
Modeling Green Development

Another Spatial Equilibrium Model

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Research Question

What characteristics of urban neighborhoods relate to the number of certified green commercial buildings?

Previously,

- General Equilibrium / Spatial Equilibrium Model
- Prediction: Neighborhood characteristics do not matter

Purpose How does firm location interact with green building adoption?

Model Describe how firms (1) decide to buy green real estate, and (2) sort into neighborhoods

Method Optimization and Equilibrium Characterization

Results We find (1) adoption is unaffected by neighborhood choice, (2) firms with higher agglomeration economies move to more productive neighborhoods

Model Overview & Environment

Model Overview

- Two Agents: Firms, Developers
- Labor Market is Exogenous
- Sorting Model: Agents need to determine where to locate
- Adoption Model: Agents need to decide green or brown
- Heterogeneous Firms:
 - ▶ Agglomeration Economies
 - ▶ Environmental Response

Model Environment

- Assume an arbitrary number of neighborhoods
- Neighborhoods have:
 - ▶ Unique “Raw Productivity”: A
 - ▶ A is the *only* unique characteristic of neighborhoods ex ante
 - ▶ Commercially Zoned Land: $\bar{\ell}$
 - ▶ As many workers as firms want, willing to work at a wage \bar{W}

Example: $A_1 < A_2 < A_3 < A_4$



Agents & Behavior



Firm Heterogeneity: Agglomeration Economies

*“Agglomeration economies exist whenever people become more productive through proximity to others. They can represent the gains that come from reducing transport costs . . . , or the **advantages associated with the free flow of ideas in dense urban environments**. Agglomeration economies are the catchall explanation for why cities can be so productive” (Glaeser, 2008)*

Summarize agglomeration effects with $\psi_i(A)$

- Raw Productivity: A
- $\psi_i(A)$ is (super-linearly) increasing in A (Gaubert, 2018)
- Agglomeration Economies: $i \in \{High, Low\}$
- $\psi_H(A) > \psi_L(A)$

Firm Heterogeneity: Green Potential

Firms differ in the benefits they can receive from going green:

Summarize benefits with λ_{jd} :

- Potential: $j \in \{High\ Potential, Low\ Potential\}$
- Design: $d \in \{green, brown\}$
- $\lambda_{Hb} < \lambda_{Lb} < \lambda_{Lg} < \lambda_{Hg}$

Firm Types

		Agg. Economies	
		Low	High
Green Potential	Low	L, L	L, H
	High	H, L	H, H

How does each type choose its design and neighborhood?

Firm's Problem

Choose inputs (*Number of workers*, *Real estate*), Design (g, b), and neighborhood (A):

$$\max_{N,R,d,A} \left\{ \psi_i(A) \lambda_{jd} N^\beta R^\gamma \bar{K} - \bar{W}N - p_d R - k_{ij} \right\}$$

- ψ Agglomeration effect to firm type i
- λ Benefit from design d to firm type j
- \bar{K} Fixed (tradeable) capital inputs
- \bar{W} Wage
- p_d Price per sq.ft. with design d
- k_{ij} Fixed capital cost for firm type ij

Developer's Problem

Chooses *height* and *land* for both green and brown real estate, subject to its land use constraint:

$$\max_{h_g, h_b, \ell_g, \ell_b} \{ \pi_g(h_g, \ell_g) + \pi_b(h_b, \ell_b) \} \quad \text{s.t.} \quad \bar{\ell} = \ell_g + \ell_b$$

where

$$\pi_d(h, \ell) = p_d h \ell - c_d h^\delta \ell - p_\ell \ell$$

Assume $c_g > c_b$ and $\delta > 1$

Equilibrium Characterization

The Adoption Decision

The Adoption Condition

Green real estate is bought and built if and only if:

$$\left(\frac{c_g}{c_b}\right)^{\frac{\gamma}{\delta}} < \frac{\lambda_{jg}}{\lambda_{jb}}$$

Where is A ? Again, neighborhood characteristics do not affect the adoption decision!

Firm Sorting: Agglomeration Economies

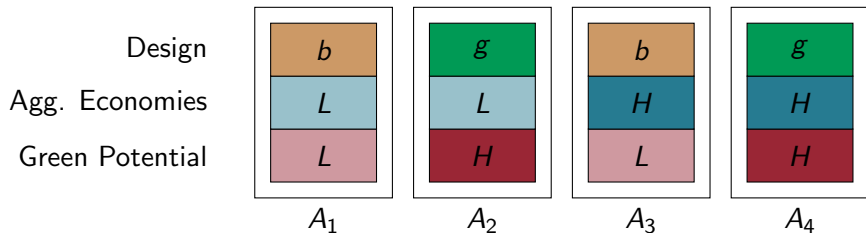
Claim

In our example, type High Agglomeration Economy firms will locate in neighborhoods with at least as high A as any Low Agglomeration Economy Firm.

- Type H firms can make better use of high A neighborhoods
- The increase production more than offsets the increase in real estate prices

Example Sorting

With $A_1 < A_2 < A_3 < A_4$,



The ordering within Agg. Economies is arbitrary

How Are Types Distributed?

High ψ_i Industries:

- Finance
- Technology
- Media

From Glaeser (2008)

High Environmental-Social Governance Industries:

- Technology (10)
- Medical Supply/Research (8)
- Finance & Insurance (8)
- Utilities & Energy (5)

From MSCI ESG Research

Continue to build the model with a focus on generalizing the model, narrowing in on an equilibrium, and working towards a testable model.

Consider:

- Arbitrary Sectors and Continuous λ
- Prove Existence and Clarify Equilibrium
- Link Agglomeration and Environmentalism – Reputation
- How would we estimate this model?

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

Glaeser, Edward Ludwig, *Cities, agglomeration, and spatial equilibrium*, Oxford University Press, 2008.