

A Spatial Explanation for the Balassa–Samuelson Effect

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Introduction

The Balassa–Samuelson effect

- ▶ Rich countries are more expensive than poor ones.
- ▶ In the Penn World Table,

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

- ▶ This is mostly due to differences in non-tradable prices, as tradable prices vary little across countries.
- ▶ Over time, as a country grows, its non-tradables become relatively more expensive.

Tradable and non-tradable prices

	Shampoo	Women's haircut	Relative price
Real GDP per capita	-0.018 (0.027)	0.387*** (0.038)	0.405*** (0.041)
Observations	135	135	135
R^2	0.00	0.47	0.49

EIU price data 1997–2006

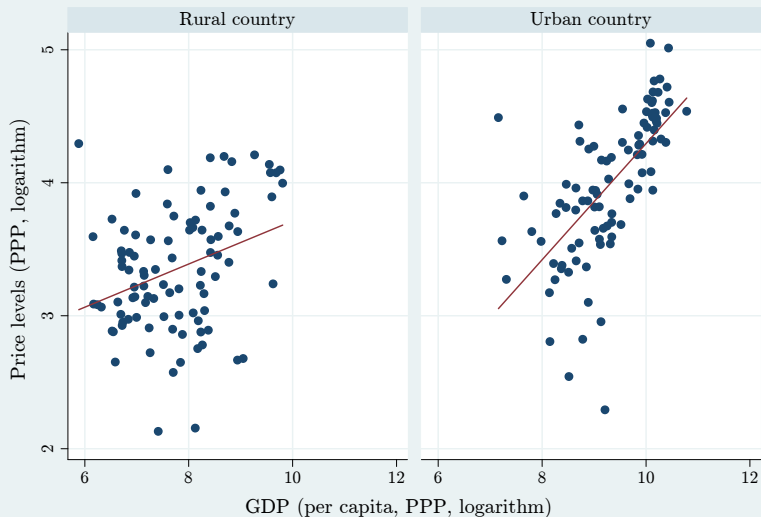
Technology-based explanations

- ▶ Balassa–Samuelson: Productivity growth in non-tradables is slower than in tradables.
- ▶ Kravis–Lipsey–Bhagwati: Non-tradables are more intensive users of the non-reproducible factor (labor).
- ▶ This raises their price with capital accumulation.

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- ▶ Balassa–Samuelson: Productivity growth in non-tradables is slower than in tradables.
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- ▶ This raises their price with capital accumulation.
 - ▶ Where do these technology differences come from?
 - ▶ Why does Balassa–Samuelson work in some cases and not in others?

Balassa–Samuelson is stronger in urban countries



Data source: Penn World Table, World Development Indicators

Not everything is technology

	Frozen chicken	Fresh chicken	Relative price
Real GDP per capita	0.072** (0.029)	0.158*** (0.030)	0.086*** (0.021)
Observations	125	125	125
R^2	0.05	0.21	0.13

EIU price data 1997–2006

What we do

What we do

We propose a simple spatial model in which relative price changes arise endogenously from the location choice of industries.

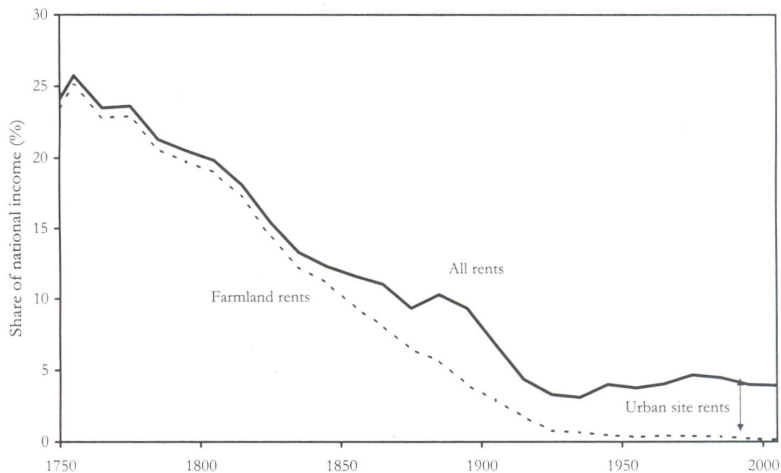
Basic idea

- ▶ 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 and location matter

Why has land disappeared from macro?

(Clark, 2007)



Land is scarce

- ▶ Population density of the Earth is $42/\text{km}^2$, so land is abundant.

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

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 on the real line.
- ▶ Residents, manufacturing and service establishments can choose their location freely on the real line.
- ▶ Location is indexed by distance to the CBD, z .

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

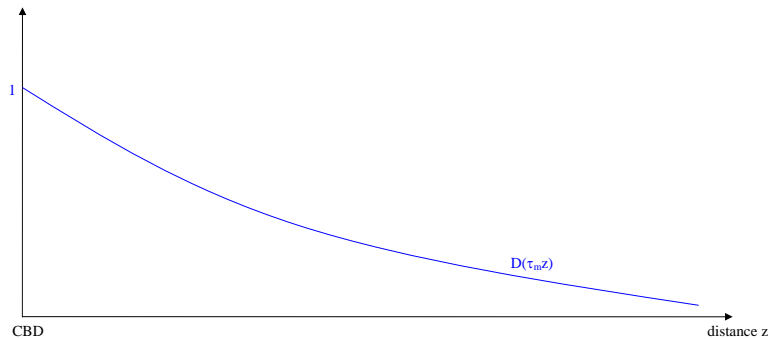
- ▶ Goods are shipped to the CBD.
- ▶ Both manufacturing and services have iceberg transport cost.
- ▶ One good i shipped from location z melts to

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

- ▶ Services are less tradable:

$$\tau_s > \tau_m.$$

Iceberg transport costs and distance



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:

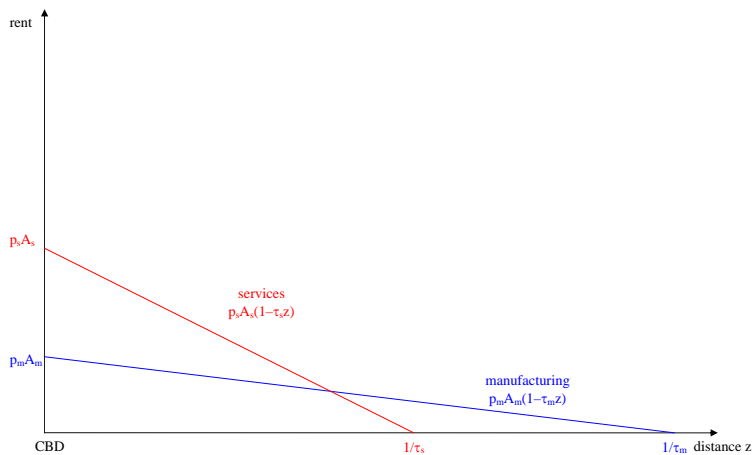
$$R_i(z) = p_i A_i D(\tau_i z).$$

- ▶ 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,

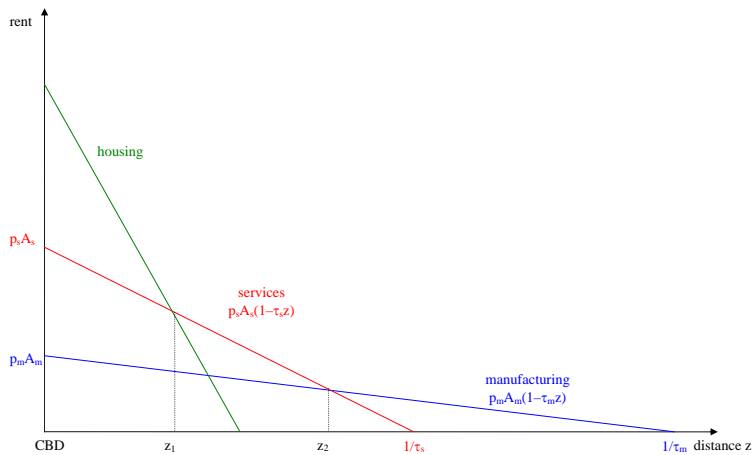
$$R_h(z) = A_h \left[\frac{D(\tau_h z)I}{u p_m^\alpha p_s^\beta} \right]^{1/\gamma}.$$

Equilibrium spatial structure

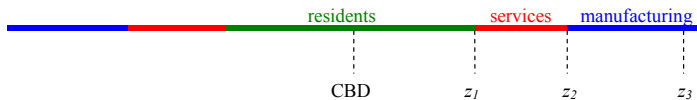
There exists a unique equilibrium.

- ▶ Residents live closest to CBD, $\in [0, z_1]$.
- ▶ With a (weakly) declining population density.
- ▶ Followed by an interval of service establishments, $\in (z_1, z_2]$.
- ▶ Followed by an interval 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



Finding the equilibrium z_1 and z_2 .

- ▶ Cutoffs pin down supply:

$$s = A_s \int_{z_1}^{z_2} D(\tau_s z) dz,$$
$$m = A_m \int_{z_2}^{z_3} D(\tau_m z) dz.$$

- ▶ Arbitrage at the manufacturing–service boundary z_2 pins down relative prices,

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

which determines demand.

- ▶ Find z_1 and z_2 such that markets clear.

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.

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Balassa–Samuelson and the sprawl

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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.

A special case

- ▶ No technical progress in housing, $A_h = \text{constant}$.
- ▶ 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,

$$m = A_m l_m^\beta n_m^{1-\beta}$$

$$s = A_s l_s^\beta n_s^{1-\beta}$$

Solution

- ▶ These assumptions lead to a closed-form solution.
- ▶ Balassa–Samuelson effect:

$$\frac{d \ln(p_s/p_m)}{d \ln A} = \frac{(\tau_s - \tau_m)z_1}{1 + \bar{\tau}z_1/\beta}$$

- ▶ Stronger if
 1. trade cost differential is large,
 2. residential land is large,
 3. land share is large.

Predictions

As productivity increases,

1. residential land increases,
2. home prices increase,
3. the rent gradient becomes steeper,
4. tradable industries move away from center,
5. services become more expensive,
6. labor productivity increases faster in manufacturing.
7. All of these effects are stronger for more densely populated countries.

Empirical evidence

Question

Does sector location affect relative prices?

Data

- ▶ We use city-level product price data from the Economist Intelligence Unit.
- ▶ We construct measures of industry location from U.S. Census data.
- ▶ GDP per capita comes from WDI.

EIU data

- ▶ Collected for cost-of-living comparisons.
- ▶ 150 products are surveyed.
- ▶ 140 cities in 89 countries.
- ▶ For each product–city pair, we take average USD price between 1997 and 2006.

Industry location

- ▶ “County Business Patterns” records the number of plants by county and NAICS sector: n_{ic} .
- ▶ Decennial Census has population density for each county, d_c .
- ▶ For each sector i , we calculate the population density of its *average plant*:

$$\rho_i = \frac{\sum_c n_{ic} d_c}{\sum_c n_{ic}}$$

- ▶ Sectors with high ρ_i locate closer to residents.
- ▶ We match EIU products to sectors in which they are *produced*.

Sectors close to residents

Product/Sector	Population density
Taxi: initial meter charge	
Taxi and Limousine Service	1316
Compact disc album	
Manufacturing Magnetic and Optical Media	1268
One good seat at cinema	
Motion Picture and Video Industries	1197
Four best seats at theatre	
Performing Arts Companies	1127
Babysitter's rate per hour	
Other Personal Services	966
Laundry (one shirt)	
Drycleaning and Laundry Services	832

Sectors far from residents

Product/Sector	Population density
Frozen fish fingers (1 kg)	
Seafood Product Preparation and Packaging	115
Electricity, monthly bill	
Electric Power Generation and Distribution	147
Chicken: frozen (1 kg)	
Animal Slaughtering and Processing	161
Lamb: chops (1 kg)	
Animal Slaughtering and Processing	161
Insect killer spray (330 g)	
Pesticide and Fertilizer Manufacturing	168
Regular unleaded petrol (1 l)	
Oil and Gas Extraction	172

Industry location and the Balassa–Samuelson effect

	Dependent variable: product price (log)			
	[1]	[2]	[3]	[4]
GDP per capita (log)	0.148*** [0.027]	0.139*** [0.027]		
GDP per capita \times proximity		0.034*** [0.009]		0.051*** [0.014]
GDP per capita \times agriculture			0.183*** [0.029]	0.192*** [0.034]
GDP per capita \times manufacturing			0.099*** [0.024]	0.094*** [0.024]
GDP per capita \times services			0.201*** [0.037]	0.182*** [0.038]
Product fixed effects	YES	YES	YES	YES
Observations	37552	33593	37552	33593
Clusters	89	89	89	89
R-squared	0.954	0.954	0.955	0.955

Standard errors (in brackets) are clustered by countries.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Conclusions

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- ▶ We developed a tractable model of industry location,
- ▶ which is consistent with regional patterns in the U.S.
- ▶ The Balassa–Samuelson effect is stronger for sectors that locate close to consumers.