# 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.

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- This raises their price with capital accumulation.
  - But the difference in labor intensity is small (Herrendorf and Valentinyi, 2007).

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- 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

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- 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

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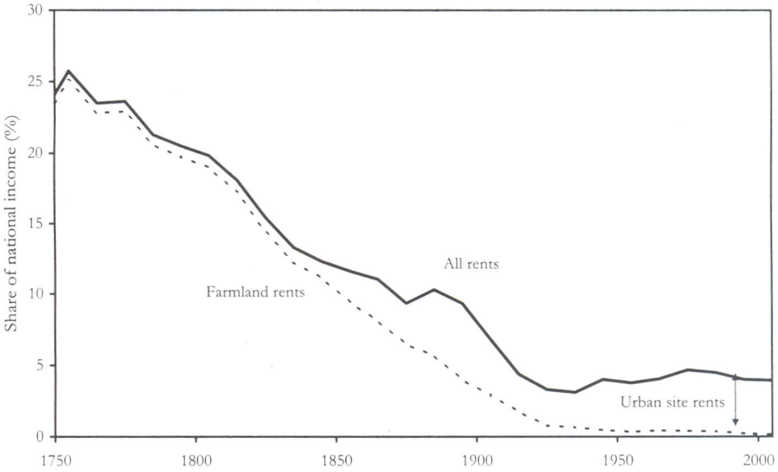
- However, the average person lives in an area with a population density of 7,300/km$^2$ (LandScan 2005), so *land close to consumers* is scarce.

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



# 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 |

# Model

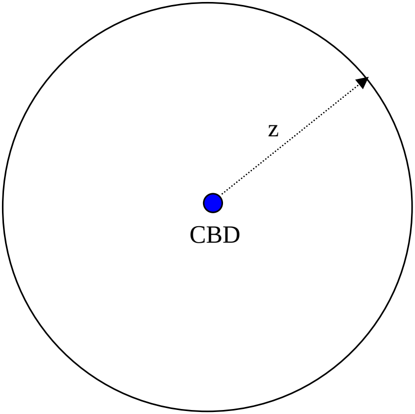
# Basic structure

- 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

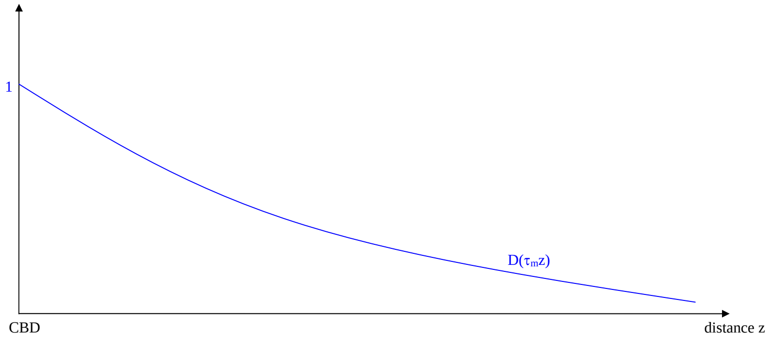
- Goods are shipped to the CBD.
- Both manufacturing and services have iceberg transport cost.
- One good $i$ shipped from location $z$ melts to

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

- Services are less tradable:

$$\tau_s > \tau_m.$$

# 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:

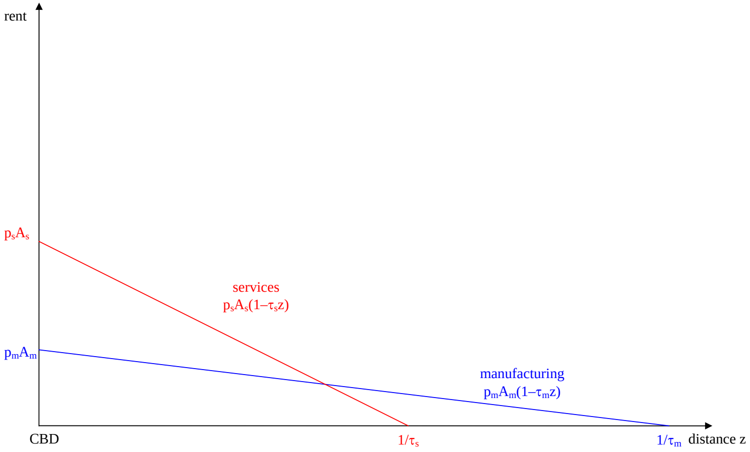
$$R_i(z) = p_i A_i D(\tau_i z).$$

- 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,

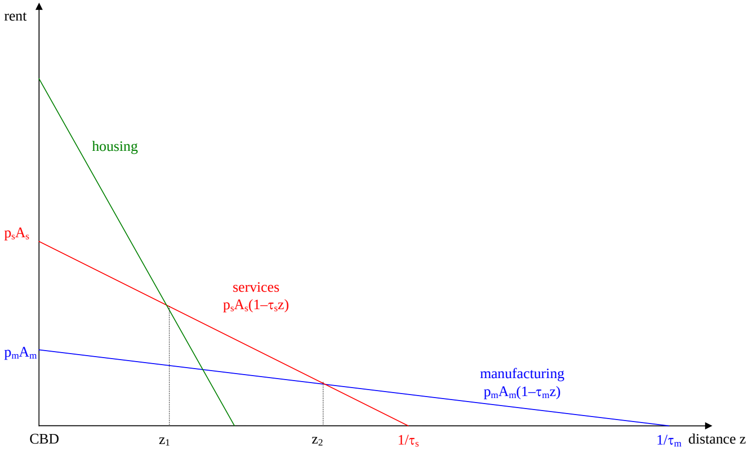
$$R_h(z) = A_h \left[ \frac{D(\tau_h z)I}{u p_m^{\alpha} p_s^{\beta}} \right]^{1/\gamma}.$$

# Equilibrium spatial structure

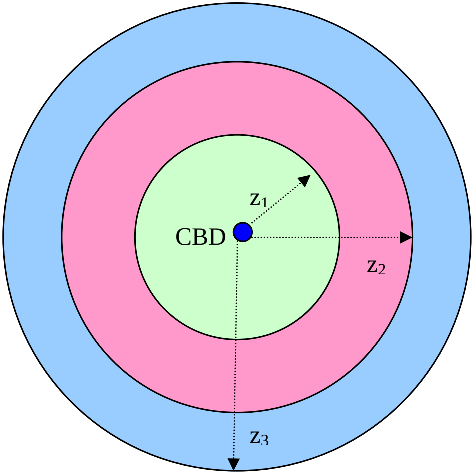
There exists a unique equilibrium.

- Residents live closest to CBD, $\in [0, z_1]$.
- With a (weakly) declining population density.
- Followed by 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



# Finding the equilibrium $z_1$ and $z_2$.

- Cutoffs pin down supply:

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

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

### Balanced growth

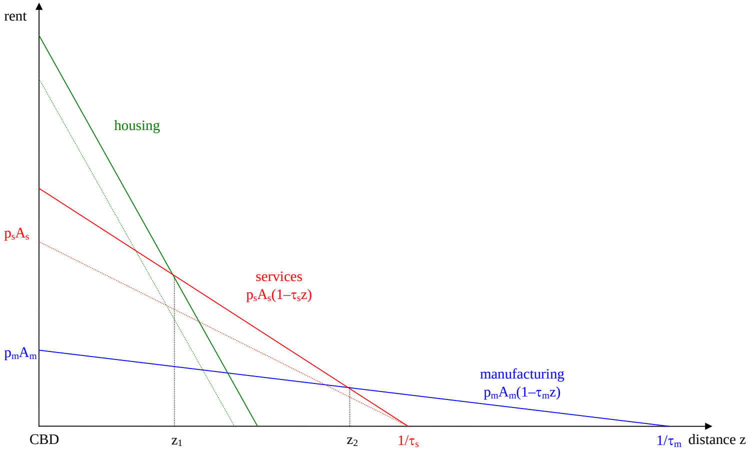
Productivity growth does not change the relative price of services if

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 $z_2$. ($\phi$ denotes $\Phi_2/\Phi_1$.)
- 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



# Functional form assumptions

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

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

- 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,

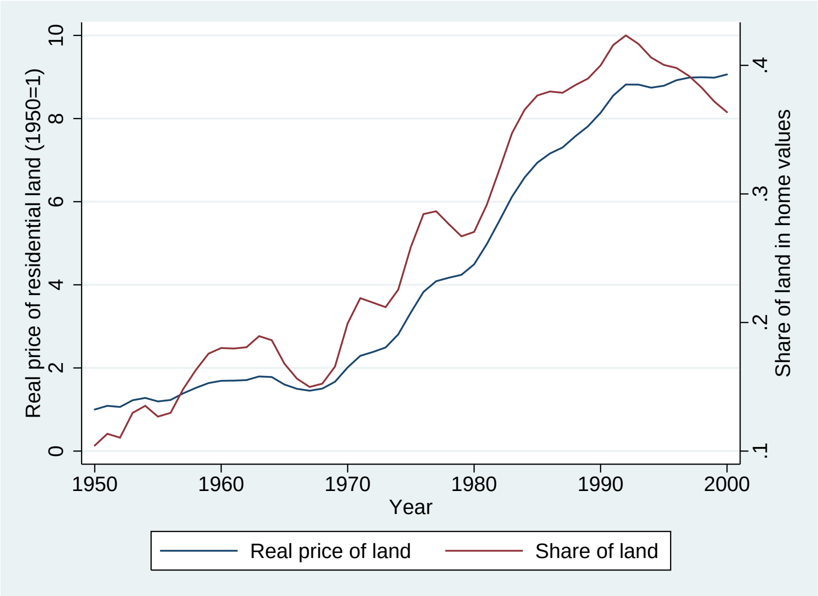
1. residential land increases,
2. home prices increase,
3. the rent gradient becomes steeper,
4. tradable industries move away from center,
5. services become more expensive,
6. labor productivity increases faster in manufacturing.
7. All of these effects are stronger for more densely populated countries.

# Empirical evidence

# 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%.

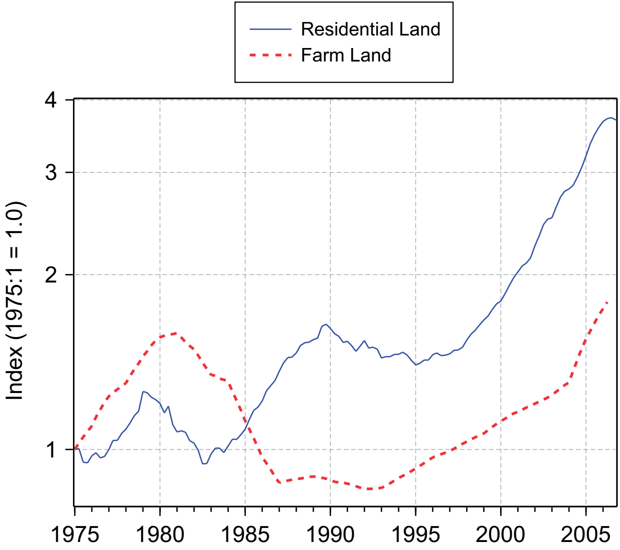
# Land prices and the share of land in home value (Davis and Heathcote, 2007)



# 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 |

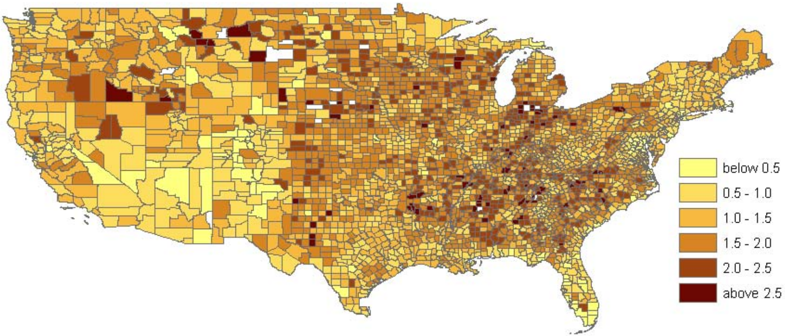
# Rent gradient became steeper.



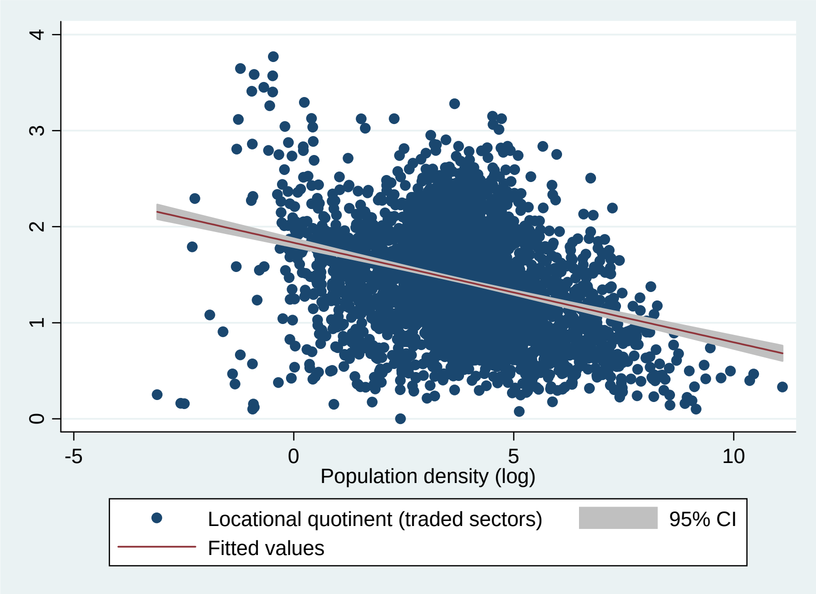
# Tradable sectors move out of cities·

- 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.

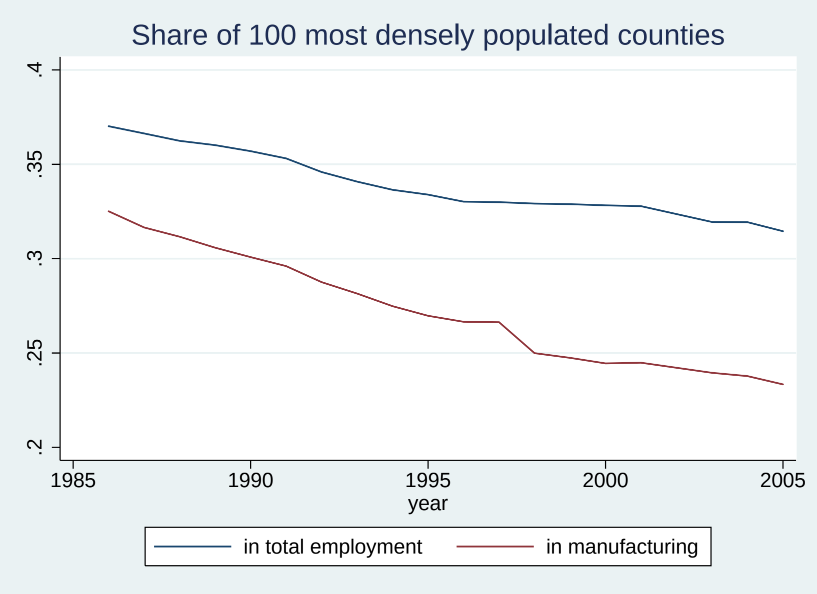
# Locational quotient of tradable sectors·



# Tradables stay away from dense counties.



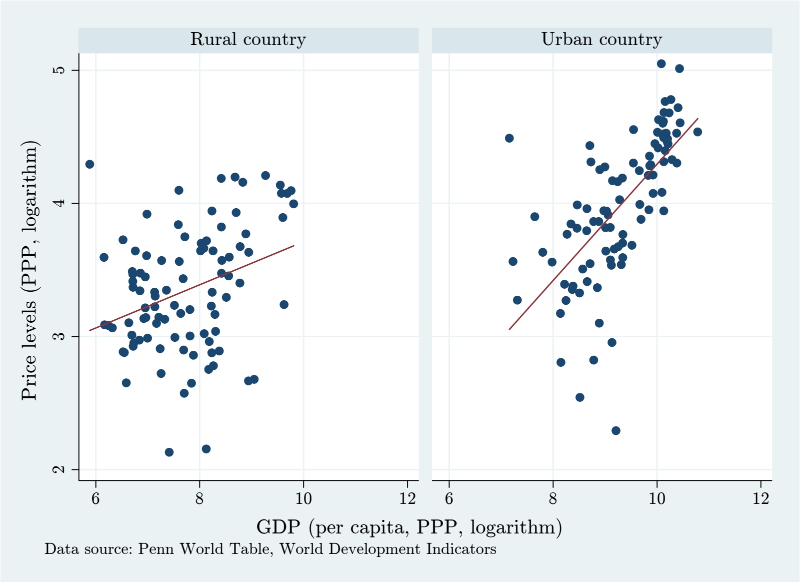
# Industries move away from dense counties



# Proximity to population and inflation

| | Employment share of the most dense counties | Inflation (1947–2006, va) |
|---|---|---|
| GDP | 31.5% | 3.4% |
| Agriculture | 3.2% | 0.5% |
| Manufacturing | 23.3% | 2.1% |
| Services | 33.4% | 3.5% |

# Balassa–Samuelson is stronger in urban countries



# Conclusions

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- The model is tractable enough to incorporate dynamics, multiple countries etc.
- Predictions are consistent with several stylized facts about urbanization, industry location, and relative prices.
- Balassa–Samuelson effect is stronger in urban countries.