A Spatial Explanation for the Balassa–Samuelson Effect

Péter Karádi (NYU)
Miklós Koren (Princeton)

Introduction

The Balassa–Samuelson effect

- Rich countries are more expensive than poor ones.
- In Penn World Tables,

$$\ln P = 0.25 \ln Y + e.$$

- This is mostly due to differences in non-tradable prices, as tradable prices vary little across countries.

Productivity-based explanations

- Balassa–Samuelson: Productivity differences in non-tradables are smaller than in non-tradables.
  - But why is technical progress slower for non-tradables?
- Kravis–Lipsey–Bhagwati: Non-tradables are more intensive users of the non-reproducible factor (labor).
- This raises their price with capital accumulation.
  - But the difference in labor intensity is small (Herrendorf and Valentinyi, 2007).
- We propose a simple spatial model in which relative price changes arise endogenously from the location choice of industries.

Basic idea

- Tradable sectors locate to where land is cheap.
- Non-tradable sectors have to locate near consumers in big cities.
- They compete with housing for scarce urban land.
- Urban land becomes more and more scarce with development.
- Raising the relative price of non-tradables.

Land matters

Land is scarce

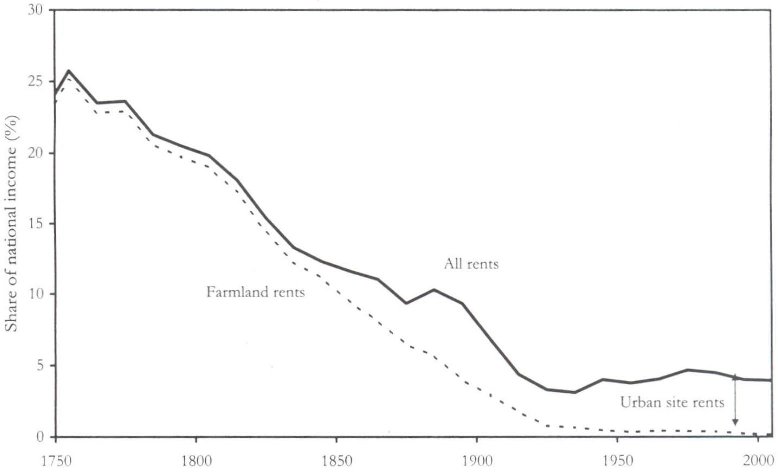
- Population density of the Earth is $42/\mathrm{km}^2$, so land is abundant.
- However, the average person lives in an area with a population density of $7{,}300/\mathrm{km}^2$ (LandScan 2005), so *land close to consumers* is scarce.

The share of land in GDP

- Decreased from 25% in mid 1700s to around 5% now — mainly because of the shrinking share of agriculture in GDP (Clark, 2007)
- Sector income shares in various industries in the US (Herrendorf and Valentinyi, 2007)

Industry	Capital	Land	Structures	Equipment
GDP	0.32	0.05	0.13	0.14
Agriculture	0.43	0.18	0.10	0.15
Manufacturing	0.31	0.03	0.08	0.20
Services	0.32	0.05	0.15	0.12

Agricultural and urban land rents in England (Clark, 2007)



Model

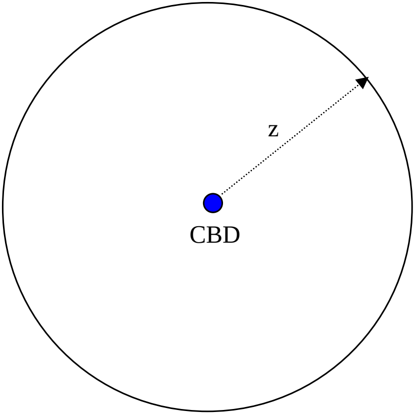
Basic structure

- There are three industries, manufacturing (m), services (s), and housing (h).
- We study how the relative prices of these industries depend on their choice of location...
- ...and how location varies with development.

Spatial structure

- We use the monocentric city model.
- All market exchange takes place in a central business district (CBD).
- CBD is a point in the plain.
- Residents, manufacturing and service establishments can choose their location freely in the plain.
- Location is indexed by distance to the CBD, z.

The monocentric city



Technology

- Land is the only factor of production. (We add labor later.)
- Production functions:

$$m = A_m l_m$$
$$s = A_s l_s$$
$$h = A_h l_h$$

Tastes

- Consumers have homothetic utility over m, s and h.
- With indirect utility function

$$u(I, p_m, p_s, p_h) = \frac{I}{P(p_m, p_s, p_h)}.$$

- Assume nested structure

$$P[\Phi(p_m, p_s), p_h].$$

Transport costs

- Goods are shipped to the center.
- Both manufacturing and services have iceberg transport cost.
- One good i shipped from location z melts to

$$D(\tau_i z) < 1, \; D' < 0.$$

- Services are less tradable:

$$\tau_s > \tau_m.$$

Commuting costs

- People go to the CBD to shop.
- Commuting costs a $1 - D(\tau_h z)$ fraction of the consumption bundle.
- So that indirect utility is

$$u(I, p_m, p_s, p_h) = \frac{D(\tau_h z) I}{P[\Phi(p_m, p_s), p_h]}.$$

- Commuting is the costliest of all,

$$\tau_h > \tau_s > \tau_m.$$

Equilibrium

- Firms maximize profits and choose location optimally.
- Households maximize utility and choose residence optimally.
- Manufacturing and service markets clear at the CBD.

Profit maximization

- Land rent at location z: $r(z)$.
- Profits for industry i at location z:

$$D(\tau_i z) p_i A_i l_i(z) - r(z) l_i(z).$$

- Optimum requires

$$D(\tau_i z) p_i A_i \leq r(z),$$

with equality if industry i produces at location z.

The bid rent curve

- Define a bid rent curve:

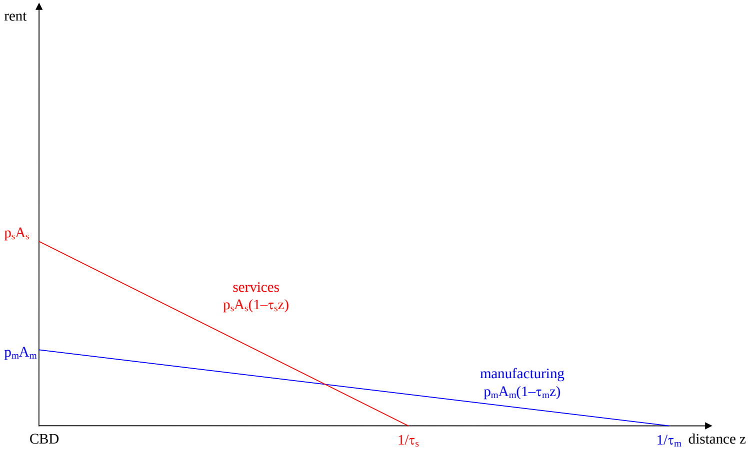
$$R_i(z) = p_i A_i D(\tau_i z).$$

- Profit maximization requires

$$r(z) \geq R_i(z)$$

- Industry i produces at location z only if equal.
- Rent $r(z)$ is the upper envelope of the bid rent curves.

Bid rent curves of two industries



The bid rent curve of households

- Housing at z costs $r(z)/A_h$.
- Other two prices do not depend on residence.
- To achieve utility u at location z,

$$u = \frac{D(\tau_h z)I}{P[\Phi(p_m, p_s), r(z)/A_h]}.$$

- Bid rent function

$$R_h(z) = A_h \Phi(p_m, p_s) P_2^{-1} \left[\frac{D(\tau_h z)I}{u\Phi(p_m, p_s)} \right].$$

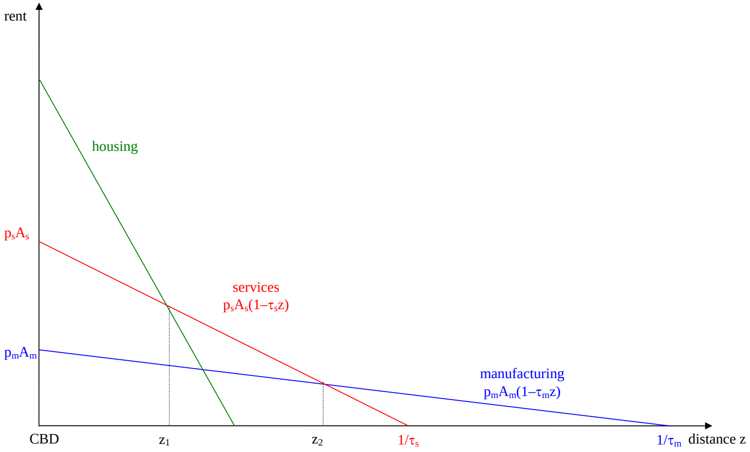
- For example, with Cobb–Douglas utility,

$$R_h(z) = A_h \left[\frac{D(\tau_h z)I}{u p_m^{\alpha} p_s^{\beta}} \right]^{1/\gamma}.$$

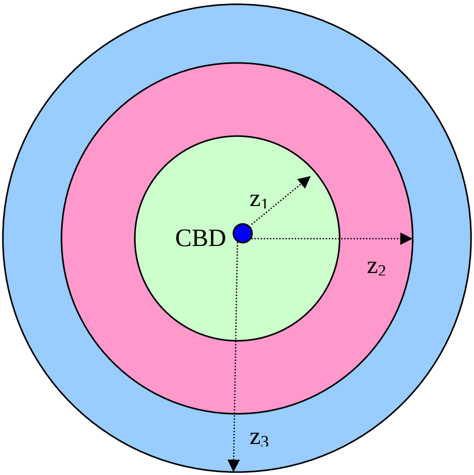
Equilibrium city structure

- Residents live closest to CBD, $\in [0, z_1]$.
- With a (weakly) declining population density.
- Followed by a ring of service establishments, $\in (z_1, z_2]$.
- Followed by a ring of manufacturing plants, $\in (z_2, z_3]$.
- City boundary is $z_3 : D(\tau_m z_3) = 0$.

Equilibrium spatial structure



Equilibrium spatial structure



Aggregate supplies

- All land between z_1 and z_2 is allocated to services.
- A fraction $\tau_s z$ gets lost in transit.
- Overall supply:

$$s = \int_{z_1}^{z_2} 2\pi z D(\tau_s z) dz = s(\underset{-}{z_1}, \underset{+}{z_2})$$
$$m = \int_{z_2}^{z_3} 2\pi z D(\tau_m z) dz = m(\underset{-}{z_2})$$

The relative price of services

- At the manufacturing–service boundary z_2,

$$p_m A_m D(\tau_m z_2) = p_s A_s D(\tau_s z_2).$$

- The relative price of services

$$\frac{p_s}{p_m} = \frac{A_m}{A_s} \frac{1 - \tau_m z_2}{1 - \tau_s z_2}.$$

- This increases if A_m / A_s does or if z_2 does (because $\tau_m < \tau_s$).

Productivity growth

- We conduct the following comparative statics.
- Increase A_m and A_s proportionally (so that productivity growth is neutral).
- What happens to industry location (z_1, z_2) and relative prices?

Propositions

Balassa–Samuelson and the sprawl

Service prices increase with development if and only if residential land increases with development.

Balanced growth

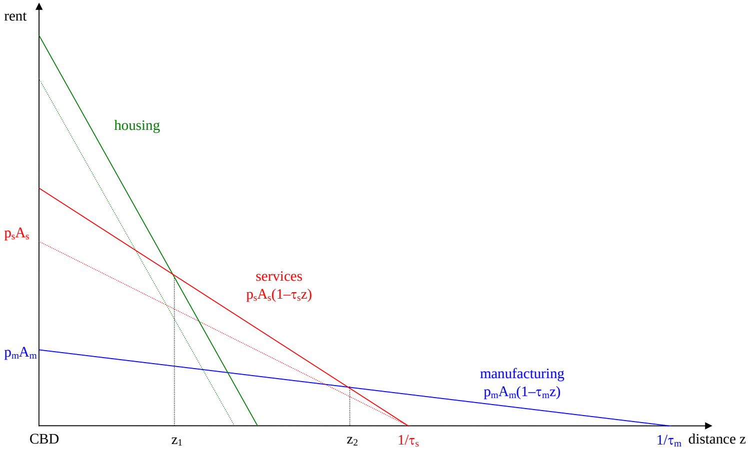
Productivity growth does not change the relative price of services if

1. housing productivity grows at the same rate,
2. *or* demand for housing is Cobb–Douglas.

Proof of Proposition 1

- From rent arbitrage at boundary z_2, the relative price of services
$$\frac{p_s}{p_m} = \frac{D(\tau_m z_2)}{D(\tau_s z_2)},$$
increasing in z_2.
- Relative demand is
$$\frac{s}{m} = \phi\left(\frac{p_s}{p_m}\right) = \phi\left(\frac{D(\tau_m z_2)}{D(\tau_s z_2)}\right),$$
decreasing in z_2. (ϕ denotes Φ_2/Φ_1.)
- Relative supply is increasing in z_2.
- For a given z_1, there is a unique z_2 that equates relative demand and supply.
- This z_2 is increasing in z_1.

Comparative statics



***

- Utility is Cobb–Douglas in goods, Leontief in housing,

$$u(m,s,h) = \min\{m^{\gamma} s^{1-\gamma}, h/H\}.$$

- Transport costs are exponential (constant hazard),

$$D(\tau z) = \exp(-\tau z).$$

- We add labor with identical intensities in both sectors,

$$m = A_m l_m^{\beta} n_m^{1-\beta}$$
$$s = A_s l_s^{\beta} n_s^{1-\beta}$$

- These lead to a closed-form solution.

Predictions

As productivity increases,

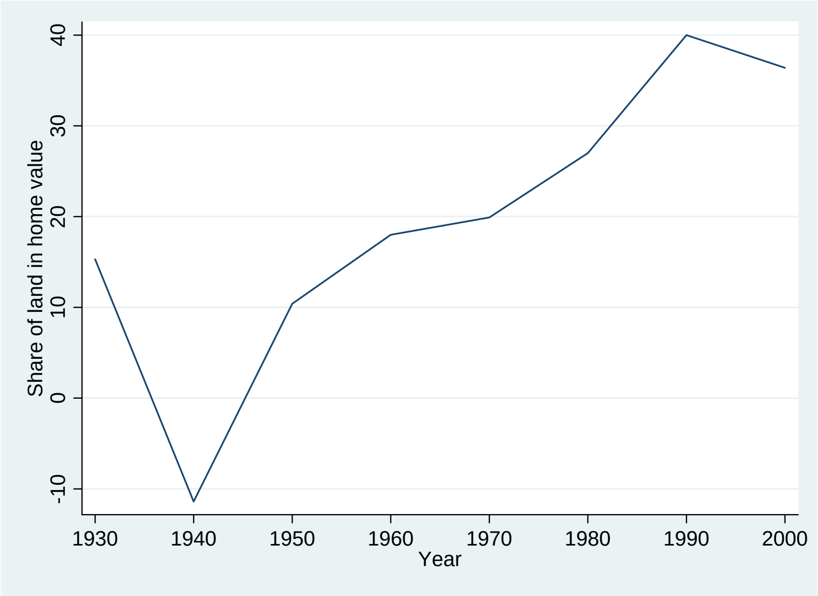
1. residential land increases,
2. home prices increase,
3. the rent gradient becomes steeper,
4. services become more expensive,
5. labor productivity increases faster in manufacturing.

Empirics

Demand for residential land increases with development

- Between 1976 and 1992, residential land per capita increased by 25%. (Burchfield, Overman, Puga and Turner, 2006; Overman, Puga and Turner, 2007)
- Between 1950 and 2000, the price of residential land increased more than nine-fold. (Davis and Heathcote, 2007)
- During the same period, the share of land in the value of a home increased from 10% to 36%.

The share of land in home value (Davis and Heathcote, 2007)



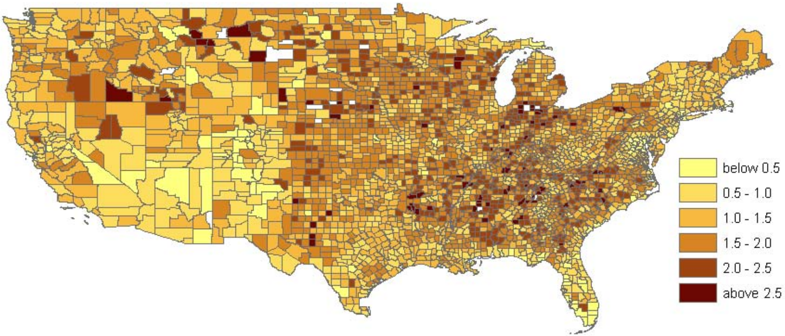
Income and the demand for housing

Explanatory variables	Dependent variable: Land value (log)	Dependent variable: Number of rooms per capita (log)
Income (log)	**2.77**	**0.26**
	(0.67)	(0.08)
Population (log)	0.13	**-0.07**
	(0.18)	(0.01)
R^2	0.42	0.26
No. of obs.	46	3219

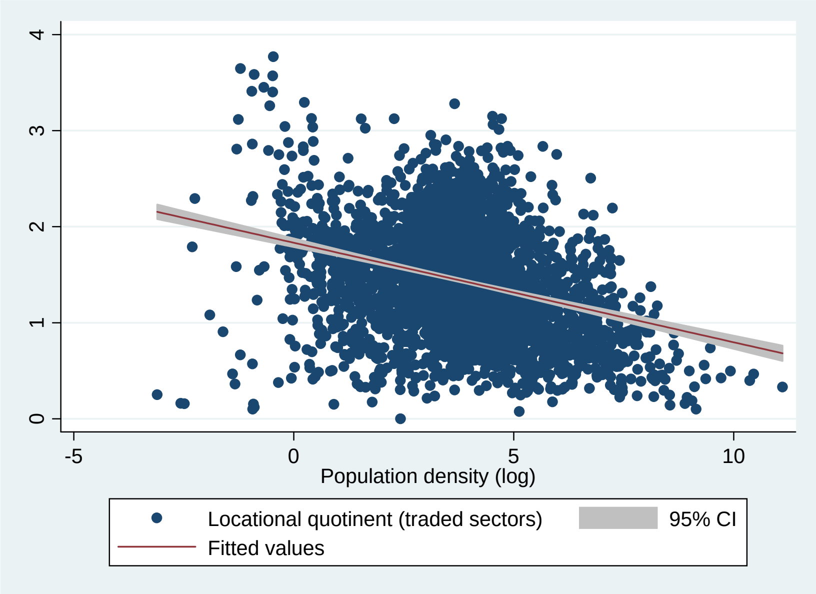
Tradable sectors move out of cities

- Burchfield, Overman, Puga and Turner (2006): commercial land is more scattered than residential land, more so in 1992 than in 1976.
- Holmes and Stevens (2004): in 1997 manufacturing is underrepresented in large cities.
- Desmet and Fafchamps (2006): manufacturing deconcentrated between 1970 and 2000.

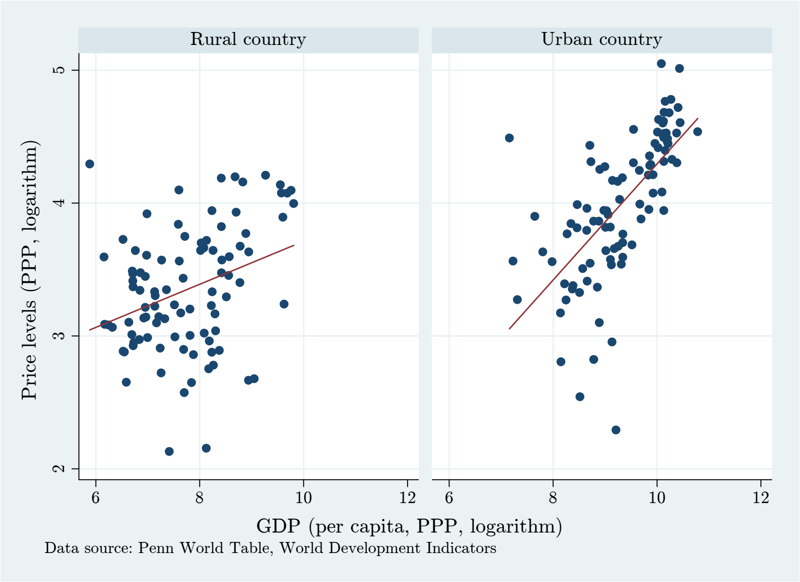
Locational quotient of tradable sectors



Tradables stay away from dense counties



Balassa–Samuelson is stronger in urban countries



Balassa–Samuelson is stronger in urban countries

Explanatory variables	Dependent variables $\log(P_{NT}/P_T)$	
$\log Y$	**0.28**	**0.33**
	(0.07)	(0.05)
urban	0.12	
	(0.34)	
urbanX	**0.43**	
	(0.19)	
log(density)	-0.02	
		0.04
densityX		0.01
		0.02
constant	**-2.96**	**-3.13**
	0.50	(0.41)
No. of obs.	113	113
R^2	0.38	0.34

Conclusion