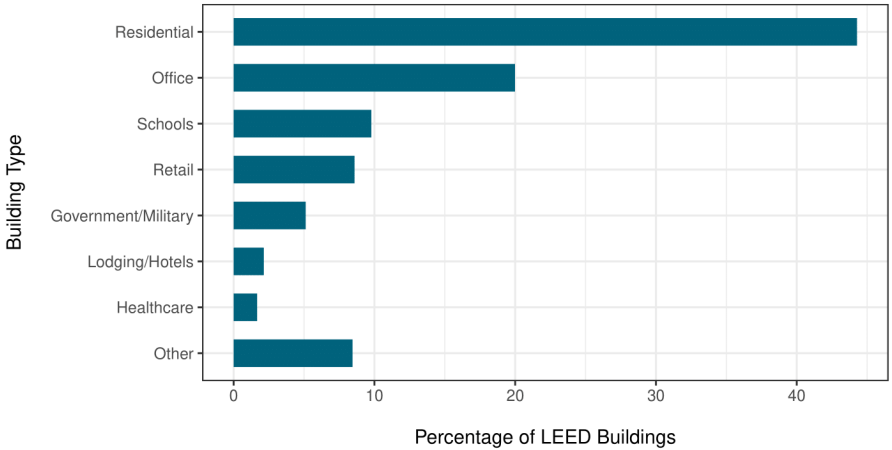


Table 3: Estimation with Log + 1

	Log [Green Real Estate (ft^2) +1]			
	$\geq$ 20 Tracts per City		$\geq$ 40 Tracts per City	
	(1)	(2)	(3)	(4)
Log Worker Population	3.221**	3.138**	3.225**	3.138**
	(0.038)	(0.045)	(0.039)	(0.046)
Log Median Resident Age		−2.501**		−2.634**
		(0.198)		(0.205)
Log Income per Capita		2.221**		2.312**
		(0.113)		(0.115)
⋮		⋮		⋮
Log Worker Density – City	✓	✓	✓	✓
Observations	33,691	28,100	31,714	26,376
R^2	0.262	0.296	0.259	0.295
Adjusted R^2	0.258	0.291	0.256	0.292

Notes: **Sig. at the 1% level; *Sig. at the 5% level

Estimation Results