A Theory of Investment for Energy-Efficient Technologies

Part IV

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Review

Research Question

What neighborhood characteristics relate to the number of certified energy-efficient commercial buildings?

Previously:

- Energy Savings v. Adoption Costs
- Premium on Green Buildings
- We still need an explicitly spatial link to the adoption decision

Paper

Brueckner, Jan K, *Lectures on urban economics*, MIT press, 2011.

- Develops the Alonso (1964), Muth (1969), Mills (1967) (AMM) Model
- Why the AMM Model?
  - Fundamental urban model
  - Empirically supported
  - Allows us to consider how different agents locate themselves within a city
- Modify this model to consider location of different types of developers

Overview

Purpose Within a city, where will developers construct green buildings?

Context The AMM Model

Model Modify the AMM model with a green developer and non-green developer

Results Green buildings cluster away from the city center

Context

An Overview of the Alonso-Muth-Mills (AMM) Model

The AMM Model Environment

- Many identical agents need to purchase housing
- Live in a linear city: pick a distance from the city center and purchase housing there

- Everyone needs to commute to the city center and gets disutility from commuting
- Spatial Equilibrium Condition: the price of housing must adjust so identical agents are indifferent between locations

The Bid-Rent Curve

Figure 1: Baseline Bid-Rent Curve

Two Important Takeaways

1. Quantity of housing each agents purchases increases as we move away from the city center

2. Rent per sq.ft. decreases as we move away from the city center

Model

Modifying the Alonso-Muth-Mills (AMM) Model

Two Developers: Green & Non-Green

$$Q = AM_i^{\alpha} L^{\beta} \qquad C = p_{M_i} M_i + p_L L$$

- Q : Commercial Space (in sq. ft.)
- C : Cost
- A : Technology Index
- M_i : Materials of type i
  - G : Green Materials
  - N : Non-Green Materials
- p_{M_i} : Price of Materials of type i
  - We say $p_{M_G} > p_{M_N}$
- L : Land (in sq. ft.)
- p_L : Price of Land (in \$/sq. ft.)

Demand for Space

Green developers can sell their output for a higher price:

$$p_G = p_N + r$$

where r is the premium for green space.

The Derivation

1. For a representative developer, derive its profit functions for green and non-green construction

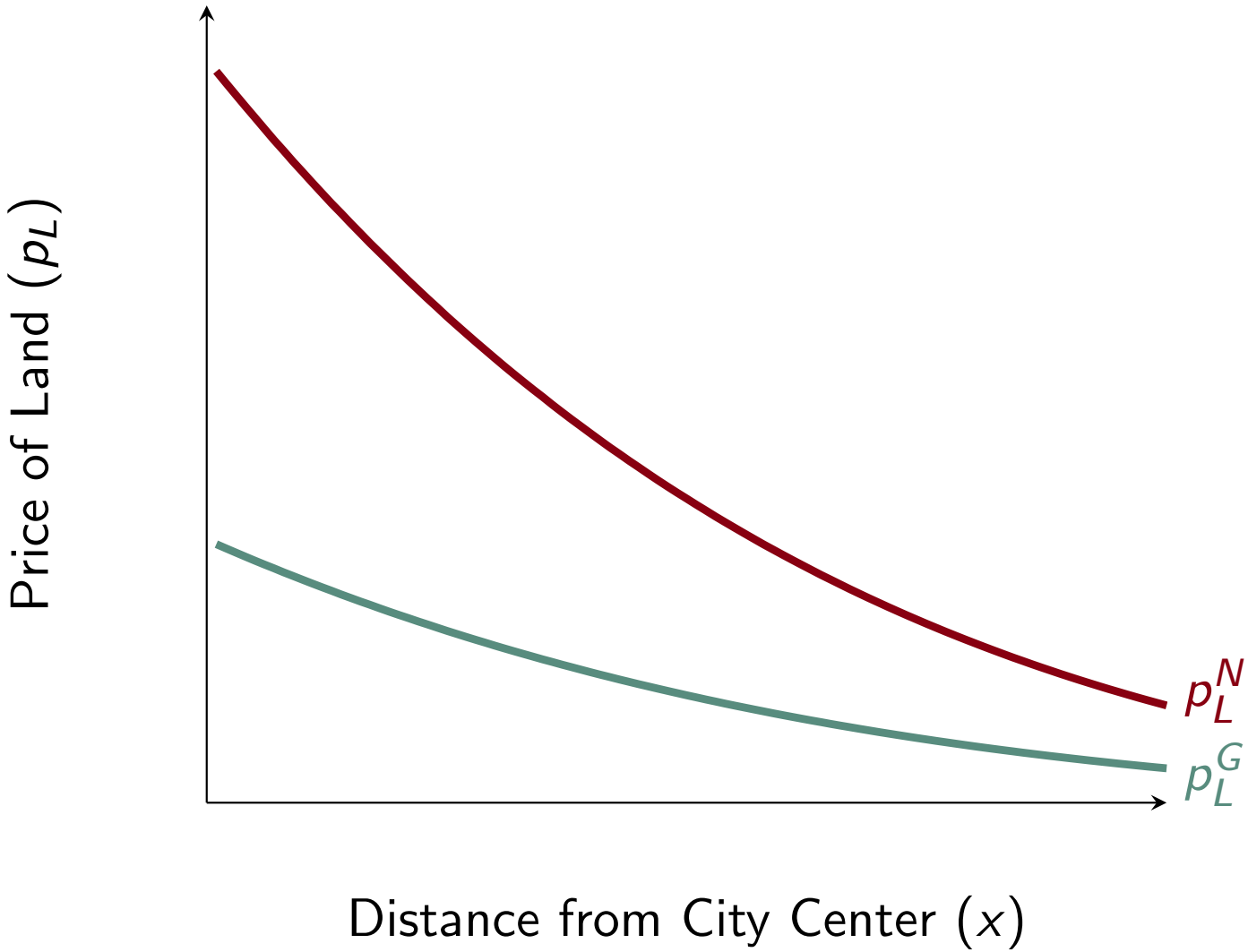
2. For several identical developers, impose spatial equilibrium and solve for their bid-rent curves

3. Use the bid-rent curves to identify where green and non-green construction happens

Results

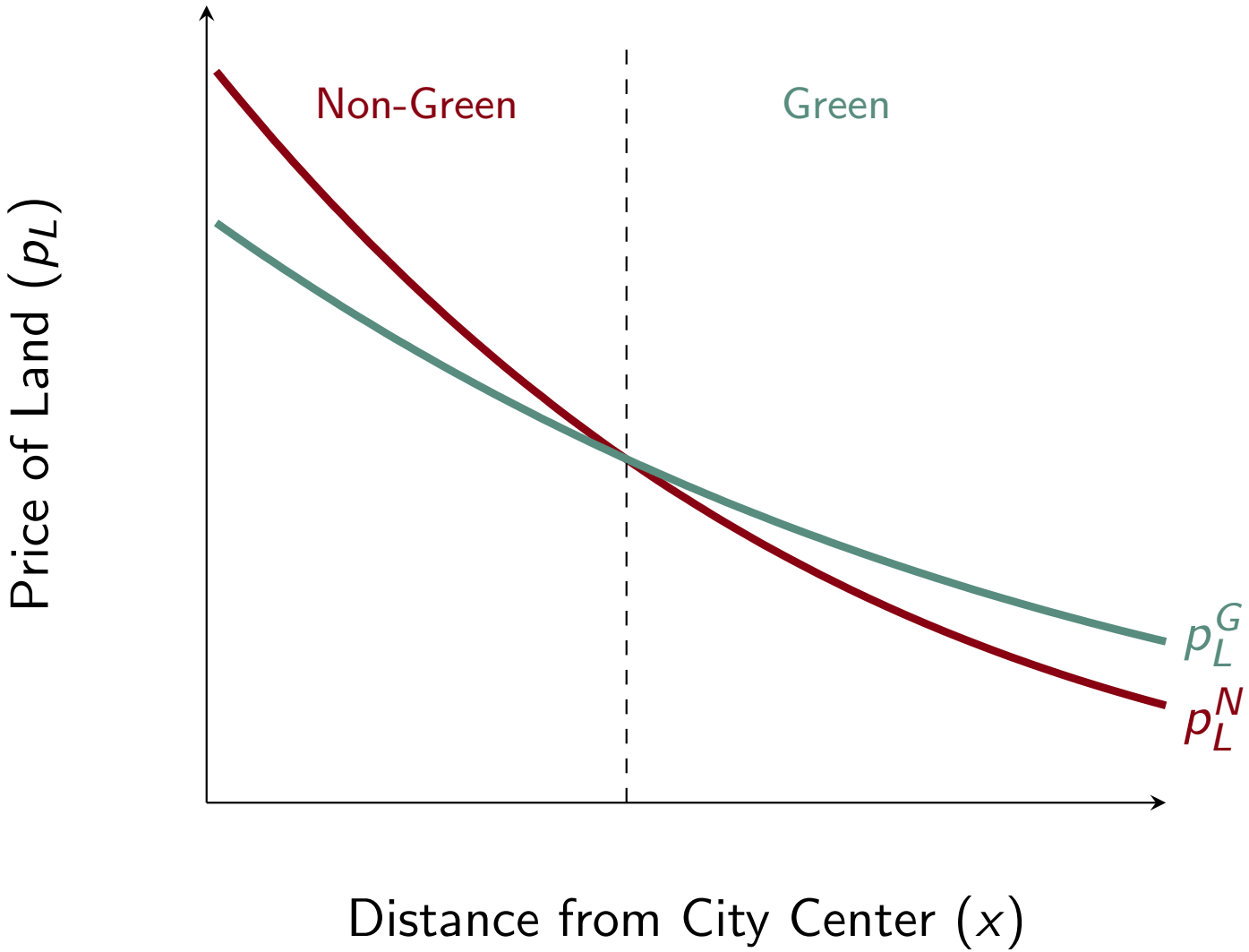
Land Intensity

Figure 2: Bid-Rent Curves without a Premium



Green and Non-Green Sorting

Figure 3: Bid-Rent Curves with a Fixed Premium



Model Takeaways

Q : Within a city, where will developers construct green buildings?

A : Developers will build green buildings away from the city center

- Production becomes more land intensive / less material intensive away from the city center
- Spaces are larger as we move away from the city center, meaning larger premiums

Next Week

Data Week

- Energy Star & LEED Database
- Initial Data Exploration
- Maps

References

Alonso, William, *Location and land use*, Harvard University Press, 1964.

Brueckner, Jan K, *Lectures on urban economics*, MIT press, 2011.

Mills, Edwin S, "An aggregative model of resource allocation in a metropolitan area," *The American Economic Review*, 1967, *57* (2), 197–210.

Muth, Richard F, *Cities and Housing; The Spatial Pattern of Urban Residential Land Use.* 1969.

Appendix

Derivations and Important Equations

First-Order Conditions

$$\mathscr{L} = p_i M_i + p_L L + k - \lambda(A M_i^{\alpha} L^{\beta} - \bar{Q})$$
$$\mathscr{L}_M = p_i - \alpha A M_i^{\alpha-1} L^{\beta} = 0$$
$$\mathscr{L}_L = p_L - \beta A M_i^{\alpha} L^{\beta-1} = 0$$
$$\mathscr{L}_\lambda = \bar{Q} - A M_i^{\alpha} L^{\beta} = 0$$

Spatial Equilibrium Condition

$$\bar{\Pi} = p_i(x) \cdot Q(x) - C(Q(x) : p_i, p_L)$$

The Bid-Rent Curve (Equation)

$$p_L^i(x) = \left(\frac{A}{Q(x)}\right)^{1/\beta} \left(\frac{1}{p_i}\right)^{\alpha/\beta} \Phi(\alpha, \beta) \left[p_i(x) \cdot Q(x) - \bar{\Pi}\right]^{(\alpha+\beta)/\beta}$$

where $Q(x) = (b - cx)^{-1}$, $p_N(x) = a(b - cx)^2$, and $p_G(x) = p_N(x) + r$.

$\Phi(\alpha, \beta)$ is a constant and $\bar{\Pi}$ is the common profit level of all developers.