

# A Spatial Explanation for the Balassa–Samuelson Effect

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# Introduction

# The Balassa–Samuelson effect

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- ▶ In the Penn World Table,

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

# 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

EU price data 1997–2006

# 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

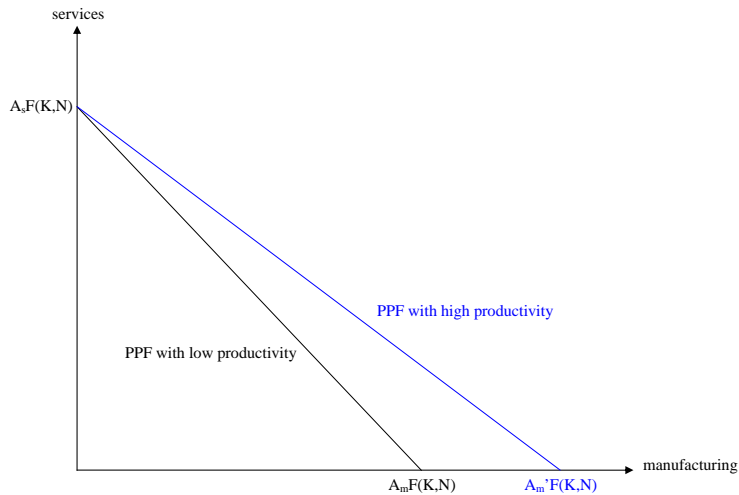
- ▶ Non-tradable sectors have to locate near consumers in big cities.
- ▶ Tradable sectors locate to where land is cheap.
- ▶ Urban land becomes more and more scarce with development.
- ▶ This raises urban rents, raising the relative price of non-tradables.

## Technology-based explanations

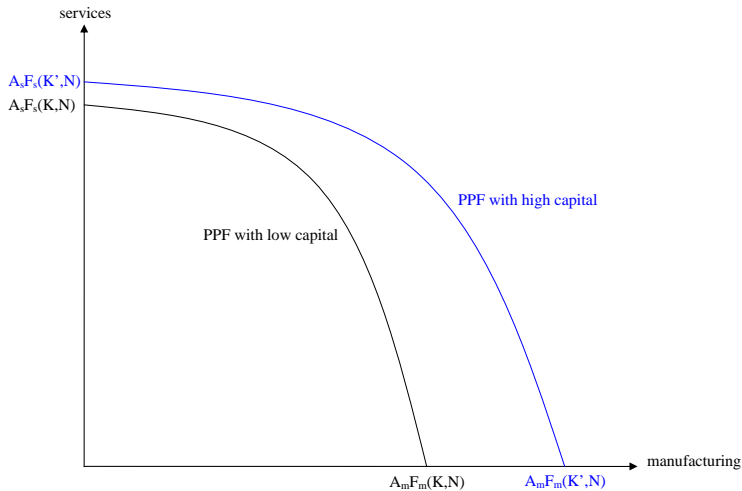
- ▶ Balassa–Samuelson: Productivity growth in non-tradables is slower than in tradables.
- ▶ Bhagwati–Kravis–Lipsey: Non-tradables are more intensive users of the non-reproducible factor (labor).
- ▶ This raises their price with capital accumulation.



# The Balassa–Samuelson explanation



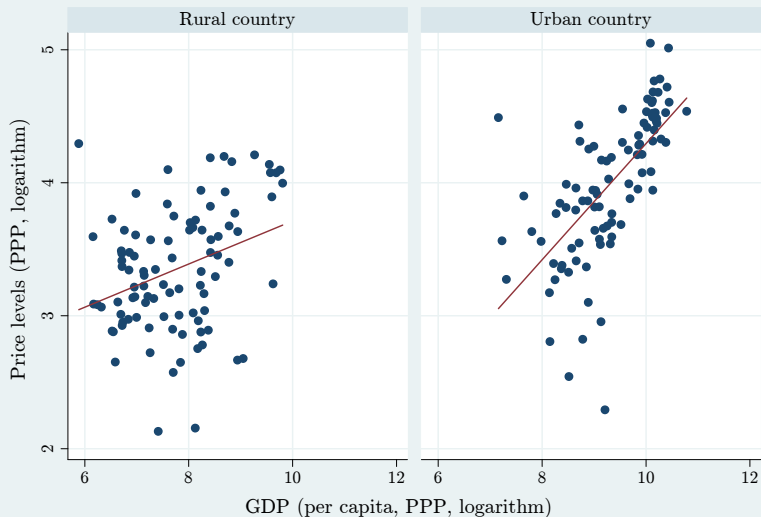
# The Bhagwati explanation



## Issues with technology-based explanations

- ▶ Is it just a coincidence that technology is correlated with tradability?
- ▶ 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

# Model

# Environment

# 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), which 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. (We add labor later.)
- ▶ 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

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

- ▶ Services are less tradable:

$$\tau_s > \tau_m.$$

## Characterizing the supply side

## 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:

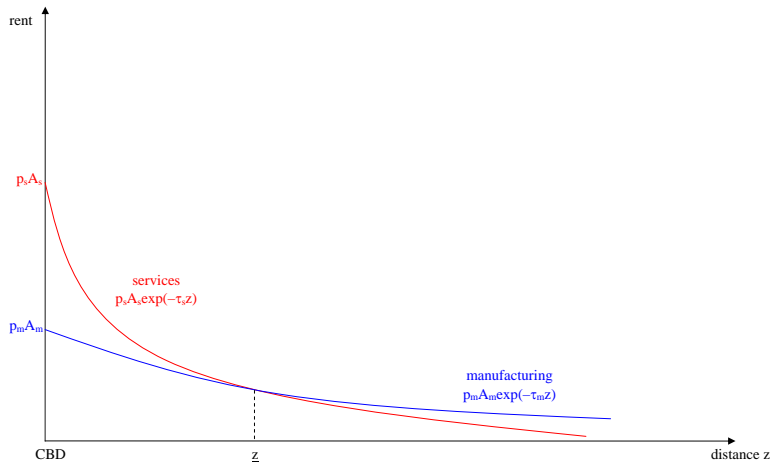
$$R_i(z) = p_i A_i e^{-\tau_i z}.$$

- ▶ Profit maximization requires

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

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

# Bid rent curves of two industries



## 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  $\infty$ .

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

- ▶ Production possibilities frontier:

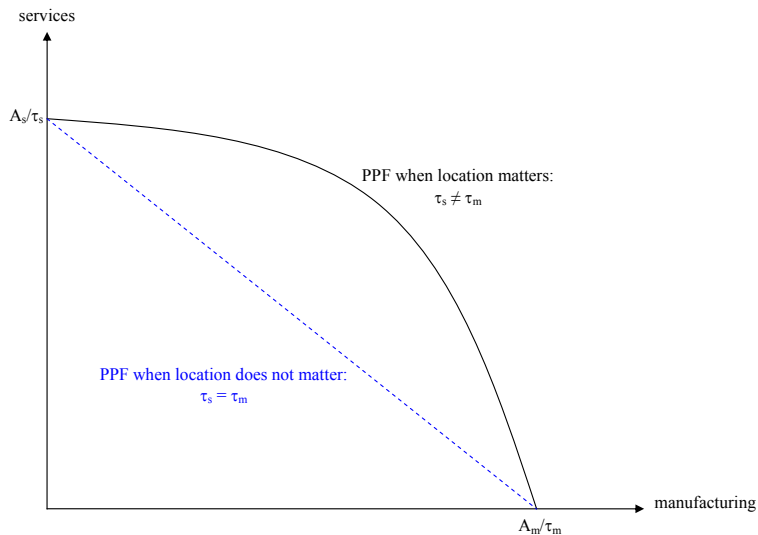
$$s = \frac{A_s}{\tau_s} \left[ 1 - \left( \frac{m}{A_m/\tau_m} \right)^{\tau_s/\tau_m} \right]$$

- ▶ Relative price is pinned down by MRT:

$$\frac{p_s}{p_m} = \frac{A_m}{A_s} e^{(\tau_s - \tau_m)\bar{z}}.$$



# The production possibilities frontier



## 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.

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### Proposition

Assume  $A_m/A_s$  is constant. Service price increases if and only if demand for “urban” land ( $\bar{z}$ ) increases relative to “rural” land.

## Closing the model

# Development and urban land

Demand for urban land may increase for a number of reasons.

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

Next we develop the housing-based explanation.

# Tastes

- ▶ Consumers have homothetic utility over  $m$ ,  $s$  and  $h$  (housing services).
- ▶ 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,

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

- ▶  $\rightarrow$  people like to live close to the CBD.

## 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,  $\in (\underline{z}, \bar{z}]$ .
- ▶ Followed by an interval of manufacturing plants,  $\in (\bar{z}, \infty)$ .

## Finding the equilibrium $\underline{z}$ and $\bar{z}$

- ▶ Cutoffs pin down supply:

$$s = A_s \int_{\underline{z}}^{\bar{z}} e^{-\tau_s z} dz,$$
$$m = A_m \int_{\bar{z}}^{\infty} e^{-\tau_m z} dz.$$

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

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

which determines demand.

- ▶ Find  $\underline{z}$  and  $\bar{z}$  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  $(\underline{z}, \bar{z})$  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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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.

## A special case

- ▶ No technical progress in housing,  $A_h = \text{constant}$ .
- ▶ Utility is Cobb–Douglas in goods, Leontief in housing,

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

- ▶ 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.

# 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.

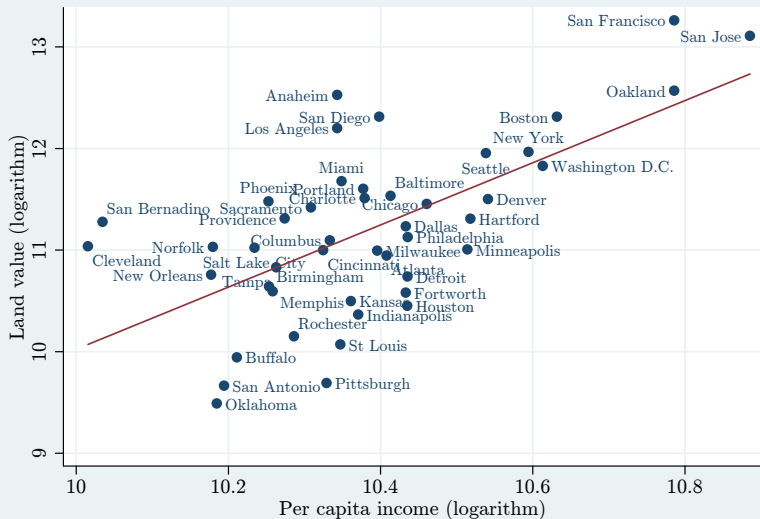
# Empirical evidence



## Question

How does the demand for residential land vary with income?

# Land prices and income across large U.S. cities



Data source: Davis-Palumbo (2007), BEA

## Land prices, demand for housing and income

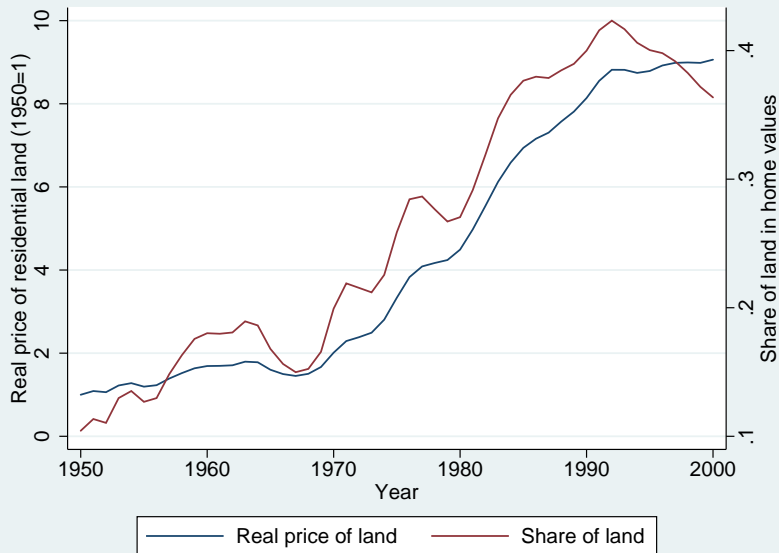
Explanatory variables	Dependent variable			
	Land price (log)	Constr. price (log)	Home price (log)	Rooms per capita
log(income)	<b>2.77</b> (0.67)	<b>0.38</b> (0.11)	<b>1.66</b> (0.38)	<b>0.26</b> (0.08)
log(population)	0.13 (0.18)	0.02 (0.03)	0.05 0.10	<b>-0.07</b> (0.01)
$R^2$	0.42	0.25	0.52	0.26
No. of obs.	46	46	46	3219

## Trends in the demand for land

- ▶ Over time, the demand for residential land has increased in the U.S.
- ▶ Overman, Puga and Turner (2006) find that the per capita residential land use between 1976 and 1992 *increased by 25.4%*.
- ▶ At the same time, land prices have increased dramatically, so *demand* must have increased.

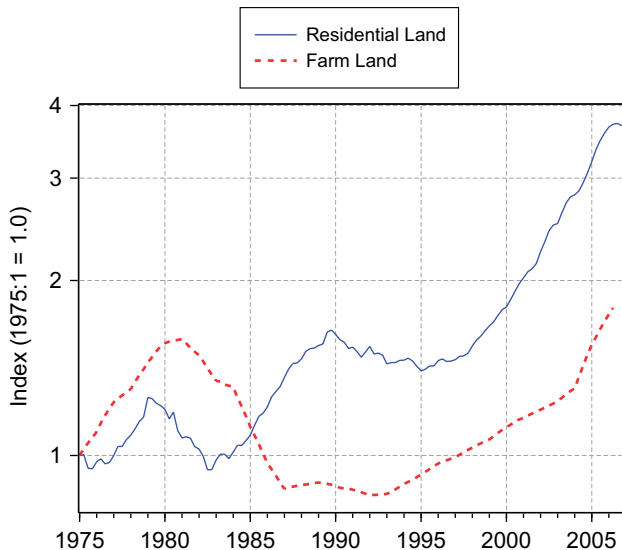
# Land prices and the share of land in home value

Source: Davis and Heathcote (2007)



# Real residential and farm land prices (log scale)

Source: Davis and Heathcote (2007).

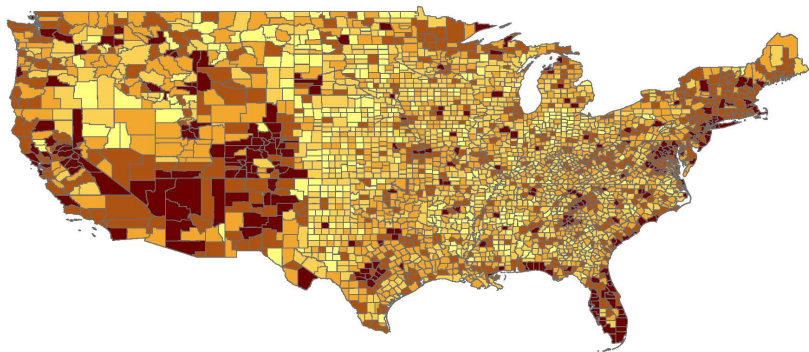


## Question

Do nontradable sectors locate closer to residents?

# The share of non-traded employment in U.S. counties

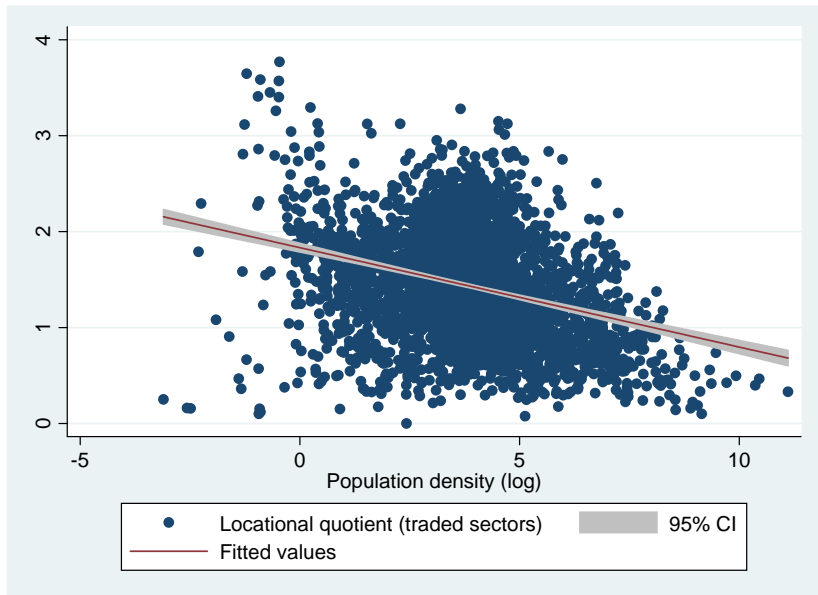
Source: 2000 U.S. Census, Summary File 3.





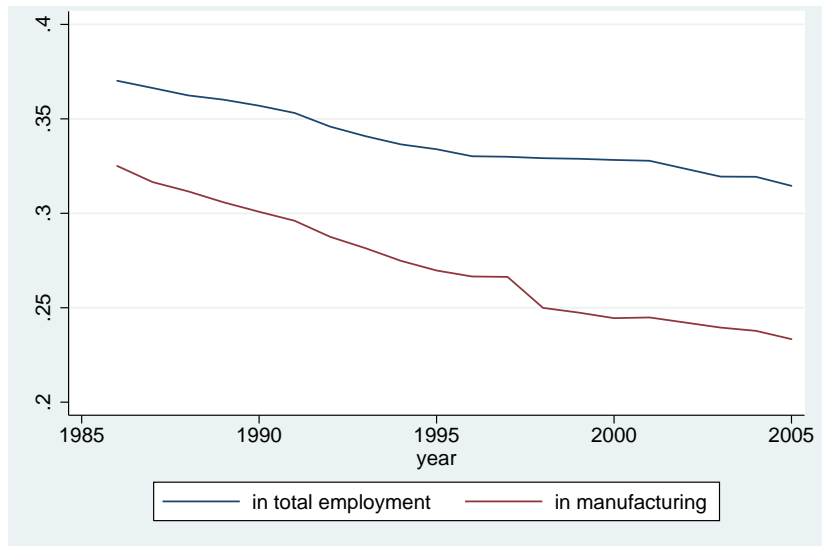
# Locational quotient and population density

Source: 2000 U.S. Census



# Share of 100 most densely populated counties

Source: County Business Patterns



## Question

Does sector location affect the relationship between prices and income?

# Data

- ▶ We use city-level product price data from the Economist Intelligence Unit.
- ▶ We construct measures of industry location from U.S. Census data. (Assuming that tradability differences are similar for all countries.)
- ▶ GDP per capita comes from WDI, other sector-level measures from the NBER productivity database.

## 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  $\rho_i$  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.

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

## Industry location and labor intensity

	Dependent variable: price (log)		
	[5]	[6]	[7]
GDP per capita (log)	0.083*** [0.024]	0.095*** [0.025]	0.084*** [0.024]
GDP per capita × proximity	0.091*** [0.016]		0.086*** [0.014]
GDP per capita × labor share		0.187* [0.097]	0.087 [0.090]
Product fixed effects	YES	YES	YES
Observations	16698	16698	16698
Clusters	89	89	89
R-squared	0.946	0.946	0.946

Robust standard errors in brackets are clustered by countries

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

# Results

- ▶ Prices of goods produced closer to residents are more sensitive to income.
- ▶ “Urban” goods have a B–S elasticity of  $0.18 - 0.20$ , “rural” goods  $-0.04 - 0.09$ .
- ▶ This effect is robust to controlling for major sectoral groupings and labor shares.

# Conclusions

# Conclusions

- ▶ We incorporated a tractable model of industry location into a macro model.
- ▶ If sectors differ in their tradability, this spatial model yields interesting sectoral shifts with development.
- ▶ The Balassa–Samuelson effect is stronger for sectors that locate close to consumers.

# Where to go from here?

- ▶ Our model can be used in a number of ways.
  1. Help us understand *sectoral development accounting*.
  2. Can be extended to study the spatial patterns of prices across a large number of sectors, relating them to development, urbanization patterns, geographical features etc.

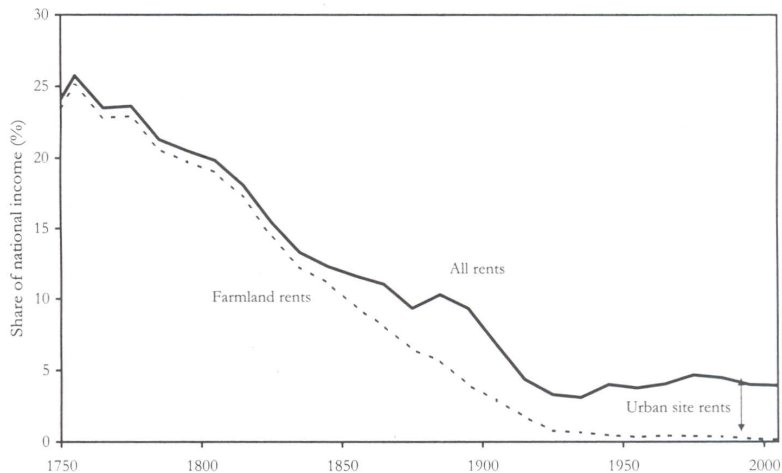
# Appendix

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.

## Land is scarce

- ▶ 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.

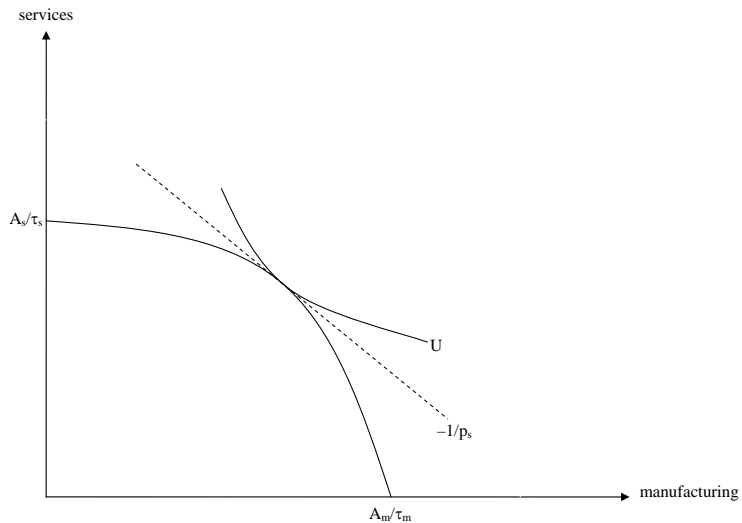
## The share of land in GDP.

Sector income shares in various industries in the US (Herrendorf and Valentinyi, 2007)

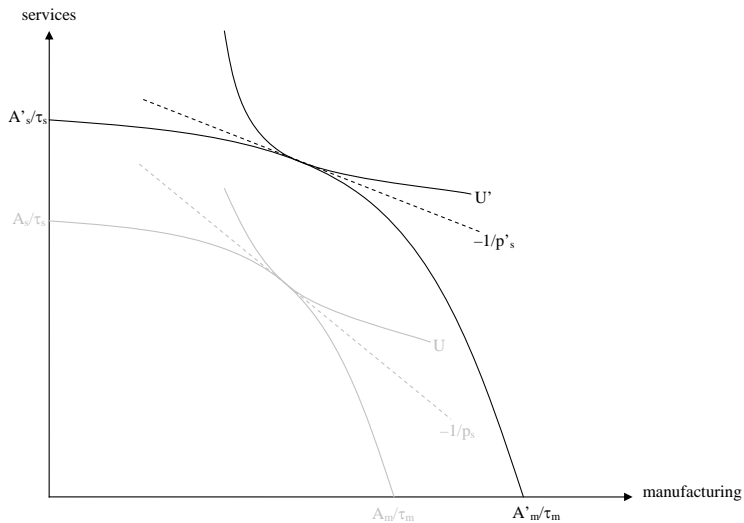
Industry	Capital	Land	Structures+Equipment
GDP	0.32	0.05	0.27
Agriculture	0.43	0.18	0.25
Manufacturing	0.31	0.03	0.28
Services	0.32	0.05	0.27

## Closing the model

# Structural change



# Structural change



# Introducing housing

- ▶ We introduce homothetic preferences for housing.
- ▶ Housing is complementary with consumption:

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

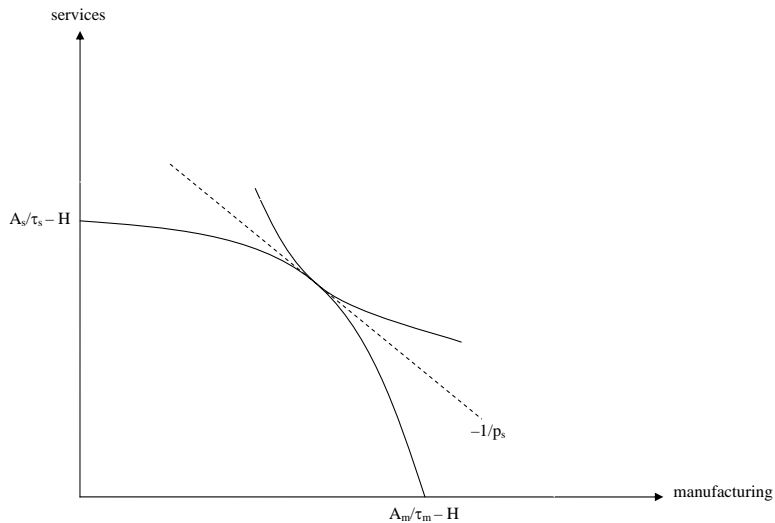
- ▶ No technical progress in housing (or slower than in manufacturing).
- ▶ High commuting costs.

These assumptions imply that

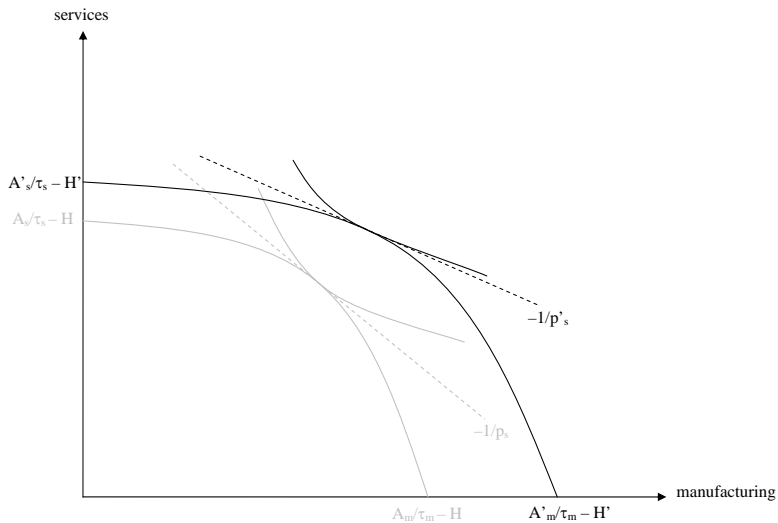
1. residents live closest to CBD,
2. residential land increases with development.



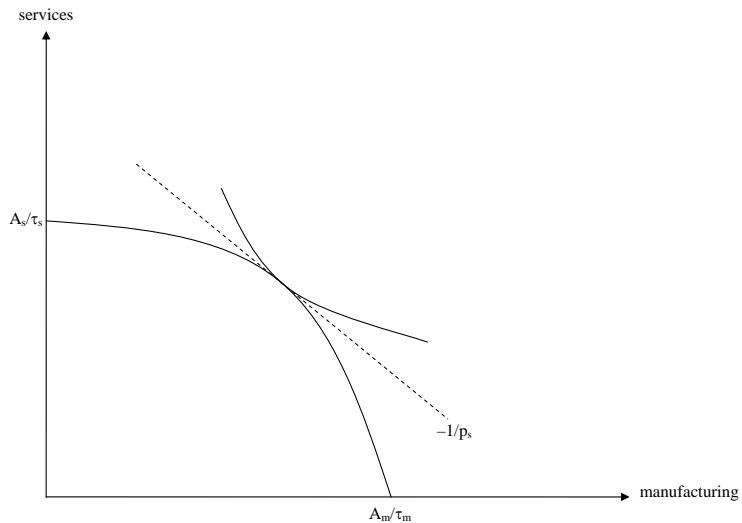
# Housing demand increases



# Housing demand increases



# Transportation becomes cheaper



# Transportation becomes cheaper

