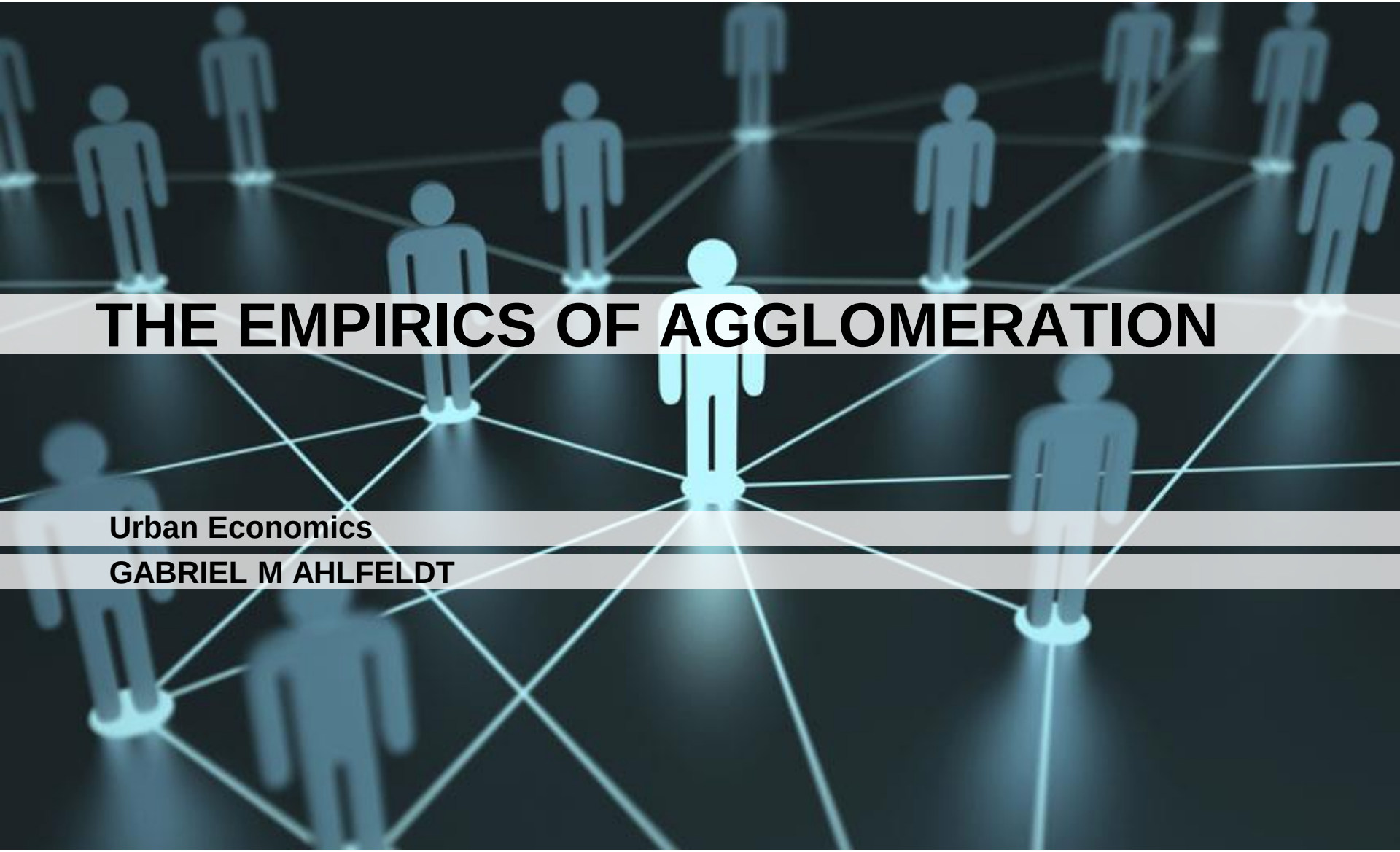


THE EMPIRICS OF AGGLOMERATION

Urban Economics

GABRIEL M AHLFELDT

I COURSE COMPONENTS

the idea

- Block I
  - Introduction to Urban and Regional Economics and Course Overview
  - Topic I: Regional and urban concentration forces
  - **Topic II: The empirics of agglomeration**
  - Topic III: Costs and benefits of agglomeration
- Block 2
  - Topic IV: Monocentric city I (household location choice)
  - Topic V: Monocentric city II (household location choice)
  - Topic VI: Firm location choice
  - Topic VII: The urban economy in general equilibrium
- Block 3
  - Topic VIII: The vertical dimension of cities
  - Topic IX: Suburbanization and gentrification
  - Topic X: Spatial inequalities

I INTRODUCTION

the idea

- **Last time: *Theory* of agglomeration**
  - **Spatial concentration in regions**
    - **C-P Model**
  - **Spatial concentration in cities**
    - **Urbanization economies**
      - **Within sectors**
    - **Localization economies**
      - **Between sectors**
    - **Marshallian externalities**
      - **Shared inputs**
      - **Pooled labour markets**
      - **Knowledge spillovers**

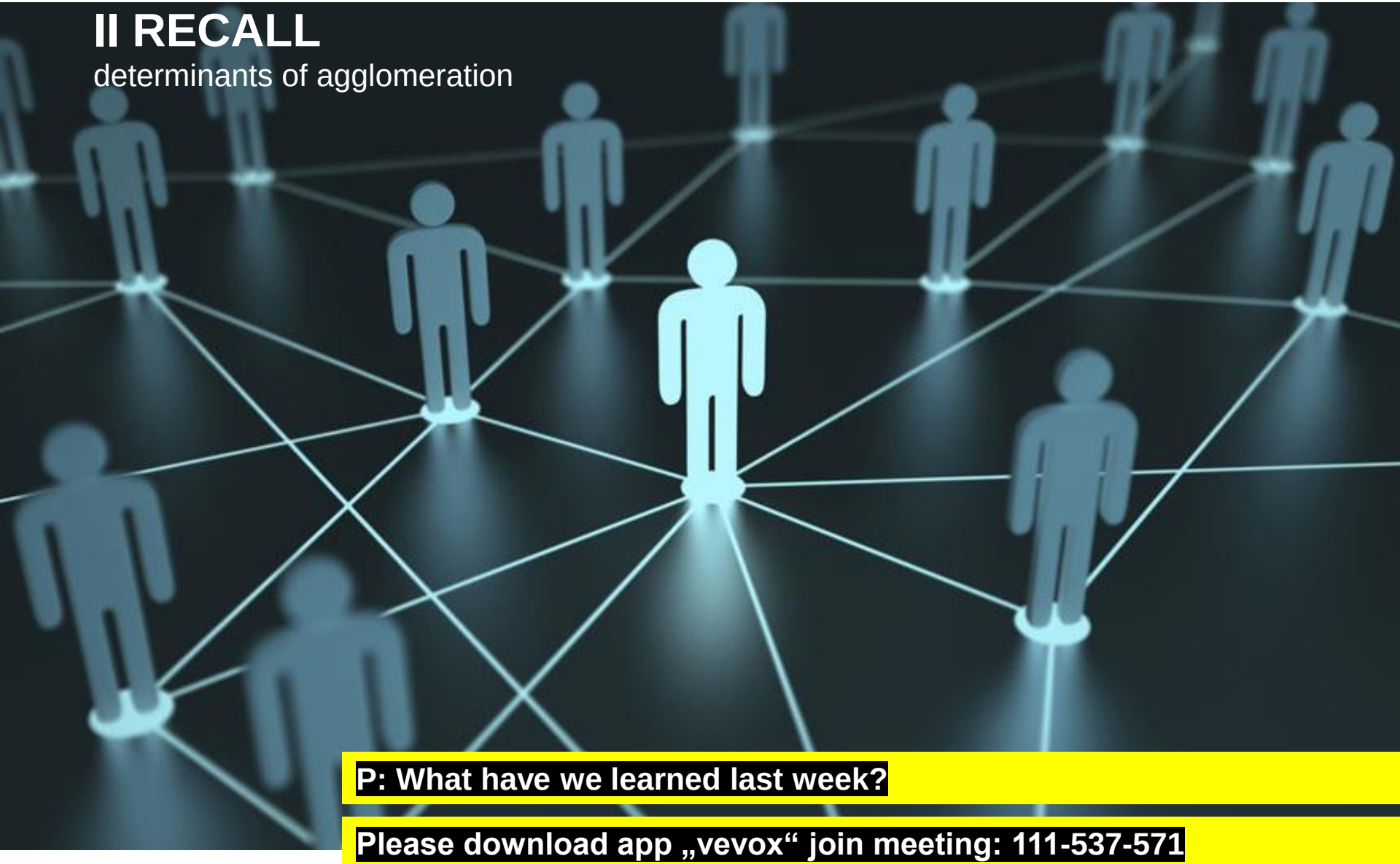
I INTRODUCTION

the idea

- **This time: *Empirics* of agglomeration**
  - **1) Determinants of agglomeration**
    - **Which sectors**
    - **At what spatial level**
    - **Correlation with proxies for MAR externalities?**
  - **2) The Spatial scale of agglomeration effects**
    - **How far to spillover effects travel?**
  - **3) The effects of agglomeration**
    - **Productivity effects in agglomerations**
  - **4) Urbanization vs. localization effects**
    - **What matters for urban growth (implications for RE markets)**

II RECALL

determinants of agglomeration

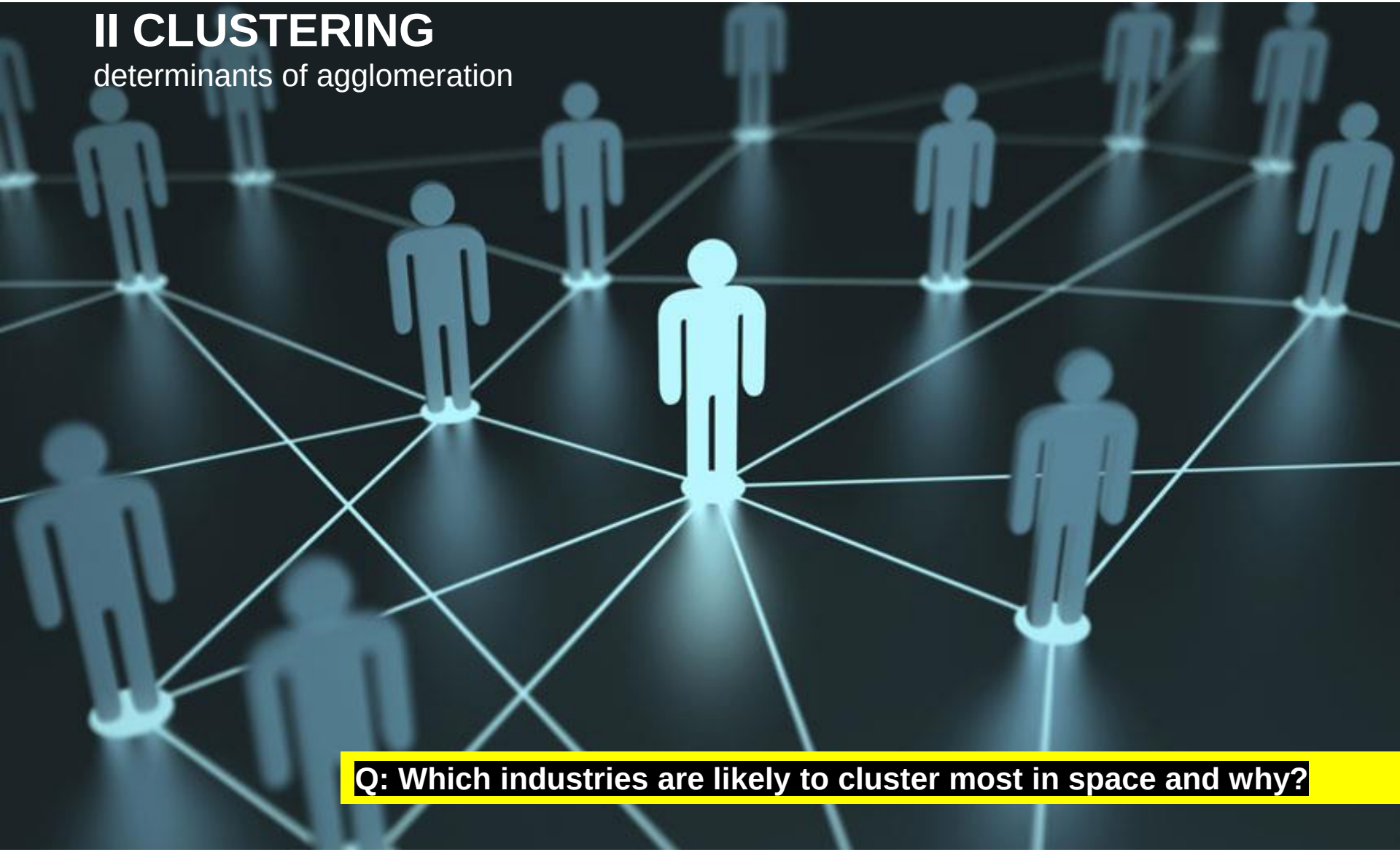


P: What have we learned last week?

Please download app „vevox“ join meeting: 111-537-571

II CLUSTERING

determinants of agglomeration



Q: Which industries are likely to cluster most in space and why?

II MEASURING SPATIAL CONCENTRATION

determinants of agglomeration

- **Rosenthal and Strange (2001) use a measure of spatial concentration to understand which industries agglomerate and (likely) why?**
- **Need a spatial concentration measure**
  - **Captures the extent to which one industry is *more* concentrated in space than overall employment (the counterfactual) [γ>0 captures the degree of relative spatial concentration]**

Ellison-Glaeser (1997) index

$$\gamma = \frac{G - \left(1 - \sum_i x_i^2\right)H}{\left(1 - \sum_i x_i^2\right)(1 - H)} \longrightarrow H = \sum_j z_j^2$$

Industry concentration (Herfendahl), with *z* being the share of industry *j* at all industries (*larger values => selected industries are important*)

$$G \equiv \sum_i (x_i - s_i)^2$$

Spatial concentration (Gini), with *x* being the share of location *i* at employment across all locations and *s* being the same for specific industry (*larger values => selected industries concentrated in few locations*)

II WHICH INDUSTRIES AGGLOMERATE?

determinants of agglomeration

SIC	Definition	State γ	County γ	Zip code γ
20	Food and kindred products	0.00347	0.00119	0.00029
21	Tobacco manufactures	0.19457	0.13002	0.03989
22	Textile mill products	0.09410	0.00601	0.00177
23	Apparel and related products	0.01159	0.00653	0.00184
24	Lumber and wood products, except furniture	0.01168	0.00284	0.00034
25	Furniture and fixtures	0.01212	0.00297	0.00074
26	Paper and allied products	0.00844	0.00213	0.00035
27	Printing, publishing, and allied products	0.00527	0.00264	0.00039
28	Chemicals and allied products	0.01047	0.00369	0.00062
29	Petroleum refining and related products	0.03605	0.01040	0.00428
30	Rubber and miscellaneous plastics products	0.00385	0.00102	0.00023
31	Leather and leather products	0.01513	0.00640	0.00298
32	Stone, clay, glass, and concrete products	0.00357	0.00209	0.00052
33	Primary metal products	0.01438	0.00202	0.00041
34	Fabricated metal products, except machinery and transportation equipment	0.00447	0.00095	0.00021
35	Machinery, except electrical	0.00170	0.00112	0.00029
36	Electrical and electronic machinery, equipment, and supplies	0.00869	0.00352	0.00050
37	Transportation equipment	0.02203	0.00462	0.00084
38	Scientific and professional instruments; photographic and optical goods; watches	0.01453	0.00429	0.00018
39	Miscellaneous manufactured commodities	0.00666	0.00306	0.00055

All industries concentrated (with positive EG-indices)

Highest level of concentration at state (regional) level

II WHICH INDUSTRIES AGGLOERATE?

determinants of agglomeration

The 10 Most Agglomerated Manufacturing Industries at the SIC 4-Digit Level

Zipcode level			County level			State level		
SIC	SIC description	γ	SIC	SIC description	γ	SIC	SIC description	γ
2371	Fur goods	0.352	2371	Fur goods	0.372	2397	Schiffli machine embroideries	0.499
3761	Guided missiles & space vehicles, parts	0.260	2397	Schiffli machine embroideries	0.251	3761	Guided missiles & space vehicles, parts	0.434
3579	Office machines & parts	0.145	3761	Guided missiles & space vehicles, parts	0.239	2284	Thread and handwork yarns	0.413
2087	Flavoring extracts & syrups	0.142	2874	Phosphatic fertilizers	0.215	2371	Fur goods	0.408
3149	Footwear, except rubber, n.e.c.	0.139	3861	Photographic equipment and supplies	0.191	2273	Carpets and rugs	0.406
2335	Womens' and misses' dresses	0.118	2111	Cigarettes	0.191	2084	Wines, brandy, and brandy spirits	0.372
2381	Fabric dress and work gloves	0.114	3149	Footwear, except rubber, n.e.c.	0.185	2251	Womens' hosiery, except socks	0.371
3764	Missile and rocket engines	0.111	2043	Cereal breakfast foods	0.180	3533	Oil & gas field equipment & parts	0.339
3676	Electronic resistors	0.086	2335	Women's, misses', and juniors'	0.178	2436	Softwood veneer and plywood	0.328
3844	X-ray apparatus, tubes, & parts	0.084	2841	Soap & detergents	0.167	2141	Manufactured tobacco	0.305

Role for location fundamentals?

Role for agglomeration externalities?

II IDENTIFYING ORIGINS OF AGGLOMERATION

determinants of agglomeration

- **How to understand the origins of industry-specific agglomeration?**
- **Find industry-specific proxies for relevance of**
  - ***Location fundamentals***
    - **Importance of energy, natural resources and water as inputs**
  - ***Transport costs***
    - **Ratio of value of end-of-year inventories over value of shipments: low inventories => perishable products => proxy for transport cost**
  - ***Input sharing***
    - **Ratio of value of manufactured and services inputs over sales**
  - ***Labour market pooling***
    - **Productivity per worker, ratio of management over production workers, share of high-skilled (bachelor degree and above)**
  - ***Knowledge spillovers***
    - **Ratio of # of innovations over value of sales**

II IDENTIFYING ORIGINS OF AGGLOMERATION

determinants of agglomeration

- **Straightforward empirical strategy**
  - **Regress industry-specific agglomeration against industry-level proxies**

$$\gamma_{j,m} = \beta_j X_m + \varepsilon_{j,m}$$

  - ***j* is the spatial level (state, county, zipcode)**
  - ***m* is the industry**
  - ***X* a vector of proxy variables for various determinants of agglomeration**
  - **β is a vector of parameters capturing the marginal effects of X on γ**
  - **The unit of analysis is industry**

A positive β indicates that at a spatial level *j* a proxy *X* explains agglomeration

To understand the relative importance of X at different spatial layers, run separate regression using the γ computed at the state/county/zipcode levels

II RESULTS

determinants of agglomeration

Determinant	Zipcode	County	State
Location fundamentals			
Transport cost			
Input sharing			
Labour market pooling			
Knowedlge spillover			
Own summary of Rosenthal & Strange (2001) conclusions			
Suggestive evidence			
No or weak evidence			

Location fundamentals, transport cost, and input sharing matter at the *regional* level

Labour market pooling matters at *all* levels

Knowledge spillovers matter at the *local* level – *Q: Is this surprising*?

III PRODUCTIVITY EFFECTS OF AGGLOMERATION

productivity effects of agglomeration

- **This time: *Empirics* of agglomeration**
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III LOCALIZATION OF KNOWLEDGE SPILLOVERS

determinants of agglomeration

"Tacit knowledge, is vague, difficult to codify and often only serendipitously recognized. Geographic proximity matters because knowledge is difficult to write down and exchange and tacit knowledge is inherently non-rival in nature (usually possible to adapt ideas to different applications)"

Jane Jacobs, 1969

"Knowledge spillovers so important that they do not decay in space"

Paul Krugman, 1991

III LOCALIZATION OF KNOWLEDGE SPILLOVERS

determinants of agglomeration

- **Convincing evidence for spatial concentration of knowledge spillovers**
- **There is a positive effect of clustering on "innovative activities"**
  - **Patents (Jaffe et. al, 1993)**
    - Defines property rights for "innovations"
    - Spatial concentration of citations of patents explained by location of research => **patents are being cited cited within clusters**!
  - Product innovations (Acs, Audretsch, Feldman, 1992)
  - US small Business Innovation Research Programme Awards (Black. 2003)
  - See Audretsch and Feldman (2004) for an extensive summary
- **Bar talks**
  - Prohibition interrupts social interaction and innovative activity (Andrews, 2020)

Jane Jacobs 1 : Paul Krugman 0

III SPATIAL SCOPE OF AGGLOMERATION EFFECTS

productivity effects of agglomeration

- **In practice, the spatial scope likely depends on concentration force**
  - **<u>Knowledge spillovers operate at neighbourhood level</u>**
    - High spatial decay, impact within walking distance
    - Evidence on productivity effects from within-city studies Ahlfeldt & Wendland (2013), Ahlfeldt, Redding, Sturm, Wolf (2015), Arzaghi & Henderson (2014), Rosenthal & Strange (2008)
  - **<u>Labour markets matter at city level</u> since (commuting) less localized**
    - Workers can commute in from all locations in the city
    - Commuting probability decay by about 8% of minute of travel time (Ahlfeldt, Redding, Sturm, Wolf, 2015)
  - **<u>Transport costs matter at regional level</u>**
    - NEG market potential effects over 100+km, e.g. Hanson (2005)

Consistent with analysis of determinants of agglomeration pointing to role of knowledge spillovers at zipcode level and labour market pooling at all levels

III PRODUCTIVITY EFFECTS OF AGGLOMERATION

productivity effects of agglomeration

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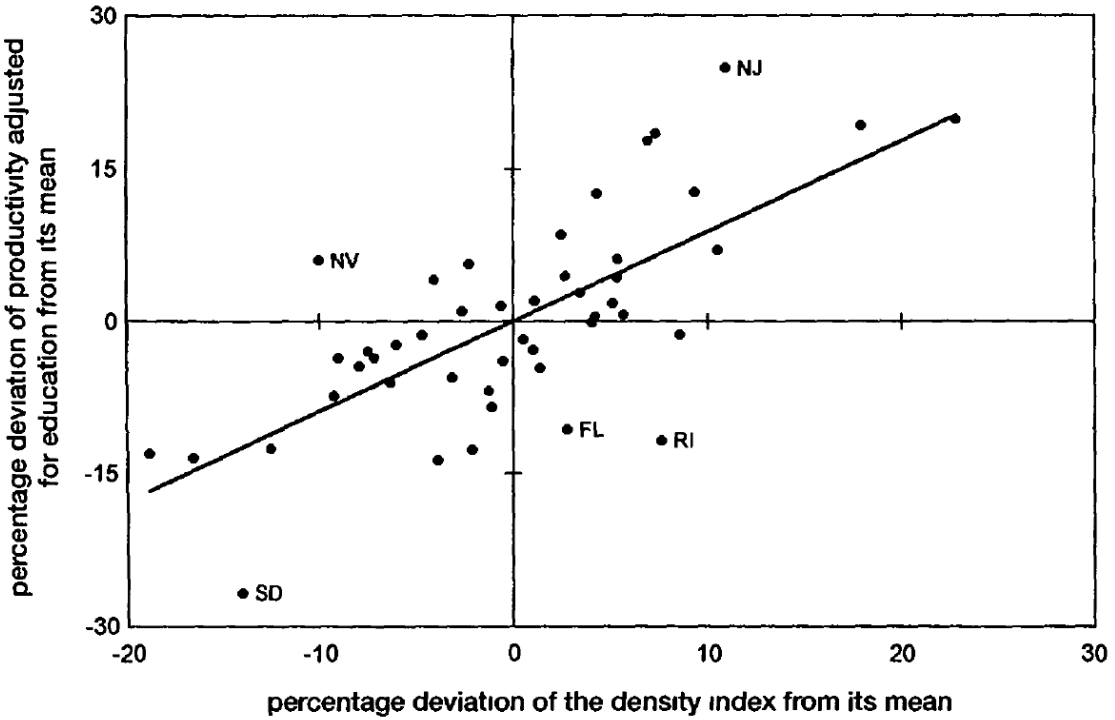
III DENSITY ELASTICITY OF PRODUCTIVITY

productivity effects of agglomeration

- **Density elasticity of productivity of 0.06**
  - **Ciccone & Hall, 1996, AER**
  - **Doubling density increases produtivity by 4.2%**
    - **Not by 6% as reported in the paper**

$$\frac{dln(y_i)}{dln(D_c)} = \frac{\frac{\Delta y_i}{y_i}}{\frac{\Delta D_c}{D_c}} = 0.06$$

$$2^{0.06} - 1 = 4.2\%$$



Cities (higher density places) are more productive

Q: Are there challenges to identification?

III CITY-LEVEL vs. INDIVIDUAL-LEVEL ESTIMATES

productivity effects of agglomeration

- **Imagine the individual-level wage *y* of individual *i* in area *c* is described as follows:**

$$y_{i,c} = u_i + \gamma Z_c + \theta X_i + \epsilon_{i,c}$$

  - u_i **is an individual unobserved fixed effect**
  - Z_c **is area-level density**
  - X_i **is an observed individual-level attribute (education)**
  - Simplified version of equation (6) in Combes & Gobillon (2005)
- **Aggregated to the area-level, this equation becomes**

$$\bar{y}_c = \gamma Z_c + \theta \bar{X}_c + \varepsilon_c$$

  - **where $\boldsymbol{\varepsilon_c = \bar{\epsilon}_c + \bar{u}_c}$ and upper bars denote area-level averages**

III CITY-LEVEL ESTIMATES

productivity effects of agglomeration

- **Many studies estimate**

$$\bar{y}_c = \gamma Z_c + \theta \bar{X}_c + \varepsilon_c \qquad [\varepsilon_c = \bar{\epsilon}_c + \bar{u}_c]$$

- **Unobserved individual effects are a concern since most likely**

$$cov(\bar{u}_c, Z_c) > 0$$

- **People with unobserved abilities (e.g. REEF graduates) sort into large and dense cities to benefit from job & business opportunities**
- **Most studies provide elasticity estimates $\hat{\gamma}$ in the range of *0.04 to 0.07***

Need to interpret such estimate as "association", NOT as causal effect of density

Still interesting! If we double density we still increase productivity in the area by 4.2%, however, this is because we are attracting smart people from elsewhere!

III INDIVIDUAL-LEVEL ESTIMATES

productivity effects of agglomeration

- **With individual data (from surveys) we can estimate**

$$y_{i,c} = u_i + \gamma Z_c + \theta X_i + \epsilon_{i,c}$$

- **By adding individual fixed effects, we control for unobserved individual characteristics**
- **The identification comes from "movers", i.e. from a comparison of wages of the same individual, realized at different areas**
- **Controlling for fixed effects, the density elasticity of productivity drops to about $\hat{\gamma} \approx 0.02$!**

Now closer to a "causal" effect of density, since it controls for sorting

Relevant for welfare calculations: What is the „pure" effect from density without „stealing" smart people from other places

From a policy-perspective it depends on whether you care about one area or all

III CITY-LEVEL ESTIMATES WITH IV

productivity effects of agglomeration

- **Another problem concernes unobserved location effect**

$$y_{i,c} = u_i + \gamma Z_c + \theta X_i + \epsilon_{i,c} \qquad \epsilon_{i,c} = \mu_c + \varepsilon_{ic}$$

- **Imagine a location fundamental μ_c with** $cov(\mu_c, Z_c) \neq 0$
  - **Individual fixed effects for u will *not* solve the problem**
- **Can use an „instrumental variable“ *V* in 2 stage least squares**
  - **First stage:** $Z_c = \varphi V_c + \theta X_i + u_i + \omega_{ic}$
  - **Second stage:** $y_{i,c} = u_i + \gamma \hat{Z}_c + \theta X_i + \epsilon_{i,c}$
  - **Requires that** $cov(V_c, Z_c) \neq 0, cov(V_c, \mu_c) = 0$

Use predicted values from first stage in second stage

“Learn how to do it” in GY458 computer classes (Stata “ivreg” command)

III GOOD IVS

productivity effects of agglomeration

- **Good instrumental variables need to be**
  - **<u>Relevant</u>: explain the instrumented variable**
    - $cov(V_c, Z_c) \neq 0$
  - **<u>Valid:</u> be uncorrelated with the unobserved factor**
    - $cov(V_c, \mu_c) = 0$
- **Good instruments are usually difficult to find!**
  - **Good instruments are usually exogenous**
- **Ciccone and Hall (1996) use**
  - **has a railroad in 1860**
  - **State population 1850 and 1880**
  - **Distance from eastern seaboard**

Need a good argument, statistical tests do not help really

Q: Are these good instruments?

III CHANGE IN EFFECTIVE DENSITY

productivity effects of agglomeration

- **Use the time time dimension to remove unobserved factor (Donaldson & Hornbeck, 2016, Ahlfeldt & Feddersen, 2018)**

$$y_{i,c,t} = u_i + \gamma^{MP}\tilde{Z}_{ct} + \theta X_i + \rho_t + \epsilon_{i,c,t} \qquad \epsilon_{i,c,t} = \mu_c + \varepsilon_{i,c,t}$$

- **$\tilde{Z}_c$ is measure of „economic mass“ (e.g. GDP or employment) within a certain travel time (or a market potential measure)**

- **If transport infrastructure hanges, we can take time differences**

  - $\Delta y_{i,c,t} = \gamma^{MP}\Delta\tilde{Z}_{ct} + \theta\Delta X_{it} + \Delta\rho_t + \Delta\epsilon_{i,c,t}$, $\Delta\epsilon_{i,c,t} = \Delta\varepsilon_{i,c,t}$

  - **Unobserved fundamental factor is removed!**

Ahlfeldt & Feddersen (2018) find an elasticity of productivity with respect to effective density of 2-3%

III AGGLOMERATION ELASTICITY AND MEASUREMENT

productivity effects of agglomeration

- **Estimates of the agglomeration elasticity depend on measurement**
  - 1% change in population ≠ 1% change in density
  - 1% change in density ≠ 1% in market potential
- **Can convert a „city size“ elasticity θ into a density elasticity γ:**

  $\gamma = \frac{\theta}{\alpha}$, where $\alpha \approx 0.4$ (Ahlfeldt & Pietrostefani (2019) is the elasticity of density with respect to city size

- **Can rescale market potential elasticity γ^{MP} to density elasticity γ**

  $\gamma = \frac{\gamma^{MP}}{\beta}$, where $\beta = \frac{\rho_{\gamma^{MP}}}{\rho_{\gamma}} \approx 3$ (Ahlfeldt & Federsen (2018) is the ratio of standard deviations in log market potential and log density

IV URBANIZATION VS. LOCALIZATION EFFECTS

what matters for productivity and growth

- **This time: *Empirics* of agglomeration**
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IV LOCALISATION ECONOMIES

urbanisation vs localisation economies

- **Localization economies**
  - **Spillovers between firms in an industry**
- **MAR: Marshall (1890)–Arrow (1962)–Romer(1986)**
  - **Focus:** Specialization
  - **Examples:** Computer chips in Silicon Valley, film industry in LA
  - **Implication:** Governments should welcome local monopolies since they lead to innovation (internalize externalities)
- **Porter (1990)**
  - **Focus:** Specialization & competition
  - **Examples:** Italian ceramics and gold industry
  - **Implication:** Governments should encourage geographically localized *competitive* industries

IV URBANIZATION ECONOMIES

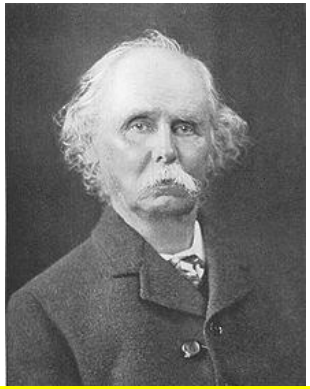
urbanisation vs localisation economies

- **Urbanization economies**
  - **Spillovers from outside the industry**
- **Jacobs (1969)**
  - **Focus:** Diversity
  - **Examples:**
    - Equipment leasing industry was innovated by a San Francisco food processor company
    - Gasoline engine firms in Detroit supplied ship builders and later car makers
  - **Implication:** Governments should encourage a variety and diversity of geographically proximate industries

IV WHAT MATTERS?

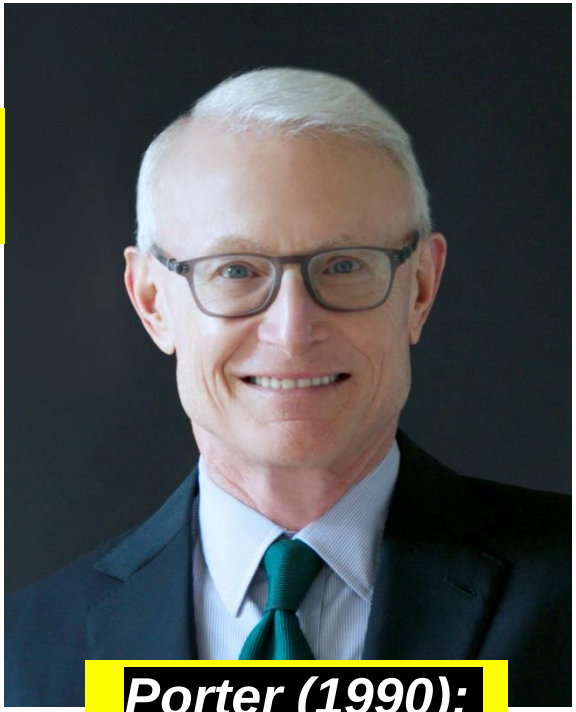
determinants of agglomeration

P: Which one is empirically most relevant?



Marshall (1890)–Arrow (1962)–Romer(1986) Specialization!

Jacobs (1969): Diversity!



Porter (1990): Competition!

IV EMPIRICAL FINDING: HENDERSON (1988)

urbanisation vs localisation economies

- **Multivariate regression**

$$q_{ij} = \beta_0 + \beta_1 Q_{ij} + \beta_2 N_j + X_{ij} b + \varepsilon_{ij}$$

  - q_{ij} **output per worker in industry *i* in city *j***
  - Q_{ij} **total industry *i* output in city *j*** (proxies localization)
  - N_j **total population/employment in city *j*** (proxies urbanization)
  - X_{ij} **vector of industry-city controls (capital per worker, education)**

- $\hat{\beta}_1$ **depends strongly on industry.**
  - **Electrical machinery 0.05 (10% increase in total industry output increases output per worker by 0.5%); Min 0.02 (pulp and paper) –Max 0.11 (petroleum)**

- $\hat{\beta}_2$ **close to zero**

Localization, not urbanization econ. good for productivity

Supports MAR, not Jacobs (predates Porter)

IV EMPIRICAL FINDING: GLAESER ET AL (1992)

urbanisation vs localisation economies

- **Regress long-run (1956-1987) city-industry-level employment growth against measures of**

$$\text{Specialization} = \frac{\frac{industry \text{ employment in } city}{total \text{ employment in } city}}{\frac{industry \text{ employment in } US}{total \text{ employment in } US}}$$

$$\text{Competition} = \frac{\frac{firms \text{ in } city - \text{industry}}{workers \text{ in } city - \text{industry}}}{\frac{firms \text{ in } US \text{ industry}}{workers \text{ in } US \text{ industry}}}$$

  - controlling for wage levels, intitial industry size
- **Competition has positive effect on growth**
- **Specialization has negative effect on growth**
- **Also find that small industries grow if large industries grow**

Competition good for economic growth

Urbanization, not localization, promote economic growth

Supports Porter and Jocobs, but not MAR

IV EMPIRICAL FINDING: HENDERSON ET AL (1995)

urbanisation vs localisation economies

- **Regress (1987) (log) city-industry-level employment against**
  - **Log 1970 employment** (captures persistency vs. convergence)
  - **1970 Industry emplyoment / city employment** (proxies specialization)
  - **1970 Hirschman-Herfindahl index** (inversely related to urbanization) $H = \sum_j z_j^2$

z is the share of industry *j* at all industries

- **Separate anlysis by type of industry**
  - Mature: (electrical) machinery, primary metals, trasportation, instruments
  - High-tech: Electronic components, medical equipment, computers

Mature industries:

Localization, not urbanization economies promote employment

Supports MAR

High-tech industries:

Localization, AND urbanization economies promote employment

Supports MAR and Jacobs

IV EMPIRICAL FINDING: DURANTON & PUGA 2001

urbanisation vs localisation economies

- **Nursery cities**
  - *New products* are developed *in diversified cites*
  - Try prototypes using *processes borrowed from different activities*
- **Specialised cities**
  - Once ideal producition process is found, firms/establishments relocate
  - Mass prodution in specialied cities where production cost are lower
    - Lower property prices
- **Evidence support theory**
  - 72% of relocations from diversified to specialised areas
  - 93% / 88% / 82% in R&D / pharma / IT sectors (France 1993-1996)

Mature industries:
Localization, MAR

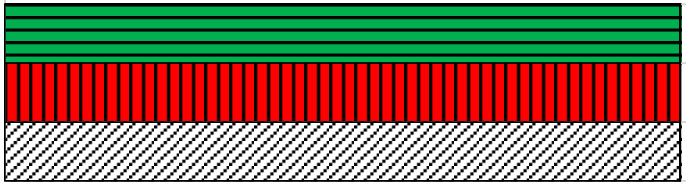
High-tech industries:
Urbanization, Jacobs

IV RESULTS SUMMARY

urbanisation vs localisation economies

	Localization	Local competition	Urbanization
	MAR	Porter	Jacobs
Productivity			
Growth: All industries			
Growth: Mature industries			
Growth: High-tech industries			

Own summary of Henderson et al. (1988), Glaeser et al. (1992), Henderson et al. (1995)



Suggestive evidence

No or weak evidence

Not tested

Urbanizaiton economies and localizaiton economies are *both empirically relevant*

Localization relevant for *productivity* levels (capturing „fundamentals“?)

Urbanization important for *growth*, especially of innovative high-tech industries

Rationalizes why often small spcialized cities are quite *productive* (high wages), but, large diverse cities tend to by more *dynamic*

SUMMARY

Conclusion

- **Determinants of agglomeration**
  - Input sharing
  - Labour market pooling
  - Knowledge spillovers
- **Productivity effects of higher agglomeration**
  - Doubling density increases area productivity by about 4%
  - Doubling density increases individual productivity by about 2%
- **Localization vs. urbanization economies**
  - Localization economies matter for distribution of productivity levels
  - Urbanization economies matter for growth
- **Next: Benefits vs. costs of agglomeration**
  - Broader range of agglomeration effects and effects on city size


THANKS

READING

- Core readings:
  - Combes & Gobillon (2015), in Duranton, Henderson, and Strange, (eds.) Handbook in Regional and Urban Economics.
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APPENDIX: DENSTY EFFECT VS. CITY SIZE EFFECT

productivity effects of agglomeration

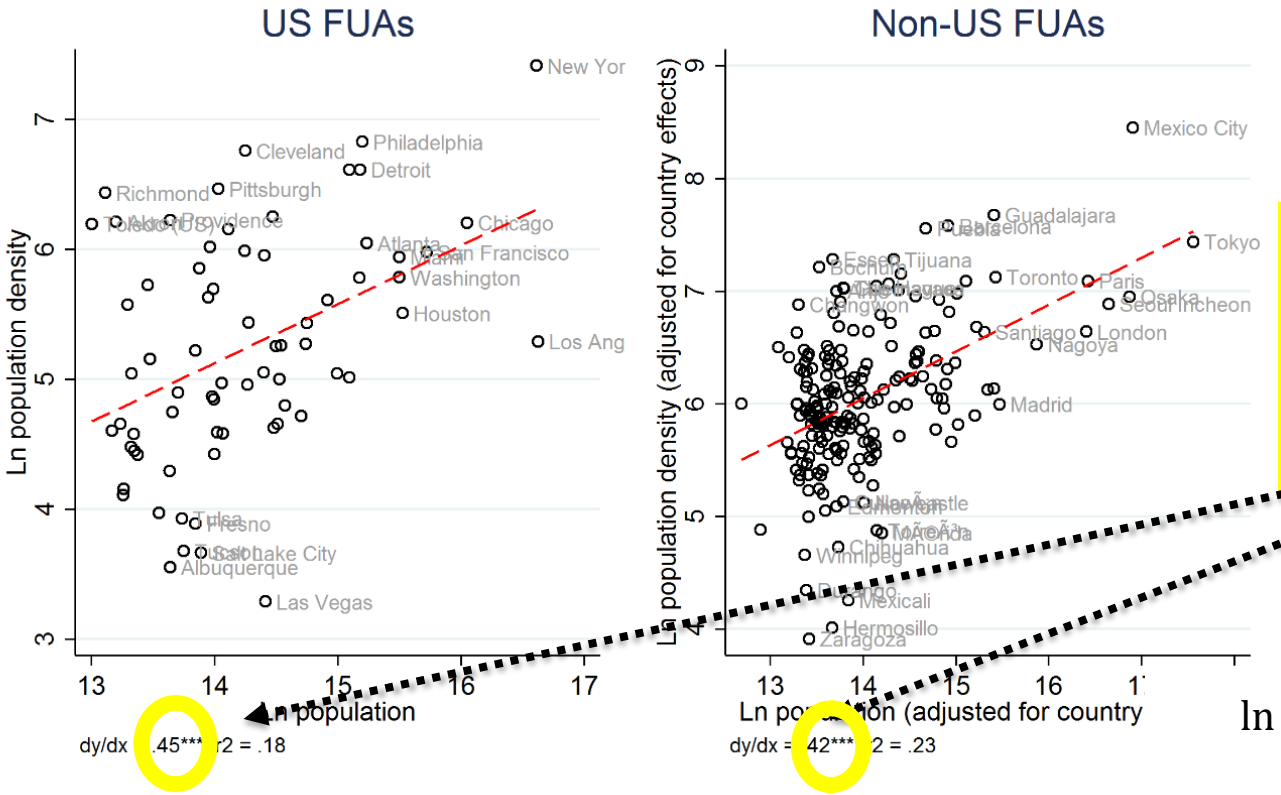
- **Agglomeration effects are attributed to density or city size**
- **Not easy to separately identify the effects**
  - **Density and city size are co-determined because there are limits to horizontal expansion (Ahlfeldt & Pietrostefani, 2019)**
    - Workers cannot commute „forever“
    - Larger cities are more expensive, which increases density
- **Most studies do not separately identify density and city size effects**

  In most cases, it is sensible to assume that if one measure changes, the other changes, too
- **Can convert a „city size“ elasticity θ into a density elasticity γ:**

  $\gamma = \frac{\theta}{\alpha}$**, where α is the elasticity of density with respect to city size**

APPENDIX: ELASTICITY OF DENSITY WITH RESPECT TO SIZE

productivity effects of agglomeration



Dotted lines are the fitted lines from linear regressions.
Non-US panel shows the partial correlation controlling for country effects.
A functional urban area (FUA) is labelled if the population is among the 10 largest or if is an o
Outliers are below the 10th/5th or above the 90th/95th percentile in the US/Non-US residual c
*** indicates significance at the 1% level.

Density and city size codetermined

Go back and forth using elasticity of density wrt to city size (0.43)

$$\ln\left(\frac{P_i}{A_i}\right) = \alpha \ln(P_i) + \mu_c + \varepsilon_{ic}$$

- P_i is the population of city *i*
- A_i is the respective land area
- μ_c is a country fixed effect
- IV for P: Rank in country distribution