Cattle, Steaks and Restaurants: Development Accounting when Space Matters

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Introduction

Development accounting

- Why do poor countries have low output per worker?
  - low capital (and other inputs)
  - low productivity

Development accounting

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  - low capital (and other inputs)
  - low productivity
- Consensus blames low productivity. (E.g., Klenow and Rodríguez-Clare, 1997; Hall and Jones, 1999; Caselli, 2005.)
  - More difficult for policy.
  - Need deeper understanding.

Sector-level development accounting

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- Agricultural productivity varies most. (Caselli, 2005; Restucciaa, Yangb and Zhu, 2008; Duarte and Restuccia, 2010)
- Services productivity is much more similar across countries. (Balassa, 1964; Samuelson, 1964; Baumol, 1966; Baumol and Bowen, 1966; Bailey and Solow, 2001; Duarte and Restuccia, 2012)

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- Upshot: the road to development leads through the farm.

This paper

1. Land matters.
2. Location matters.
3. They matter relatively more for services.

An example of two cities

Large productivity difference in producing beef

	New York City	Budapest	Relative
Roast beef (1 kg)	\$6.75	\$3.50	
Hourly wages	\$16.70	\$3.23	
Beef per hour (kg)	2.47	0.92	2.68
Manufacturing productivity	1.00	0.31	3.23

Smaller productivity difference in restaurant meals

	New York City	**Budapest**	**Relative**
Two-course meal	$198	$65	
Hourly wages	$16.70	$3.23	
Meals per hour	0.08	0.05	1.70
Services productivity	1.00	0.55	1.82

Basic idea

- We believe development accounting should control for the land demand and the location of sectors.
- Without this, services in expensive large cities will be deemed unproductive.
- This matters because rich countries have large service-cities.

Outline

1. A *simple* equilibrium model of sector location
2. A first look at the data
3. Calibrating the spatial features to U.S. data: internal validation
4. Development accounting in the model

A model of sector location

Technology

In each sector i (agriculture, manufacturing, services), technology is Cobb–Douglas:

$$Q_i(z) = A_i L_i(z)^{\beta_i} N_i(z)^{1-\beta_i}$$

- z: location of production (see later)
- A_i: Hicks-neutral productivity
- L_i: land (spatially immobile factor)
- N_i: labor (spatially mobile factor)
- β_i: land share

The role of space

- Von Thünen monocentric city model: All market exchange takes place in a central business district (CBD).
  - Stand-in for other externalities the city may provide.
- Shipping to distance z entails proportional costs

$$1 - e^{-\tau_i z}.$$

τ_i: *hazard* of iceberg melting, goods damaged etc. per km

Aggregation over space

- Aggregate value added at producer prices:

$$\tilde{Q}_i = \int_{z \in Z_i} \tilde{P}_i(z) A_i L_i(z)^{\beta_i} N_i(z)^{1-\beta_z} dz$$

- Define representative location $\tilde{z}_i$:

$$e^{-\frac{\tau_i}{\beta_i}\tilde{z}_i} = \int_{z \in Z_i} \frac{L_i(z)}{L_i} e^{-\frac{\tau_i}{\beta_i} z} dz$$

- All aggregates are a function of $\tilde{z}_i$ only, as if all production happened at that point.

Productivity

- Output per worker

$$\frac{\tilde{Q}_i}{N_i} = A_i \left(\frac{L_i}{N_i} \right)^{\beta_i} e^{-\tau_i \tilde{z}_i}.$$

- Low if
  - productivity is low (technology, capital)
  - land is scarce (especially for land intensive sectors)
  - trade costs are high
  - cities are large
- Interation between sector characteristics (β, τ) and sector location ($\tilde{z}$).

Spatial equilibrium

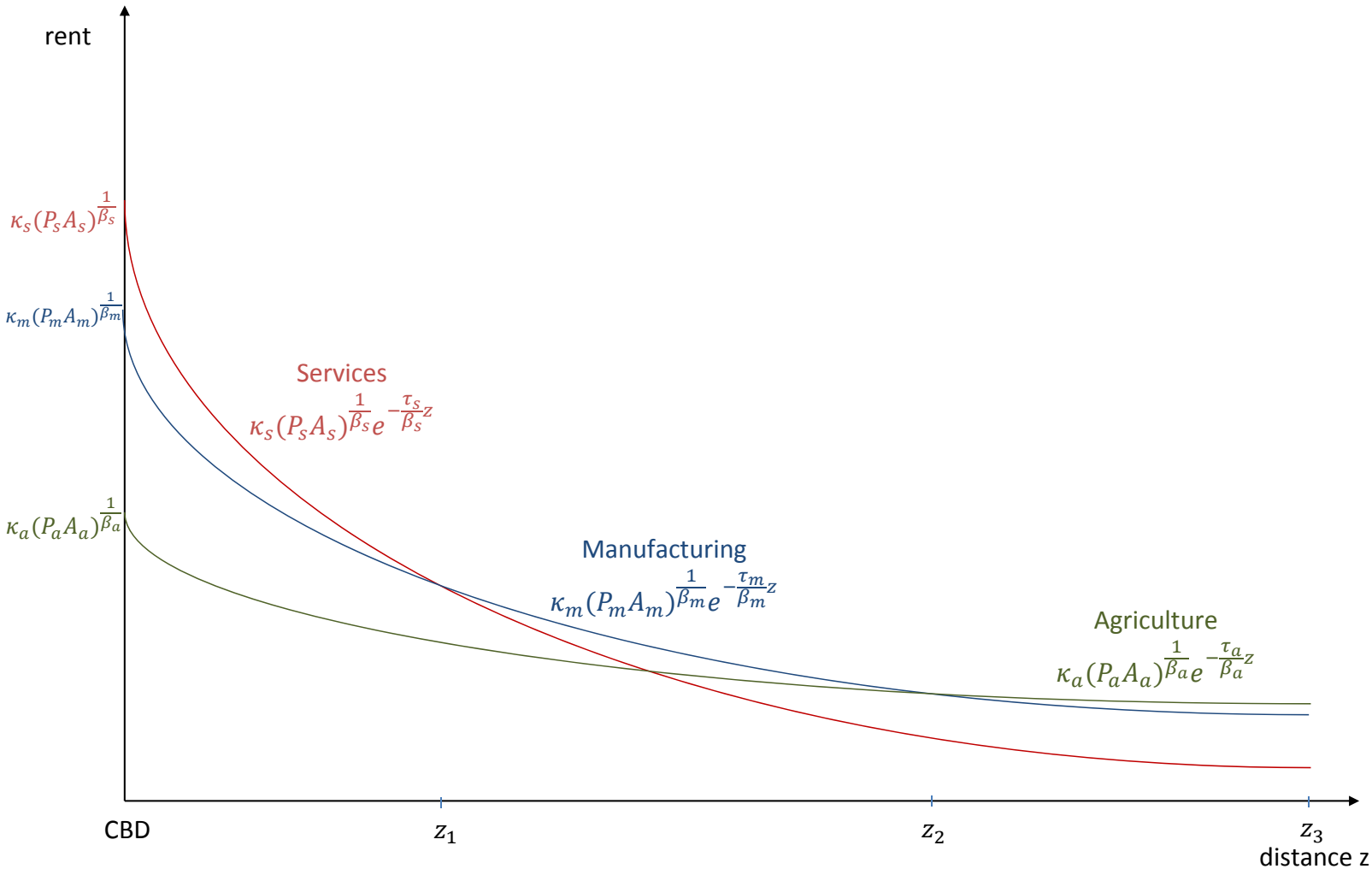
The bid rent curve

- Markets are competitive, firms choose location freely.
- Bid-rent curve:

$$R_i(z) = \beta_i(1-\beta_i)^{1/\beta_i - 1}(P_i A_i)^{1/\beta_i} W^{1-1/\beta_i} e^{-\frac{\tau_i}{\beta_i} z}$$

- Each location goes to the highest bidder.

Spatial equilibrium



Spatial equilibrium

Sectors sort by τ_i/β_i. Less tradable and less land intensive sectors locate closer to cities.

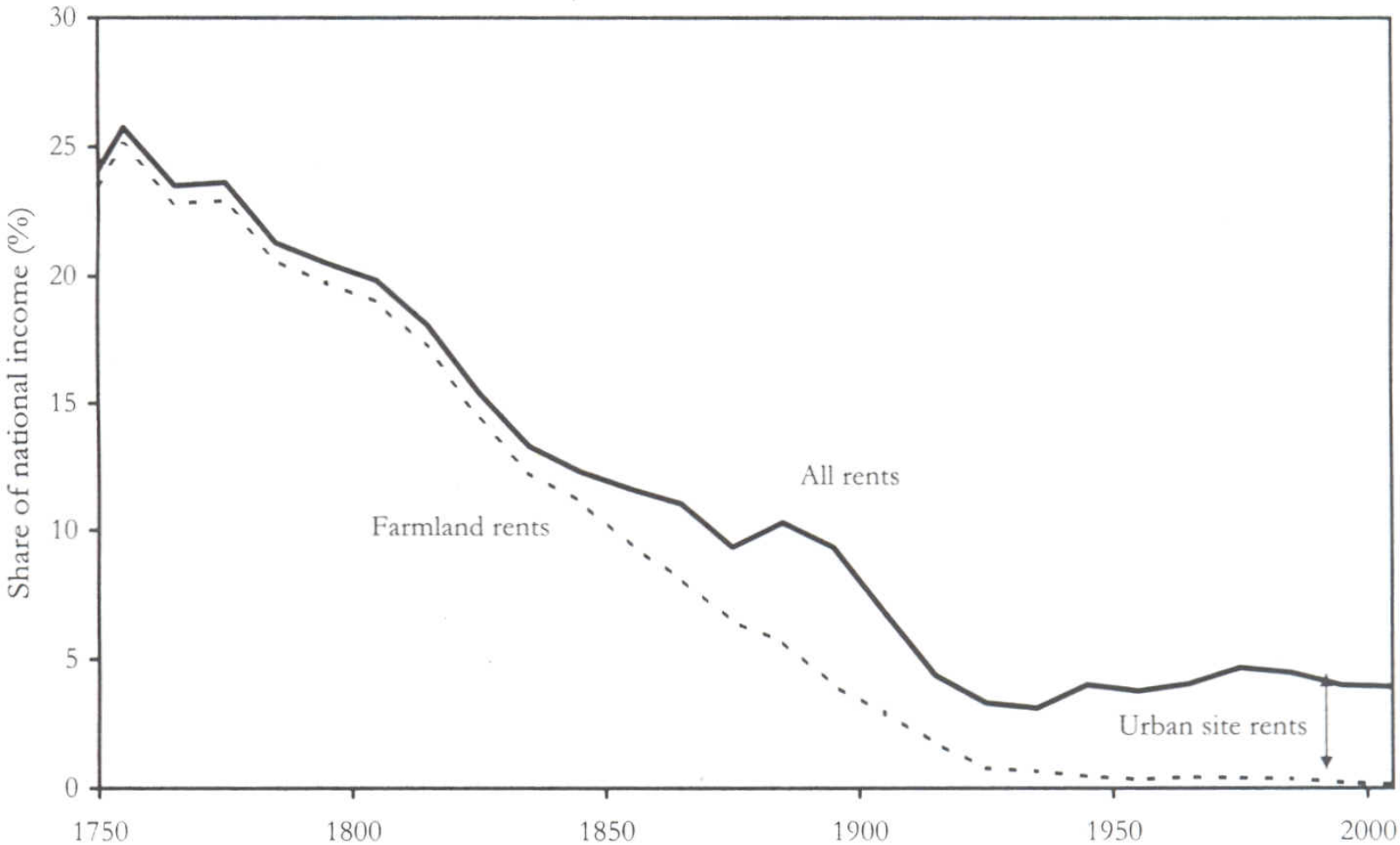
1. services locate in $[0, z_1]$
2. manufacturing locates in $(z_1, z_2]$
3. agriculture locates in $(z_2, z_3]$

Solving for sector location

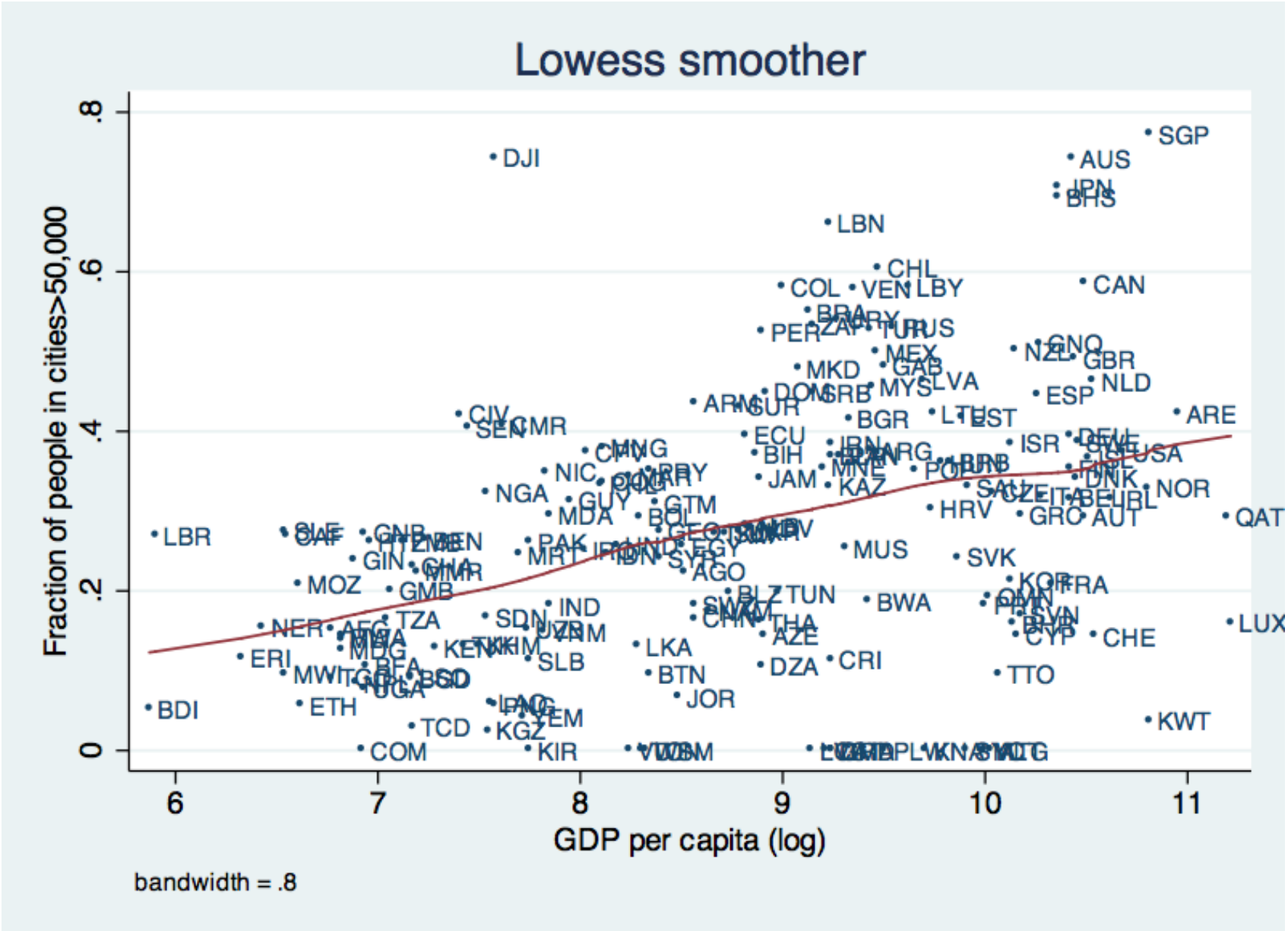
- Take two neighboring sectors. The cutoff between them determines
  1. the relative supply of land in each
  2. the relative price of land in each (by spatial aribtrage)
- Goods market clearing then pins down cutoff.
- Under Cobb–Douglas preferences and technologies, equilibrium spatial structure is independent of development.
- Spatial structure only depends on
  - sectoral composition α_i
  - city size z_3

A first look at the data

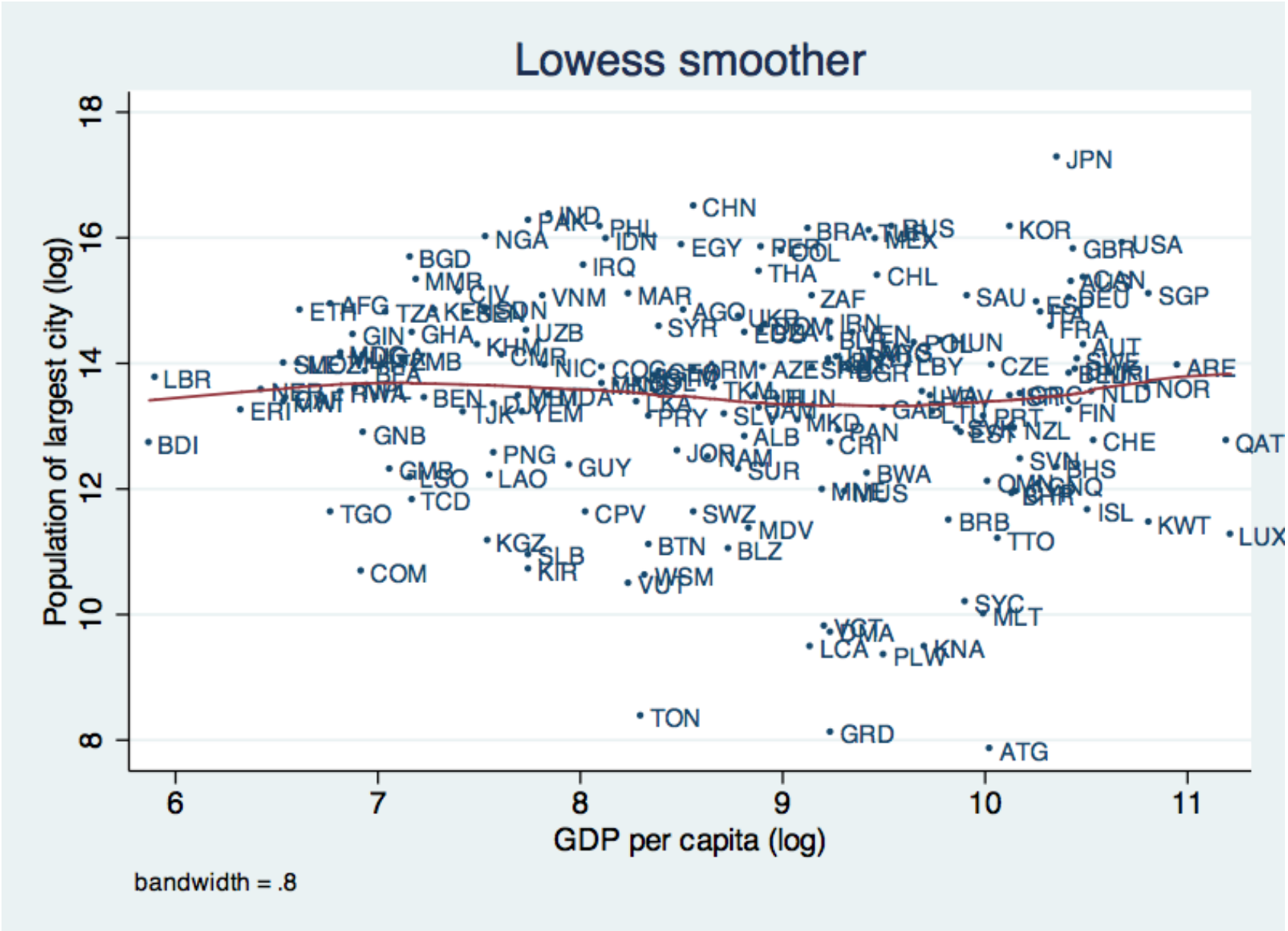
Land is no longer important but urban land is (Clark, 2007)



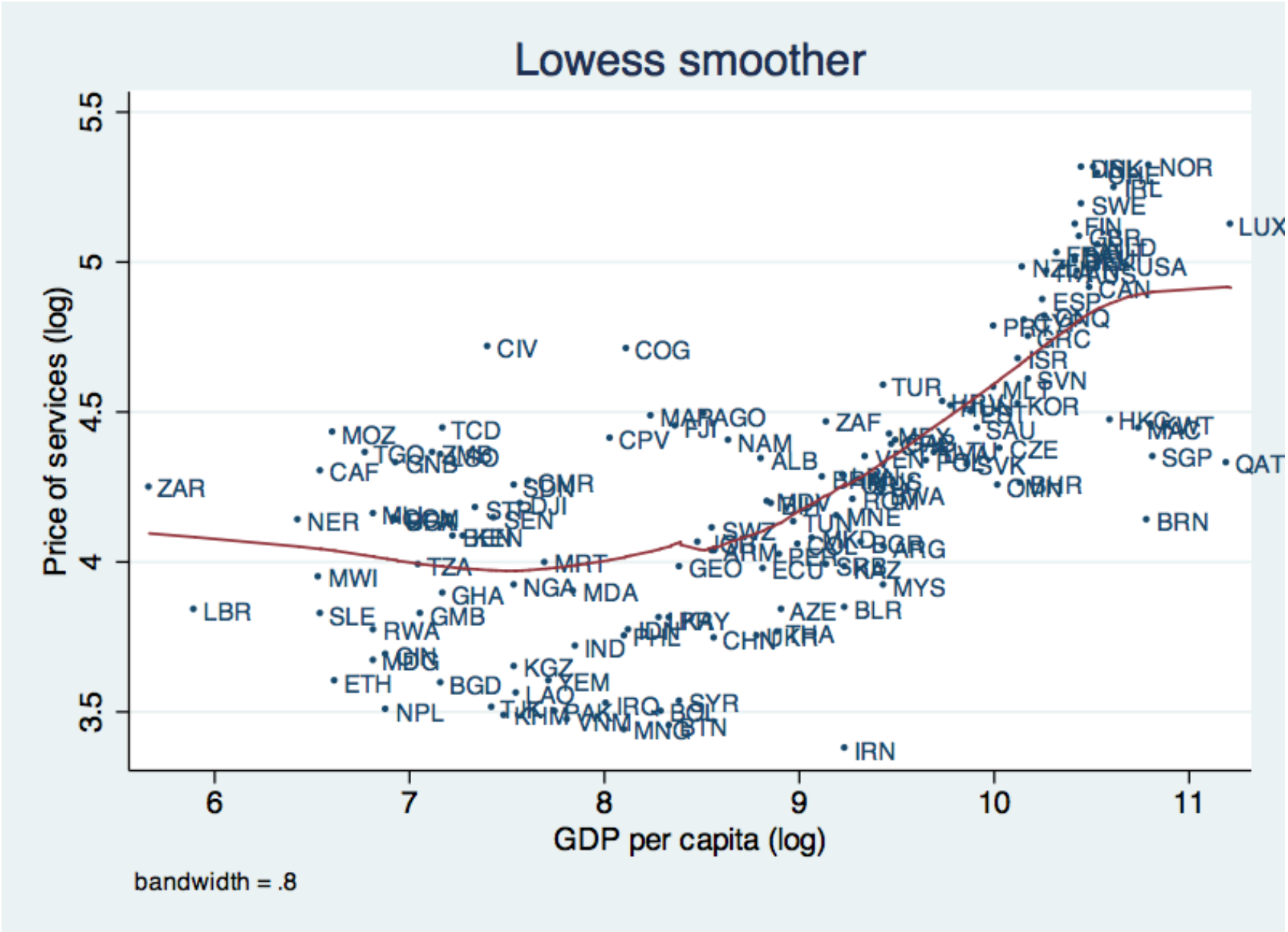
Rich countries are more urbanized



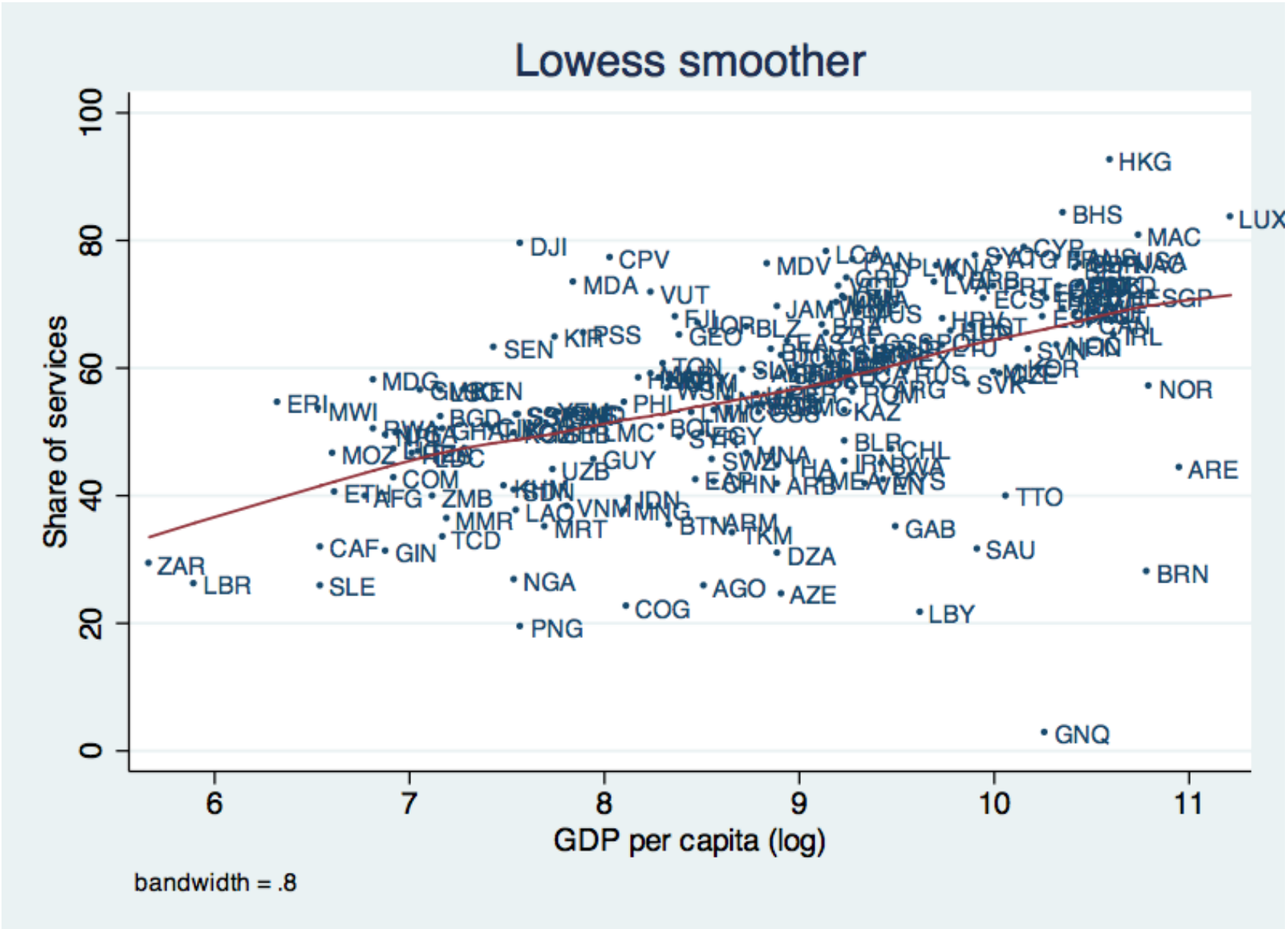
But their cities are similar



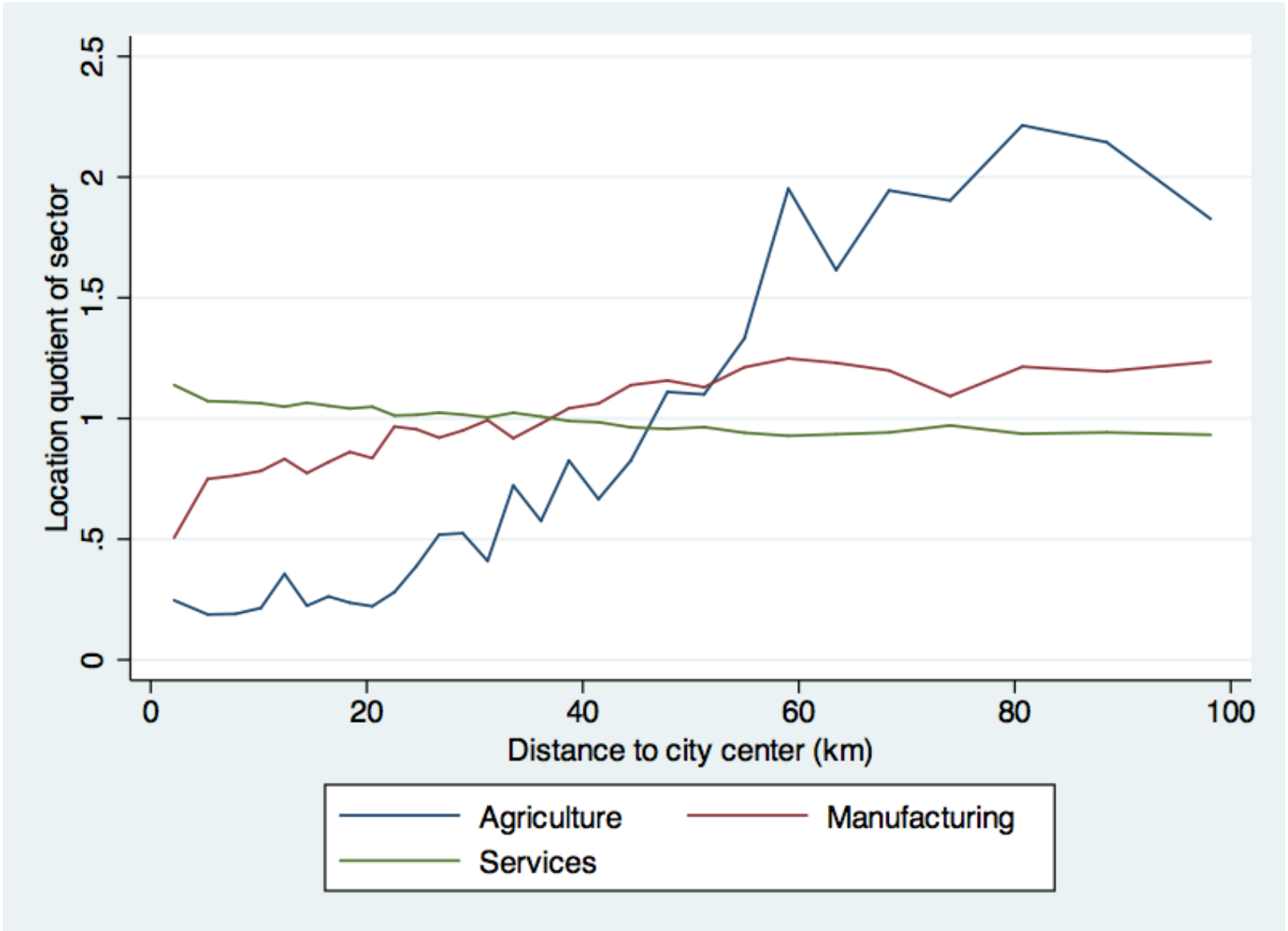
Service prices rise steeply with income



Richer countries produce more services



Sectors sort as in the model



Calibration

Road map

1. Estimate parameters τ and β from U.S. spatial and NIPA data.
2. Measure country-specific sectoral shares α.
3. Infer city size z_3 from population of cities in each country.
4. Solve for equilibrium sector locations $\tilde{z}_1$, $\tilde{z}_2$, $\tilde{z}_3$.
5. Conduct productivity decompositions.

Calibration

- We calibrate production and shipping technologies to U.S.
- Land shares come from Herrendorf and Valentinyi (2008):

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

- Complemented with indirect use of land:
  - workers' housing expenditure (0.30 from BLS)
  - of which devoted to land (0.36 from Davis and Palumbo, 2008)

Sectoral locations

- We use the 2007 ZIP Business Patterns to measure sector locations in the U.S.
  - Establishment and employment counts for 38,000 ZIP codes in 6-digit NAICS codes.
- For each ZIP-code, we identify the nearest Urbanized Area (city above 50,000) and calculate its distance.
  - 11215 is 6km from NYC, 07030 is 4km.
- Estimate τ_i from employment-density gradients for each sector.

Employment density

- Emplyoment per km2 at location z,

$$\frac{N_i(z)}{L_i(z)} = (1-\beta_i)^{1/\beta_i} \left(\frac{P_i A_i}{W}\right)^{1/\beta_i} e^{-\frac{\tau_i}{\beta_i} z}.$$

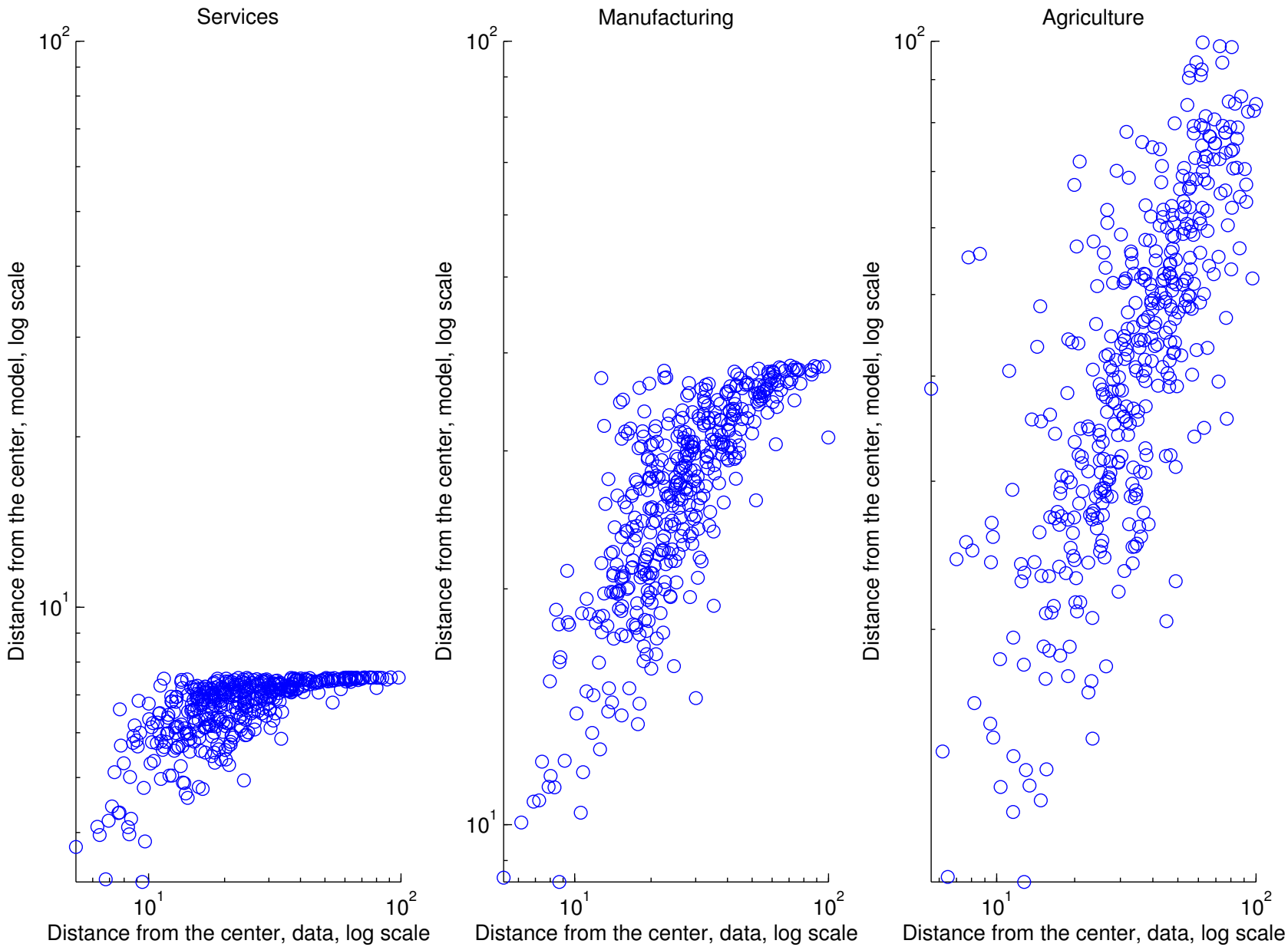
- Estimate with Poisson:

$$\frac{n_{izc}}{l_{izc}} = e^{\mu_c + \nu_i - \gamma_i d(z,c)}.$$

Sectoral land shares and estimated gradients

		Gradient (per km)	
	Land share	**Rents**	**Prices**
Services	13%	13.15%	1.71%
Manufacturing	10%	5.15%	0.52%
Agriculture	23%	3.54%	0.81%

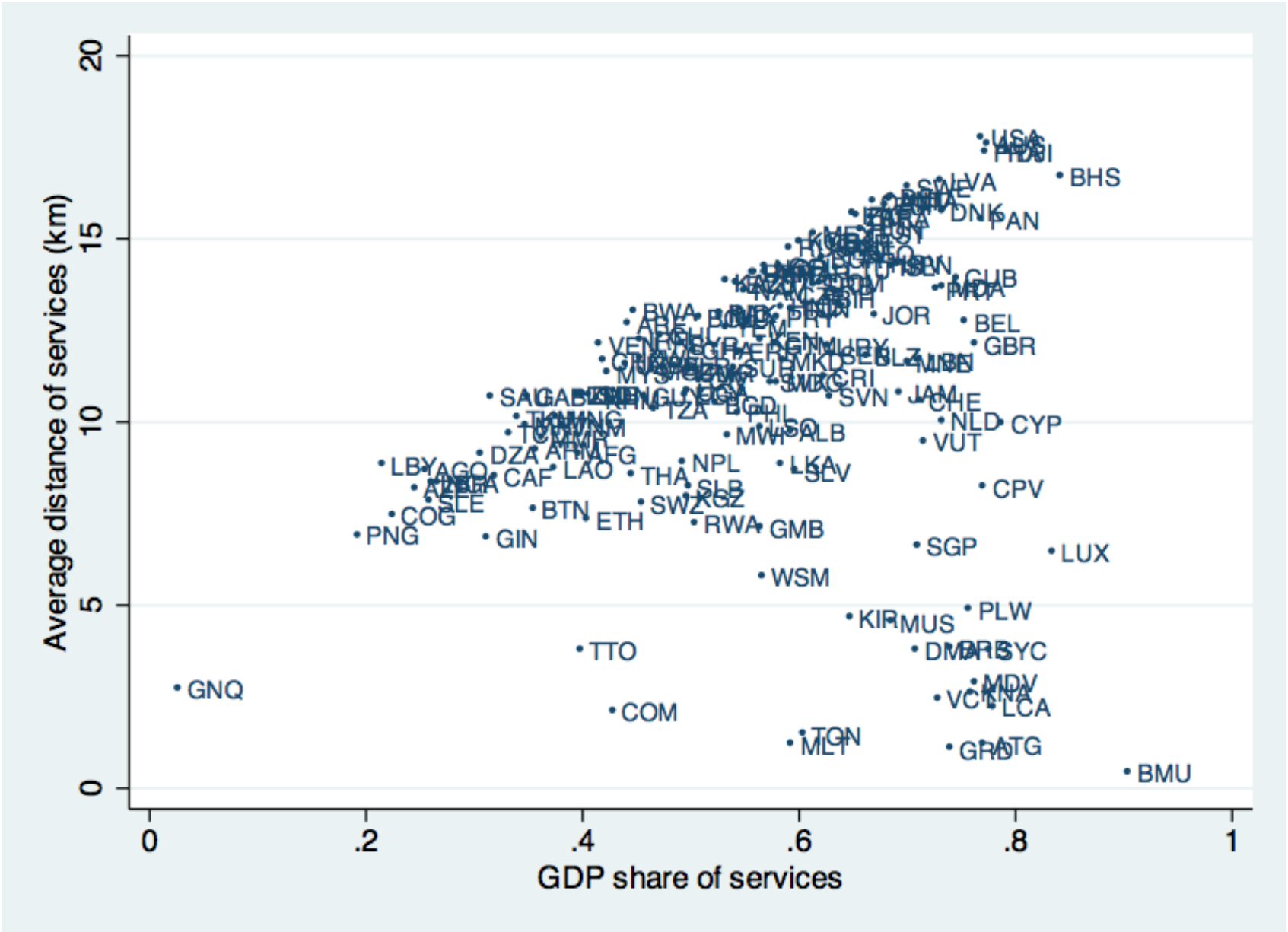
Validation of model across U.S. cities



Determining sector locations in other countries

- Take global list of cities with population data (45,000) from MaxMind.
- Exogenously divide up country land area across cities (z_3).
- Given sector shares α_i, solve for sector location in each city *in isolation*.
- Present results with largest city.

Cities in service-intensive countries have larger service cores



Development accounting

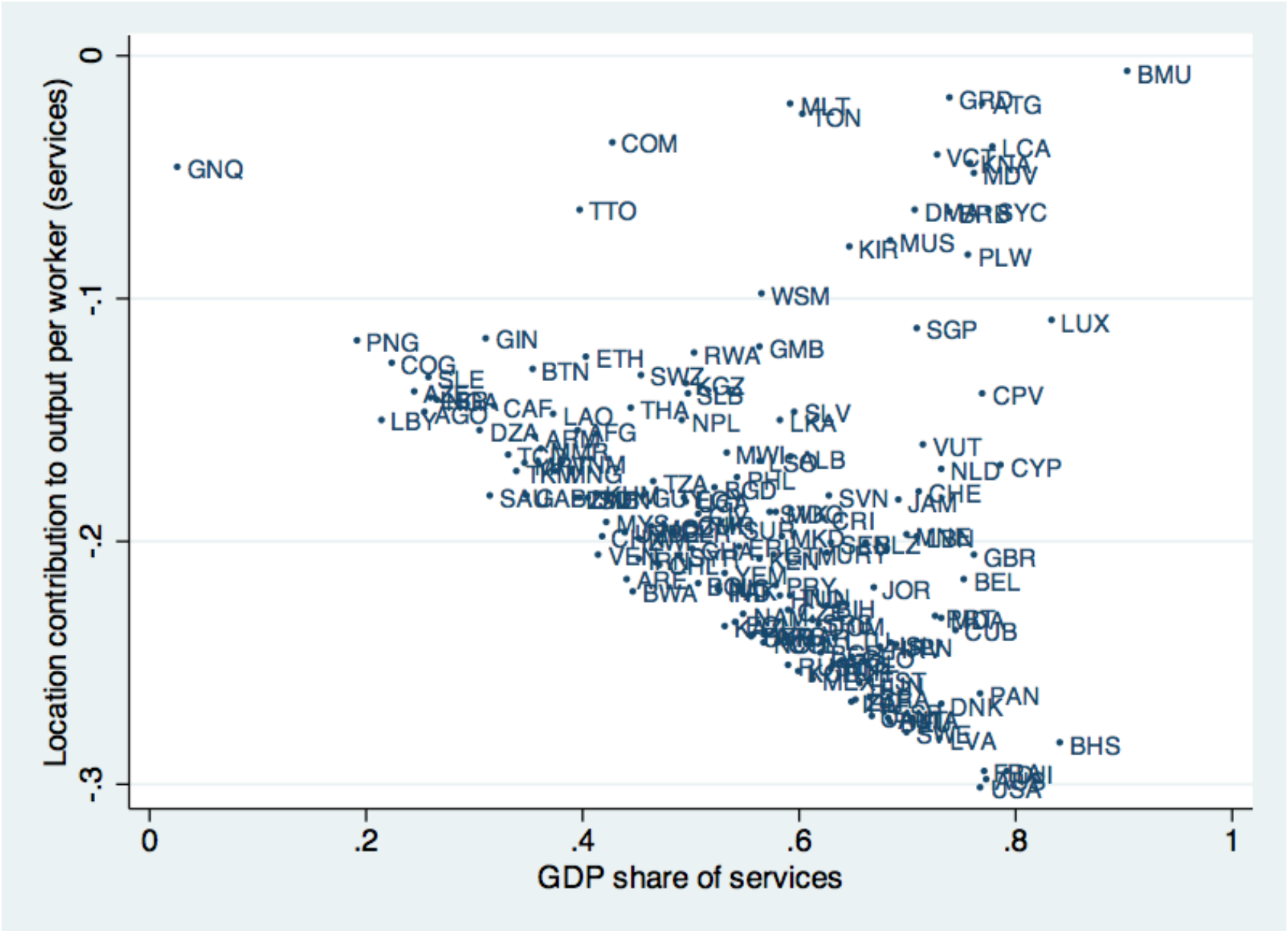
Development accounting

- Decompose log output per worker into

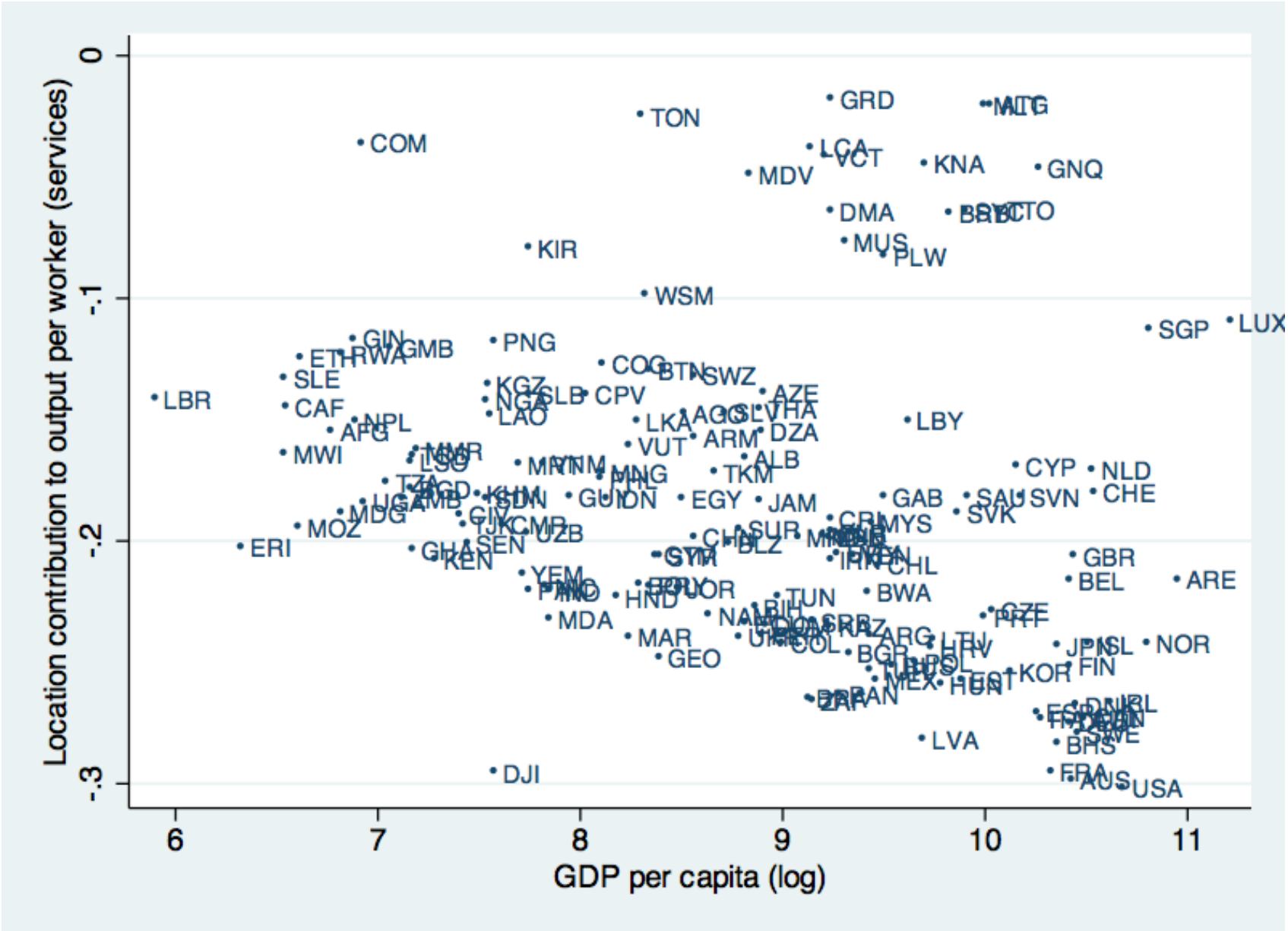
$$\ln \frac{\tilde{Q}_i}{N_i} = \underbrace{\ln A_i}_{\text{productivity}} + \underbrace{\beta_i(\ln L_i - \ln N_i)}_{\text{land}} \underbrace{-\tau_i \tilde{z}_i}_{\text{location}}$$

- Document, for each sector, how the components vary with development.
  1. Last two components across 191 countries (no productivity data).
  2. All components across 14 EUKLEMS countries (little variation).

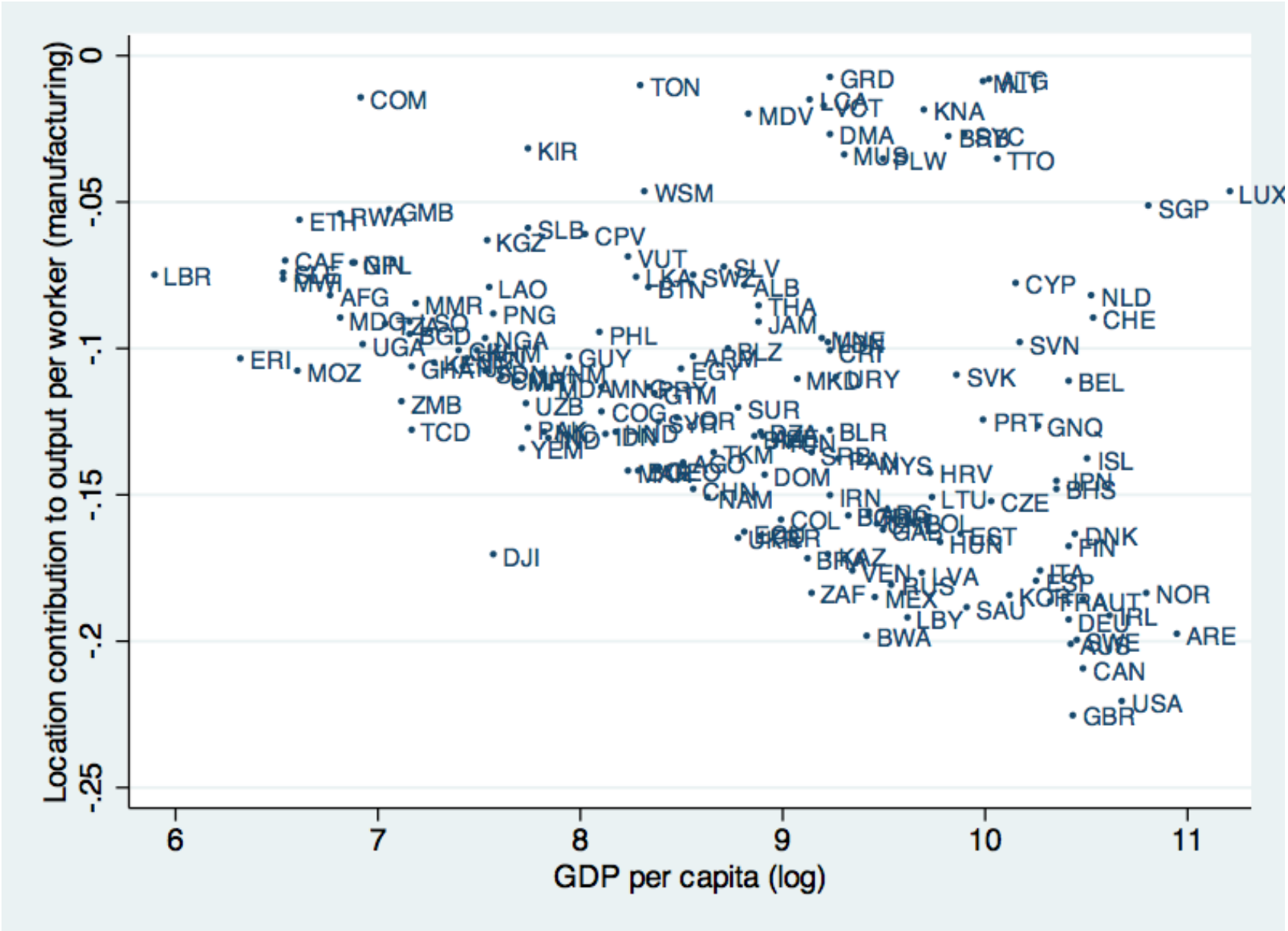
Location leads to lower output per worker in service cities



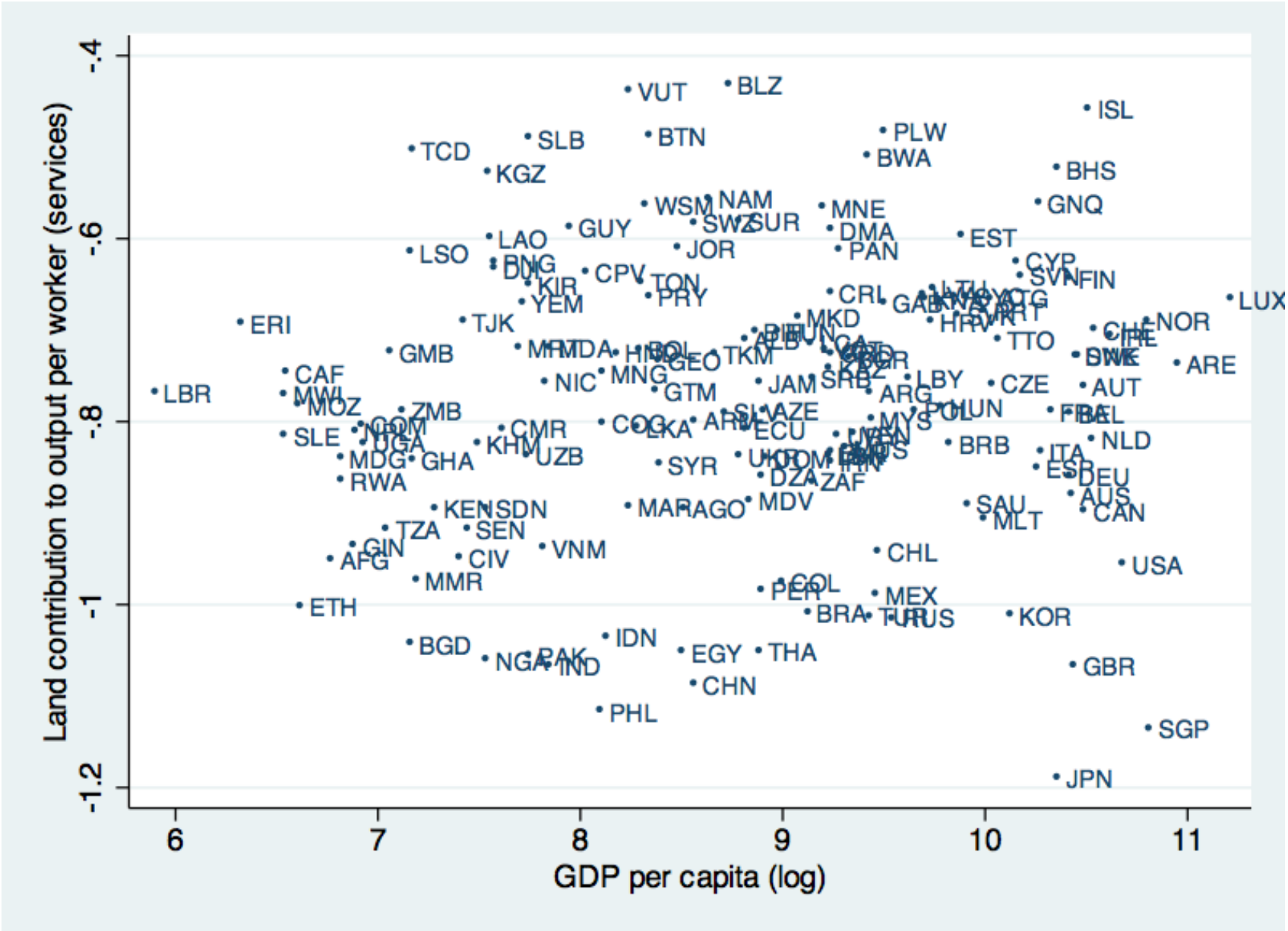
...reducing service output in rich countries



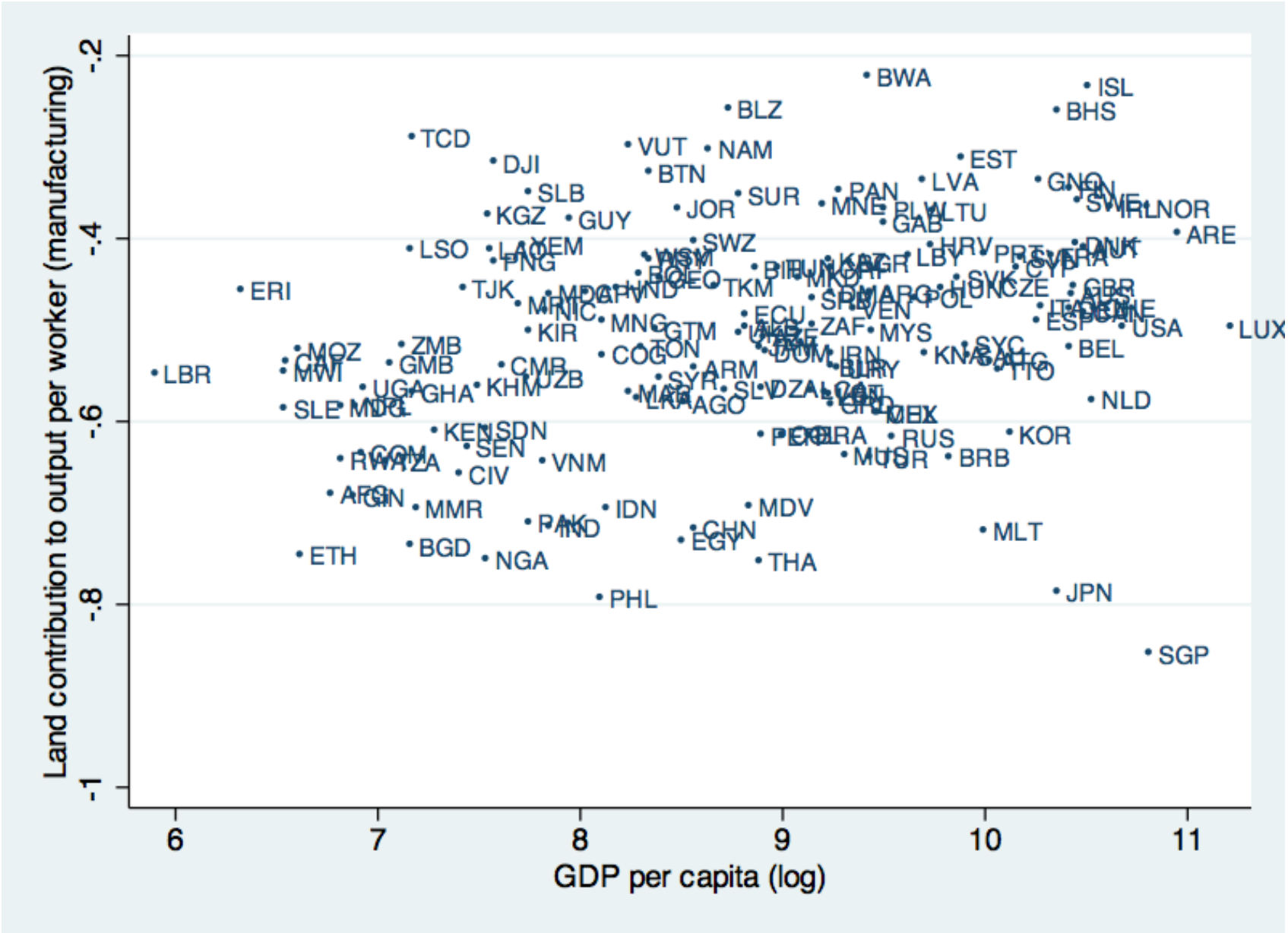
Manufacturing is crowded out of cities in rich countries



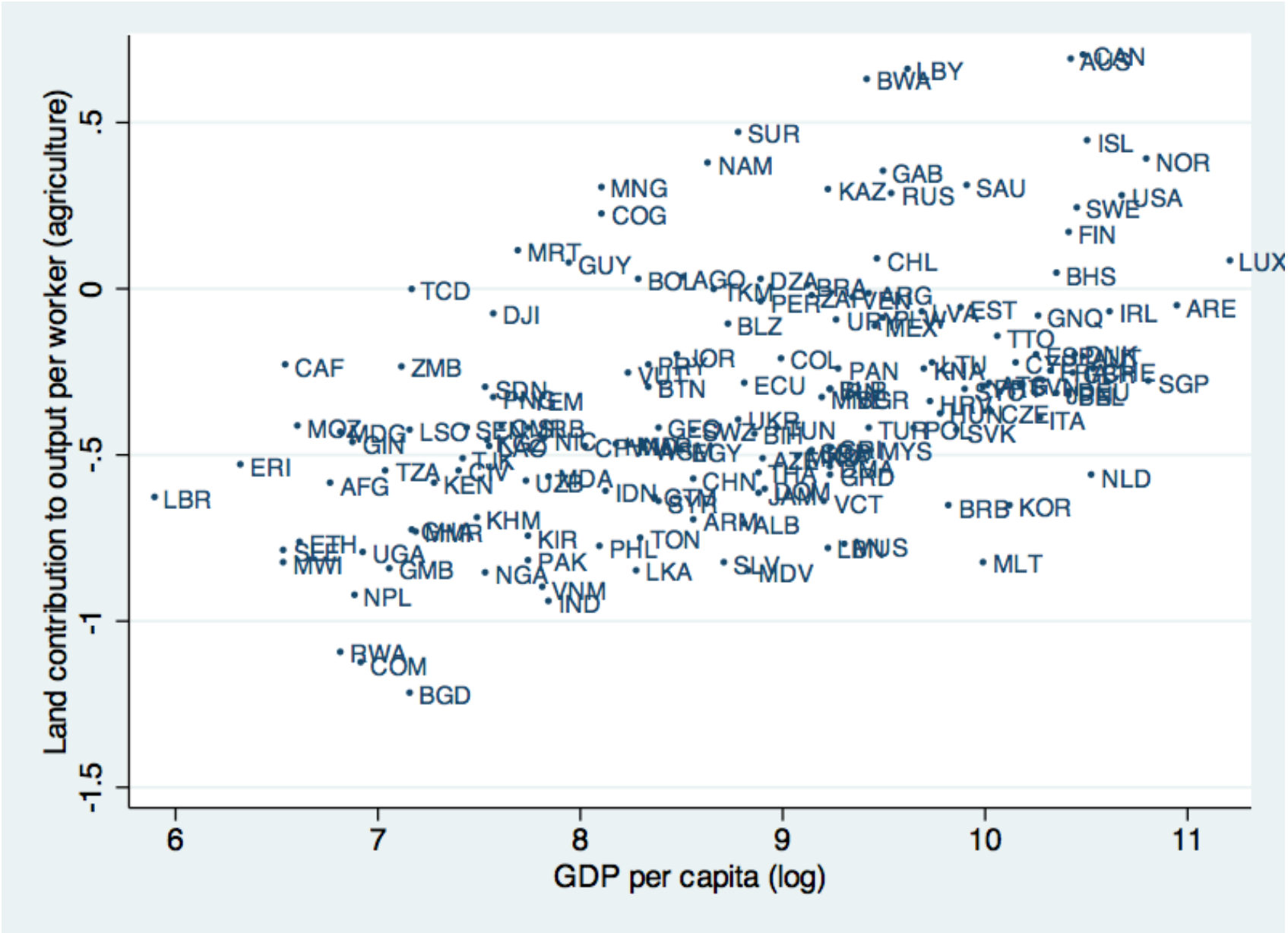
Land use of services is uncorrelated with development



Land makes manufacturing somewhat more productive in rich countries



Land makes agriculture much more productive in rich countries



The elasticity of productivity with respect to GDP per capita

	Measured	**Location-corrected**
Services	0.628	0.855
Manufacturing	0.867	0.926
Agriculture	1.634	1.806

Conclusion

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- Services in rich countries would be even more productive in poor cities.
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- Simple macro model with space to talk about sectoral aggregates.
- Services in rich countries would be even more productive in poor cities.
- Agriculture in rich countries would be less productive in poor rural areas.
- Productivity dispersion is more similar across sectors than previously thought.

Takeaway

1. Back to square 1: we still don't know which sector drives productivity differences.

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2. Variation might come from macro policies and institutions and may not be sector specific.

Appendix

Measurement

Measuring land

OECD Manual "Measuring Capital"

Valuing stocks of land is also problematic when land prices vary significantly between locations and applying an "average" price of land seems liable to significant bias.

EUKLEMS

Note that we only include fixed reproducible assets. To have a complete capital accounts, however, land and inventories should also be taken into consideration, as capital compensation in the national accounts includes the user costs of these items as well.

Measuring prices

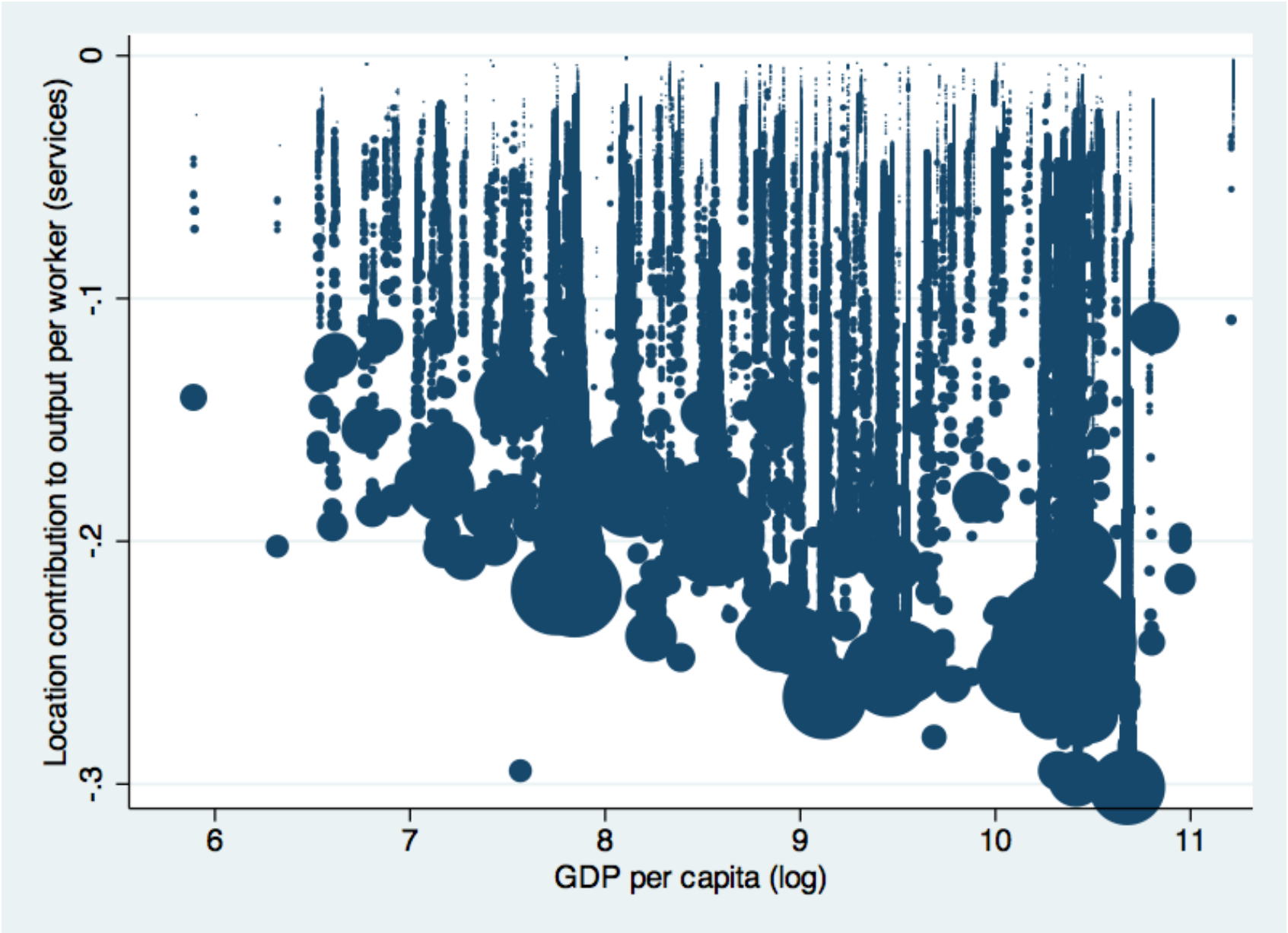
- Precise consumer and producer prices by location would lead to precise productivity measures.
- However:
  1. Location variation is difficult to track.
  2. Service prices are hard to measure (BLS PPI).
  3. Service trade costs are almost impossible to measure (BEA IO).

Extensions

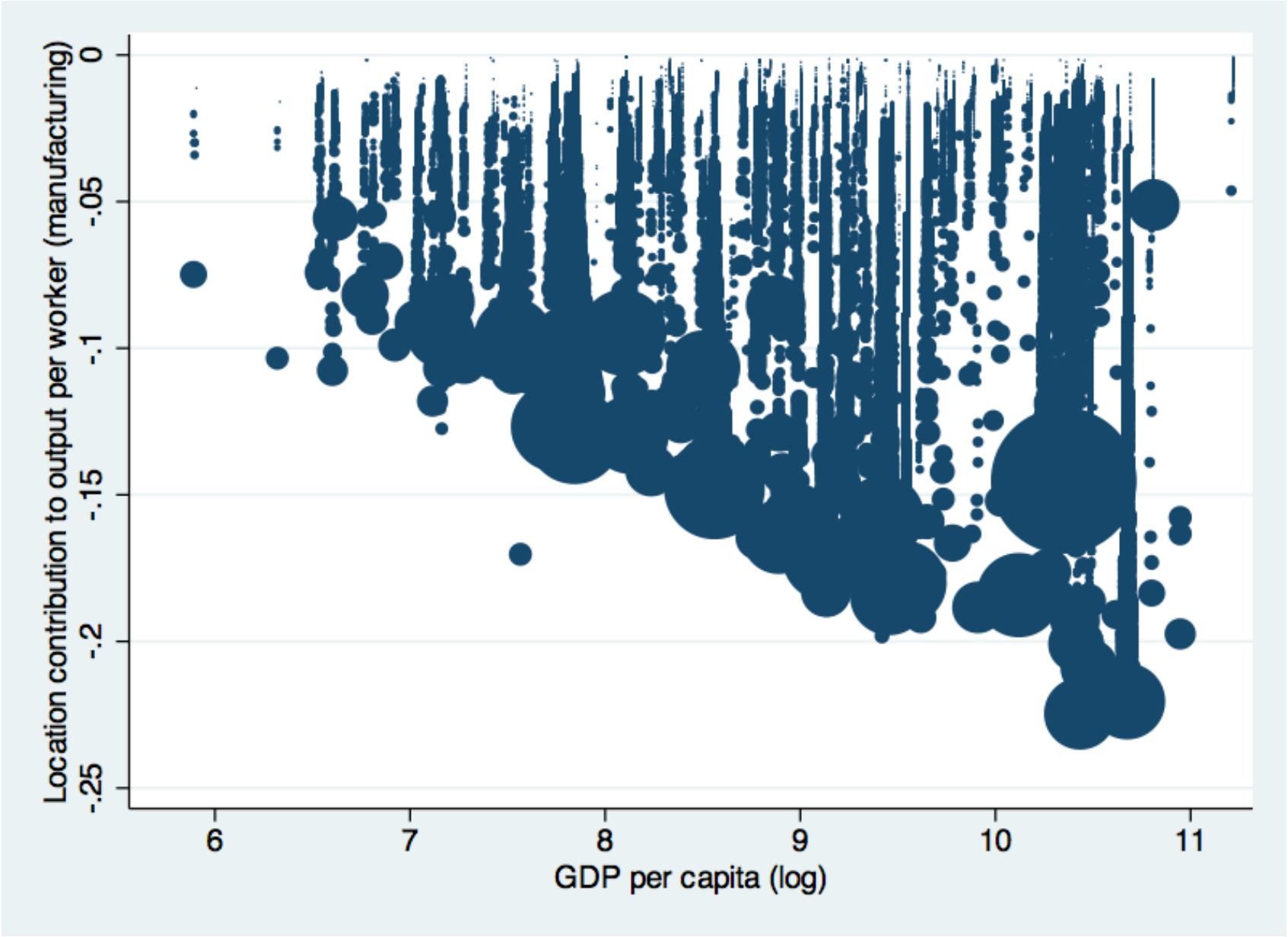
Multiple cities

- Taking city structure as given, estimate z_1, z_2 and z_3 for each city.
- With weighting, patterns are similar to single-city version.

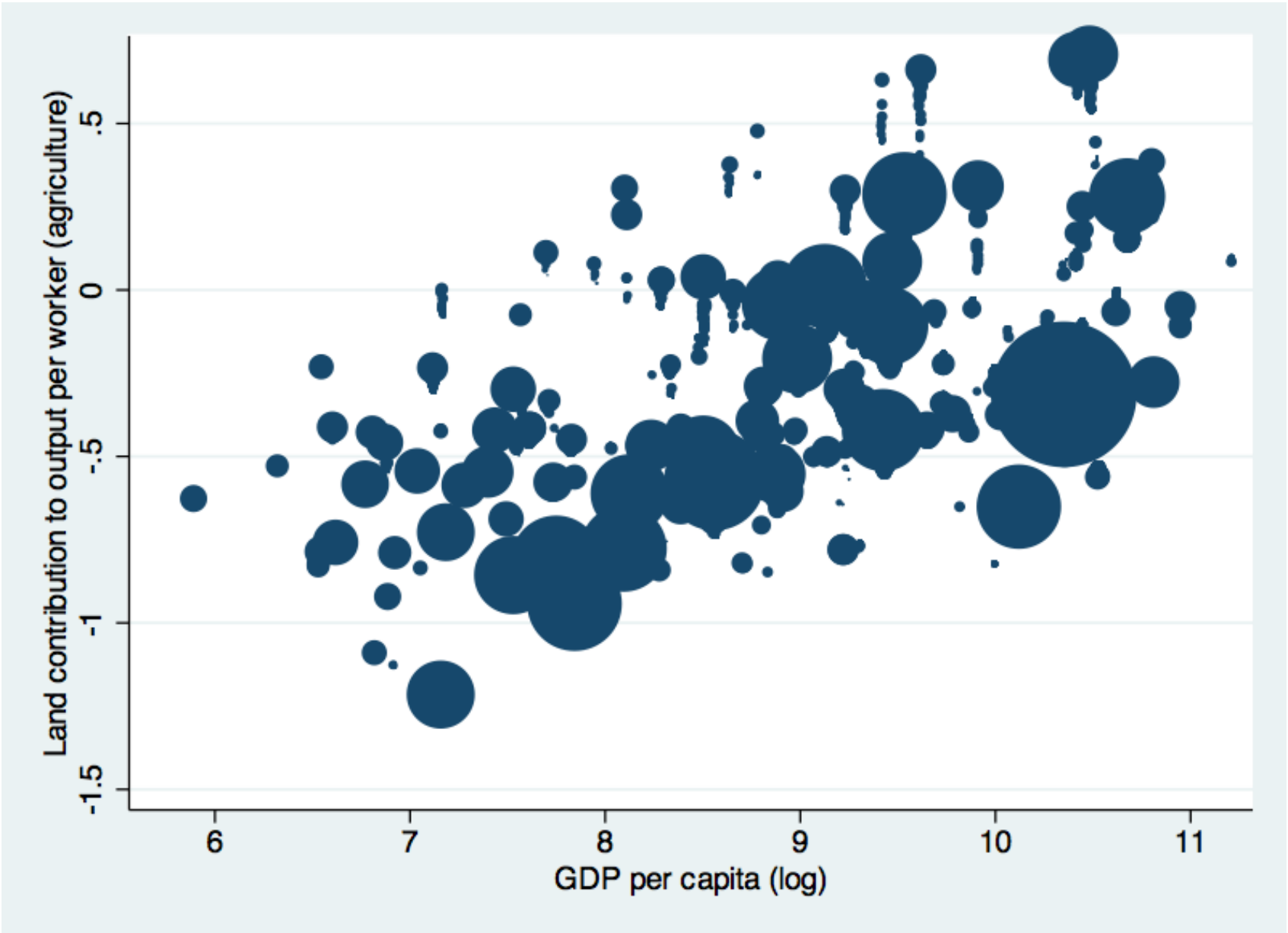
Location makes services less productive in rich countries



Location makes manufacturing less productive in rich countries



Land makes agriculture more productive in rich countries



Endogenous cities

Tradable services

Agglomeration externalities