A Spatial Explanation for the Balassa–Samuelson Effect

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Introduction

The Balassa–Samuelson effect

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

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

Technology based explanations I.

Technology

Product i is produced using $A_i F_i(k_i, n_i)$.

Production possibilities set

Feasible (m, s) such that $k_m + k_s = K$ and $n_m + n_s = N$.

Marginal rate of transformation

Number of ms sacrificed for a unit of s:

$$MRT = \frac{A_m F_{mk}(k_m, n_m)}{A_s F_{sk}(k_s, n_s)}$$

Relative price

In equilibrium, the relative price is pinned down by the MRT.

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

Issues with technology-based explanations

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- Factor intensity differences seem to be small. Income shares
- Why does Balassa–Samuelson work in some cases and not in others? Urban Chicken

What we do

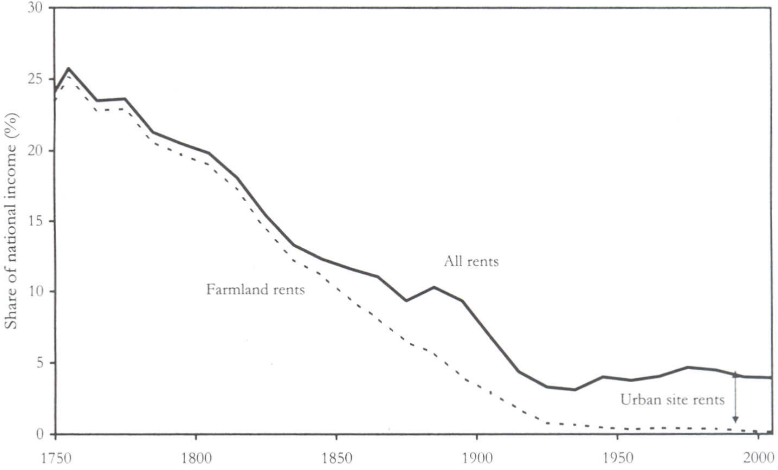
- We propose a simple spatial model in which relative price changes arise endogenously from the location choice of industries.
- Industries share the exact same technology, they only differ in *tradability*.

Basic idea

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

Location matters

Why has land disappeared from macro? (Clark, 2007)



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- 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.

Firms

Basic structure

- There are two sectors, manufacturing (m) and services (s).
- 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.
- 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.
- Production functions:

$$m = A_m l_m$$
$$s = A_s l_s$$

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 iceberg

$$e^{-\tau_i z}.$$

- Services are less tradable:

$$\tau_s > \tau_m.$$

Profit maximization

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

$$e^{-\tau_i z} p_i A_i l_i(z) - r(z) l_i(z).$$

- Optimum requires

$$e^{-\tau_i z} p_i A_i \leq r(z),$$

with equality if industry i produces at location z.

The bid rent curve

- Define a bid rent curve:

$$R_i(z) = p_i A_i e^{-\tau_i z}.$$

- Profit maximization requires

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

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

Optimal location choice

- Services are produced between 0 and $\bar{z}$:

$$s = \int_0^{\bar{z}} A_s e^{-\tau_s z} dz.$$

- Manufacturing takes place between $\bar{z}$ and ∞.

$$m = \int_{\bar{z}}^{\infty} A_m e^{-\tau_m z} dz.$$

- Production possibilities frontier PPF:

$$s = \frac{A_s}{\tau_s} \left[1 - \left(\frac{m}{A_m/\tau_m} \right)^{\tau_s/\tau_m} \right]$$

- Marginal rate of transformation:

$$MRT = \frac{A_m}{A_s} \left(\frac{m}{A_m/\tau_m} \right)^{-(\tau_s - \tau_m)/\tau_m}$$

Balassa–Samuelson with location-specific land

- Trade costs make land location specific: “urban” land is different from “rural” land.
- Services are more intensive users of “urban” land.
- With only trade cost differences across sectors, service price increases if and only if “urban” land becomes *scarce* relative to “rural” land.

Manufacturing and development

Urban land may become relatively scarce for a number of reasons.
evidence

1. Manufacturing shipping costs decline disproportionately PPF.
2. Structural change shifts resources towards services.

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1. Manufacturing shipping costs decline disproportionately PPF.
2. Structural change shifts resources towards services.
3. Development increases the demand for residential land.

Consumers

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

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

Commuting costs

- People go to the CBD to shop.
- Commuting costs a $1 - e^{-\tau_h z}$ fraction of the consumption bundle.
- So that indirect utility is

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

- Commuting is the costliest of all,

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

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,

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

- Bid rent function

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

- For example, with Cobb–Douglas utility,

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

Equilibrium spatial structure

There exists a unique equilibrium.

- Residents live closest to CBD, $\in [0, \underline{z}]$.
- With a (weakly) declining population density.
- Followed by an interval of service establishments, $\in (\underline{z}, \overline{z}]$.
- Followed by an interval of manufacturing plants, $\in (\overline{z}, \infty)$.

Finding the equilibrium $\underline{z}$ and $\overline{z}$

- Cutoffs pin down supply:

$$s = A_s \int_{\underline{z}}^{\overline{z}} e^{-\tau_s z} dz,$$

$$m = A_m \int_{\overline{z}}^{\infty} e^{-\tau_m z} dz.$$

- Arbitrage at the manufacturing–service boundary $\overline{z}$ pins down relative prices,

$$p_m A_m e^{-\tau_m \overline{z}} = p_s A_s e^{-\tau_s \overline{z}},$$

which determines demand.

- Find $\underline{z}$ and $\overline{z}$ 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 ($\underline{z}$, $\overline{z}$) and relative prices?

A special case

- No technical progress in housing, $A_h =$constant.
- Utility is Cobb–Douglas in goods, Leontief in housing,

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

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

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

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

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***	0.139***		
	[0.027]	[0.027]		
GDP per capita × proximity		0.034***		0.051***
		[0.009]		[0.014]
GDP per capita × agriculture			0.183***	0.192***
			[0.029]	[0.034]
GDP per capita × manufacturing			0.099***	0.094***
			[0.024]	[0.024]
GDP per capita × services			0.201***	0.182***
			[0.037]	[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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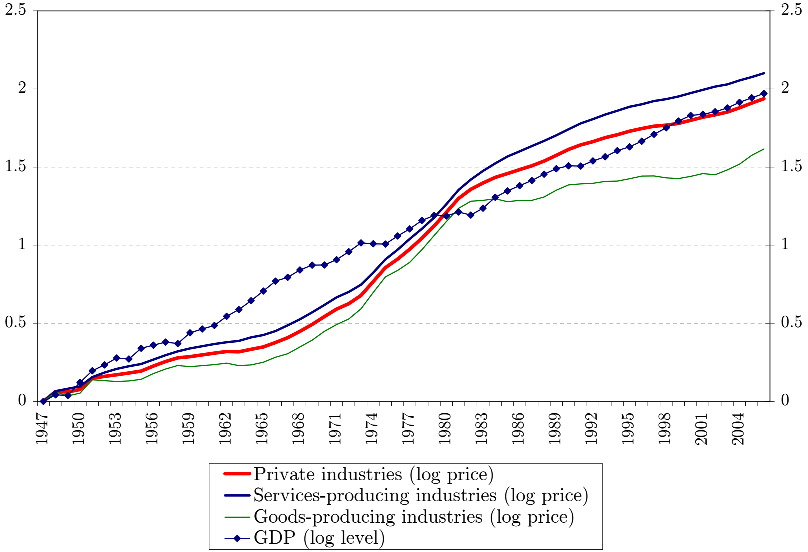
- We developed a tractable model of industry location,
- which is consistent with regional patterns in the U.S.
- The Balassa–Samuelson effect is stronger for sectors that locate close to consumers.

Tradable and non-tradable prices

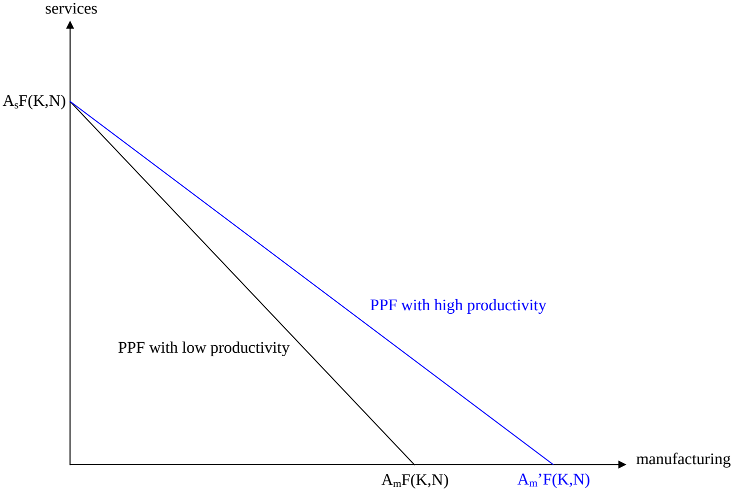
	Shampoo	Women's haircut	Relative price
Real GDP per capita	-0.018	0.387***	0.405***
	(0.027)	(0.038)	(0.041)
Observations	135	135	135
R^2	0.00	0.47	0.49

EIU price data 1997–2006

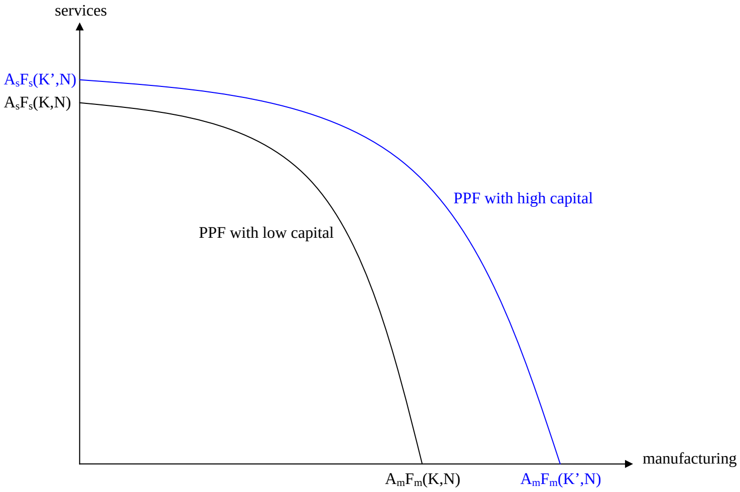
Price levels and GDP in the US (VA, 1947-2006



The Balassa–Samuelson explanation



The Bhagwati explanation

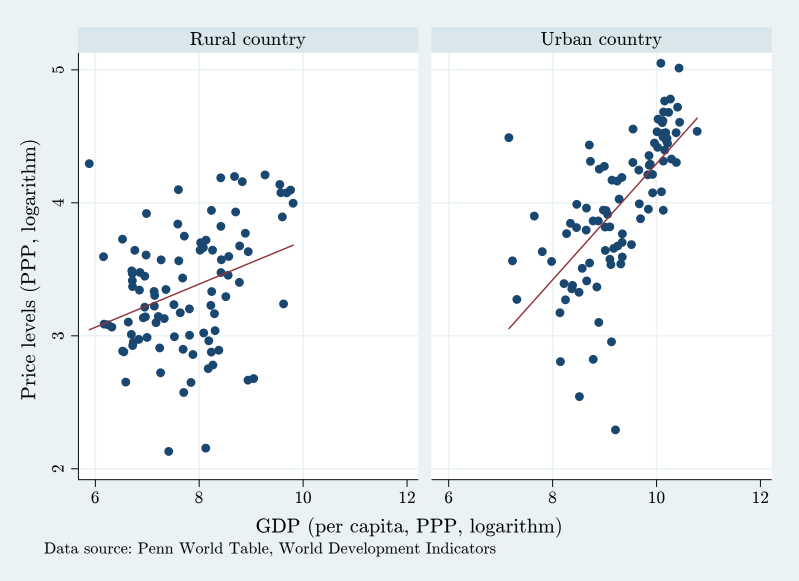


The share of land in GDP·

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

Balassa–Samuelson is stronger in urban countries

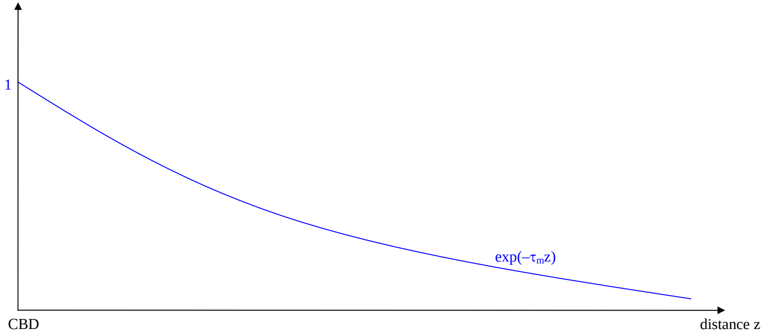


Not everything is technology

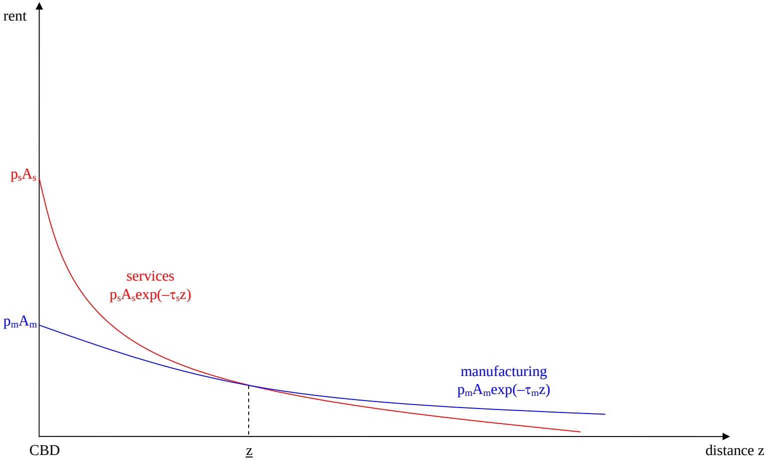
	Frozen chicken	Fresh chicken	Relative price
Real GDP per capita	0.072**	0.158***	0.086***
	(0.029)	(0.030)	(0.021)
Observations	125	125	125
R^2	0.05	0.21	0.13

EIU price data 1997–2006

Iceberg transport costs and distance



Bid rent curves of two industries



The production possibilities frontier