What Causes Industry Agglomeration? Evidence from Coagglomeration Patterns (AER, 2010)

By G. Ellison, E. L. Glaeser, and W. R. Kerr

Palermo Penano

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Research Question

- **Why do firms cluster near one another?**

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- **Why do firms cluster near one another?**
  1. Reduce shipping cost of inputs and finished goods (input-output linkage)
  2. Take advantage of gains from a larger labour pool
  3. Take advantage of gains from intellectual or technological spillovers
  4. Natural advantages
- Marshall (1920)

Method

- Regression analysis to test the contribution of each of the three Marshallian theories of industrial agglomeration + natural advantages to industry coagglomeration
- Addresses reverse causality where coagglomeration patterns $\Longrightarrow$ industrial relationships

Main Results

- Individually, each Marshallian force are important for explaining variation in industrial coagglomeration
- Taken together, Marshallian forces explain more of the variation in coagglomeration than natural advantages

Measuring Extent of Industry Coagglomeration

Ellison-Glaeser Index (JPE, 1997)

$$\gamma_{ij}^{c} = \frac{\sum_{m=1}^{M}(s_{mi} - x_m)(s_{mj} - x_m)}{1 - \sum_{m=1}^{M} x_m^2}$$

- s_{mi} = share of indistry i's employment
- x_m =
  mean employment share in region m across all manufacturing industr
- Two industry version of index developed in Ellison and Glaeser, JPE 1997
- Derived from a model where local industry-specific spillovers, natural advantages, and random chance all contribute to geographic concentration
- Level: state, PMSA, county

Ellison-Glaeser Index

$$\gamma_{ij}^{c} = \frac{\sum_{m=1}^{M}(s_{mi} - x_m)(s_{mj} - x_m)}{1 - \sum_{m=1}^{M} x_m^2}$$

- + Comparable across industries
- + Accounts for region "size"
- + Localization vs industrial concentration
- − Establishments arbitrarily allocated to spatial units
  - distance between establishments not explicitly accounted for
  - different size spatial units
  - Agglomerated industries cut by an administrative border?
- − Statistical significance (departure from agglomeration arising from randomness)

Duranton-Overman Index (ReStud, 2005)

$$\hat{K}_{ij}^{Emp}(d) = \frac{1}{h \sum_{r=1}^{n_i} \sum_{s=1}^{n_j} e(r)e(s)} \sum_{r=1}^{n_i} \sum_{s=1}^{n_j} e(r)e(s) f\left(\frac{d - d_{r,s}}{h}\right)$$

- $e(r)$: employment in establishment r
- $d_{r,s}$: distance between establishments r and s
- h : bandwidth
- n_i : number of firms in industry i
- $f(.)$: Gaussian kernel (bell curve)
- d: scale at which localization is measured
- Estimates the probability density function of the the distribution of bilateral distances between every establishment in industry i and every establishment in industry j

Duranton-Overman Index

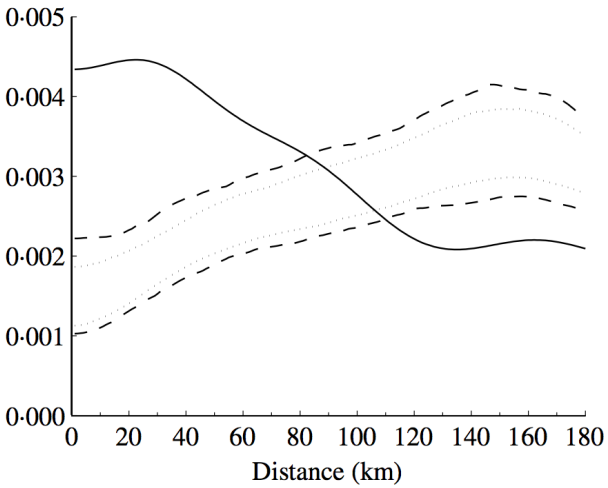
$$\hat{K}_{ij}^{Emp}(d) = \frac{1}{h\sum_{r=1}^{n_i}\sum_{s=1}^{n_j} e(r)e(s)} \sum_{r=1}^{n_i}\sum_{s=1}^{n_j} e(r)e(s) f\left(\frac{d - d_{r,s}}{h}\right)$$

- Explicitly accounts for distance between establishment (missing in EG index)
- Index of localization:

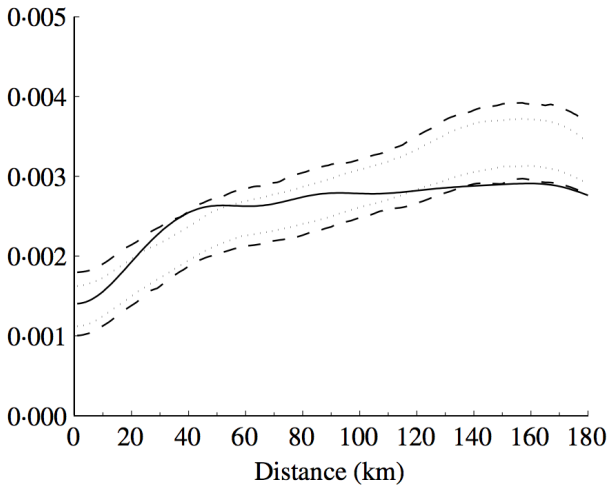
$$\gamma_{ij}(d) \equiv max(\hat{K}_{ij}^{Emp}(d) - \bar{K}_{ij}^{Emp}(d), 0)$$

- $\bar{K}_{ij}^{Emp}(d)$ is the upper 5% confidence interval in randomly generated counterfactual distribution
- Estimate for each industry pair ij and each distance $d \in \{100km, 250km, 500km, 1000km\}$

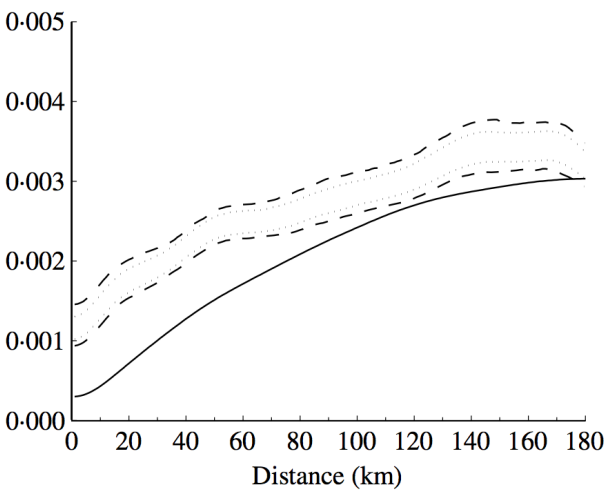
Duranton-Overman Index



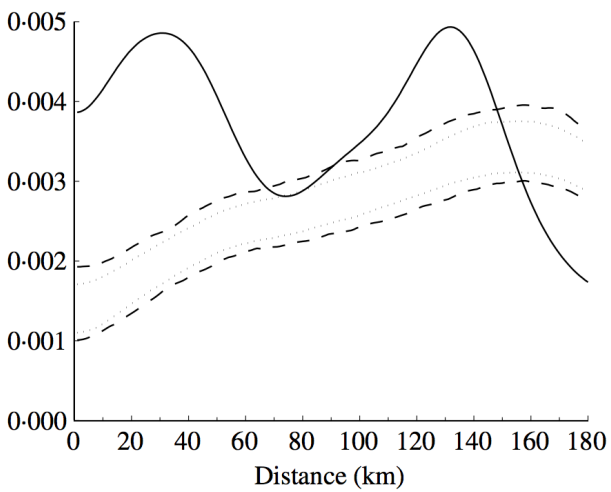
(a) Basic Pharmaceuticals (SIC2441)



(b) Pharmaceutical Preparations (SIC2442)



(c) Other Agricultural and Forestry Machinery (SIC2932)



(d) Machinery for Textile, Apparel and Leather Production (SIC2954)

Data used to estimate indices

- US Census Bureau's Census of Manufacturing
- 300,000 establishments employing 17 million workers
- 3-digit level SIC3
- 7381 industry pairs per year (1987, 1997). 122 industries

Why do Firms Agglomerate?

$$Coagg_{ij} = \alpha + \beta_{NA} Coagg_{ij}^{NA} + \beta_L LaborCorrelation_{ij} + \beta_{IO} InputOutput_{ij} + \beta_T Tech_{ij} + \varepsilon_{ij}$$

A. Proximity to Customers: Goods

- Firms cluster to reduce shipping costs
- 1987 Input-Output account as measure of extent to which industries buy and sell from one another
- $Input_{i \to j} = 0.39$: Leather Tanning and Finishing input from Meat Products
- $Output_{i \to j} = 0.82$: Public building and Related Furniture sales to Motor Vehicles and Equipment
- Most values for an industry pair is zero
- $Input_{ij} = max\{Input_{i \to j}, Input_{i \leftarrow j}\}$,
  $Output_{ij} = max\{Output_{i \to j}, Output_{i \leftarrow j}\}$
- $InputOutput_{ij} = max\{Input_{ij}, Output_{ij}\}$

B. Labour Market Pooling: People

- Larger labour pool $\Longrightarrow$ risk sharing, worker-firm matches, higher investment in human capital by workers (lower ex post appropriation in clusters)
- Need measure of extent to which industries use same type of worker
- $Share_{io}$: share of industry i 's employment in occupation o
- $LabourCorrelation_{ij} = corr(Share_{io}, Share_{jo})$
- Most correlated: Motor vehicles and Motorcycles, Bicycles, and Parts (0.984)
- Least correlated: Logging and Aircraft and Parts (-0.046)

C. Intellectual or Tech. Spillovers: Ideas

- Firms cluster to speed the flow of ideas
- Scherer (1984)'s measure of extent to which R&D activity from one industry flow out to benefit another
- NBER Patent data: measure extent to which tech. in industry i cite tech. in industry j (normalized by total citations for the industries)
- $Tech_{ij}$ and $Patent_{ij}$ (construction similar to $InputOutput_{ij}$)

D. Natural Advantages

- Firms cluster in a region because the region has resources useful for their production
- Forests, areas with exogenously cheap electricity, coastal regions, etc.
- Coagglomeration may exist if two industries are attracted to the same natural advantage
  - even if industries would not otherwise have interacted through Marshallian forces
  - e.g. ship building and oil refining
- Controls for coagglomeration between i and j due to natural advantages
  - $Coagg_{ij}^{NA}$
  - Ellison and Glaeser (AER PP, 1999)

D. Natural Advantages: Ellison-Glaeser (AER PP, 1999)

TABLE 1—EFFECT OF "NATURAL ADVANTAGES" ON STATE-INDUSTRY EMPLOYMENT

A. State variable × industry variable	Coefficient (*t* statistic)
(a) Electricity price × electricity use	0.170 (17.62)
(b) Natural gas price × natural gas use	0.117 (6.91)
(c) Coal price × coal use	0.119 (4.55)
(d) Percentage farmland × agricultural inputs	0.026 (2.58)
(e) Per capita cattle × livestock inputs	0.053 (5.08)
(f) Percentage timberland × lumber inputs	0.152 (11.98)
(g) Average mfg wage × wages/value added	0.059 (4.11)
(h) Average mfg wage × exports/output	−0.014 (−1.28)
(i) Average mfg wage × import competition	0.036 (3.10)
(j) Percentage without HS degree × percentage unskilled	0.157 (7.38)
(k) Unionization percentage × percentage precision products	0.100 (12.17)
(l) Percentage with B.A. or more × percentage executive/professional	0.170 (12.70)
(m) Coast dummy × heavy exports	−0.031 (−2.20)
(n) Coast dummy × heavy imports	0.017 (0.92)
(o) Population density × percentage to consumers	0.043 (3.68)
(p) (Income share − mfg share) × percentage to consumers	0.025 (4.49)

Empirical Results

OLS

$$Coagg_{ij} = \alpha + \beta_{NA} Coagg_{ij}^{NA} + \beta_L LaborCorrelation_{ij} + \beta_{IO} InputOutput_{ij} + \beta_T Tech_{ij} + \varepsilon_{ij}$$

OLS-Univariate

TABLE 3—OLS UNIVARIATE SPECIFICATIONS FOR PAIRWISE COAGGLOMERATION

Each entry reports separate estimation with single regressor	EG coagglomeration index, 1987				DO coagglomeration index, 1997			
	State total empl.	PMSA total empl.	County total empl.	State entry empl.	Bilateral firm employments with localization threshold 1,000 mi.	500 mi.	250 mi.	100 mi.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Natural advantages [DV Specific]	0.210 (0.020)	0.188 (0.017)	0.222 (0.014)	0.120 (0.016)	0.442 (0.013)	0.406 (0.012)	0.253 (0.013)	0.531 (0.019)
R^2	0.044	0.036	0.049	0.014	0.200	0.165	0.064	0.282
Labor correlation	0.180 (0.014)	0.106 (0.016)	0.082 (0.013)	0.077 (0.015)	−0.155 (0.012)	0.008 (0.012)	0.127 (0.015)	0.103 (0.013)
R^2	0.032	0.011	0.007	0.006	0.024	0.000	0.016	0.011
Input-output	0.205 (0.037)	0.167 (0.028)	0.130 (0.022)	0.112 (0.022)	0.100 (0.019)	0.162 (0.029)	0.188 (0.036)	0.112 (0.029)
R^2	0.042	0.028	0.017	0.012	0.010	0.026	0.035	0.013
Technology flows Scherer R&D	0.180 (0.037)	0.148 (0.031)	0.107 (0.019)	0.089 (0.024)	0.046 (0.019)	0.107 (0.029)	0.136 (0.038)	0.094 (0.029)
R^2	0.032	0.022	0.012	0.008	0.002	0.011	0.019	0.009
Technology flows patent citations	0.081 (0.012)	0.100 (0.016)	0.085 (0.013)	0.068 (0.013)	−0.001 (0.012)	0.056 (0.012)	0.103 (0.012)	0.092 (0.013)
R^2	0.007	0.010	0.007	0.005	0.000	0.031	0.011	0.008

OLS-Multivariate

TABLE 4—OLS MULTIVARIATE SPECIFICATIONS FOR PAIRWISE COAGGLOMERATION

	EG coaggl. index with state total emp.				DO coaggl. index, 250 mi.			
	Base estimation	Exclude natural advantages	Separate input & output	Exclude pairs in same SIC2	Base estimation	Exclude natural advantages	Separate input & output	Exclude pairs in same SIC2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Natural advantages [DV specific]	0.163 (0.017)		0.162 (0.017)	0.172 (0.016)	0.251 (0.012)		0.252 (0.012)	0.253 (0.013)
Labor correlation	0.118 (0.011)	0.146 (0.012)	0.114 (0.011)	0.085 (0.012)	0.069 (0.012)	0.098 (0.013)	0.066 (0.012)	0.029 (0.012)
Input-output	0.146 (0.032)	0.149 (0.032)		0.110 (0.022)	0.162 (0.035)	0.150 (0.035)		0.177 (0.032)
Input			0.106 (0.029)				0.097 (0.029)	
Output			0.093 (0.039)				0.107 (0.038)	
Technology flows Scherer R&D	0.096 (0.035)	0.112 (0.035)	0.079 (0.035)	0.046 (0.019)	0.076 (0.033)	0.075 (0.034)	0.065 (0.032)	0.033 (0.020)
R^2	0.103	0.077	0.110	0.059	0.113	0.051	0.117	0.102
Observations	7,381	7,381	7,381	7,000	7,381	7,381	7,381	7,000

IV

- Industries may be collocated not because of Marshallian factors.
- Reverse causality: collocation could be driving input-output linkages or hiring patterns
  - Industries may be collocated due to some random event, but their flexible production technologies allow them to adjust to nearby labour and material inputs
- Unmodeled natural advantages may bias estimates

IV

- UK IV
  - Measures of input-out linkage, labour market, and technology for U.K. industries (two industries randomly coagglomerated in U.S. will not be coagglomerated in the U.K.)
- US Spatial IV
  - Measures input-output and labour patterns in one industry in places where the other industry is quite rare
  - Addresses issue where input / labour choices is affected by proximity of plants in the other industry (biasing measures of the Marshallian forces variables)

IV-Results

TABLE 5—IV MULTIVARIATE SPECIFICATIONS FOR PAIRWISE COAGGLOMERATION

	EG coaggl. index with state total emp.			DO coaggl. index, 250 mi.		
	Base OLS	UK IV	US spatial IV	Base OLS	UK IV	US spatial IV
	(1)	(2)	(3)	(4)	(5)	(6)
Natural advantages	0.173	0.173	0.171	0.254	0.210	0.233
[DV specific]	(0.016)	(0.019)	(0.016)	(0.013)	(0.016)	(0.012)
Labor correlation	0.083	0.079	0.091	0.027	0.501	0.248
	(0.012)	(0.060)	(0.023)	(0.012)	(0.060)	(0.023)
Input-output	0.122	0.191	0.185	0.186	0.164	0.213
	(0.023)	(0.048)	(0.036)	(0.031)	(0.054)	(0.049)
Observations	7,000	7,000	7,000	7,000	7,000	7,000

End

Descriptive Statistics

TABLE 1—DESCRIPTIVE STATISTICS FOR PAIRWISE COAGGLOMERATION REGRESSIONS

	Mean	SD	Minimum	Maximum
Panel A. Pairwise EG coagglomeration measures				
EG state total employment coagglomeration	0.000	0.013	−0.065	0.207
EG PMSA total employment coagglomeration	0.000	0.006	−0.025	0.119
EG county total employment coagglomeration	0.000	0.003	−0.018	0.080
EG state firm birth employment coagglomeration	0.000	0.015	−0.082	0.259
EG expected coagglomeration due to natural advantages	0.000	0.001	−0.008	0.022
	Industry count	Relevant industries (nonzero) Mean	SD	Maximum
Panel B. Pairwise DO coagglomeration measures				
DO global localization coagglomeration, 1,000 mi.	7,371	0.133	0.073	0.454
DO global dispersion coagglomeration, 1,000 mi.	10	0.592	0.078	0.746
DO expected global localization coagglomeration, 1,000 mi.	7,381	0.181	0.027	0.256
DO global localization coagglomeration, 250 mi.	6,429	0.017	0.019	0.283
DO global dispersion coagglomeration, 250 mi.	952	0.042	0.029	0.307
DO expected global localization coagglomeration, 250 mi.	7,381	0.029	0.010	0.077
	Mean	SD	Minimum	Maximum
Panel C. Marshallian factors				
Labor correlation	0.470	0.226	−0.046	1.000
Input-output maximum	0.007	0.029	0.000	0.823
Input maximum	0.005	0.019	0.000	0.392
Output maximum	0.005	0.026	0.000	0.823
Scherer R&D technical maximum	0.005	0.026	0.000	0.625
Patent citation technical maximum	0.015	0.025	0.000	0.400

Industries that are most coagglomerated

TABLE 2—HIGHEST PAIRWISE COAGGLOMERATIONS

Rank	Industry 1	Industry 2	Coagglomeration
Panel A. EG index using 1987 state total employments			
1	Broadwoven mills, cotton (221)	Yarn and thread mills (228)	0.207
2	Knitting mills (225)	Yarn and thread mills (228)	0.187
3	Broadwoven mills, fiber (222)	Textile finishing (226)	0.178
4	Broadwoven mills, cotton (221)	Broadwoven mills, fiber (222)	0.171
5	Broadwoven mills, fiber (222)	Yarn and thread mills (228)	0.164
6	Handbags (317)	Photographic equipment (386)	0.155
7	Broadwoven mills, wool (223)	Carpets and rugs (227)	0.149
8	Carpets and rugs (227)	Yarn and thread mills (228)	0.142
9	Photographic equipment (386)	Jewelry, silverware, plated ware (391)	0.139
10	Textile finishing (226)	Yarn and thread mills (228)	0.138
11	Broadwoven mills, cotton (221)	Textile finishing (226)	0.137
12	Broadwoven mills, cotton (221)	Carpets and rugs (227)	0.137
13	Broadwoven mills, cotton (221)	Knitting mills (225)	0.136
14	Carpets and rugs (227)	Pulp mills (261)	0.110
15	Jewelry, silverware, plated ware (391)	Costume jewelry and notions (396)	0.107
Panel B. DO index using 1997 firm employments, 250 mi. threshold			
1	Broadwoven mills, fiber (222)	Yarn and thread mills (228)	0.283
2	Carpets and rugs (227)	Yarn and thread mills (228)	0.262
3	Broadwoven mills, fiber (222)	Carpets and rugs (227)	0.226
4	Broadwoven mills, cotton (221)	Yarn and thread mills (228)	0.219
5	Broadwoven mills, cotton (221)	Carpets and rugs (227)	0.218
6	Footwear cut stock (313)	Costume jewelry and notions (396)	0.217
7	Jewelry, silverware, plated ware (391)	Costume jewelry and notions (396)	0.208
8	Knitting mills (225)	Yarn and thread mills (228)	0.200
9	Broadwoven mills, fiber (222)	Knitting mills (225)	0.190
10	Broadwoven mills, cotton (221)	Broadwoven mills, fiber (222)	0.175
11	Textile finishing (226)	Yarn and thread mills (228)	0.163
12	Footwear cut stock (313)	Jewelry, silverware, plated ware (391)	0.157
13	Handbags (317)	Costume jewelry and notions (396)	0.151
14	Broadwoven mills, cotton (221)	Knitting mills (225)	0.149
15	Women's and misses' outerwear (233)	Costume jewelry and notions (396)	0.149

EG Coagglomeration Index Intuition

- The HHI index measures market concentration in a given industry

$$\sum_{l=1}^{N_F} m_l^2$$

- where m_l is the market share (e.g. employment share of firm l) of firm l and N_F is the total number of firms in the industry
- This index tells us the probability of drawing any firm twice. A high value of this index suggests that the market is highly concentrated

EG Coagglomeration Index Intuition

- To measure the geographical concentration of an industry we can use the following index

$$\sum_{m=1}^{M} s_{mi}^2$$

- M is the number of regions in the country; s_{mi} is the employment share of industry i in region m
- This index tells us the probability (where employment share is used as an estimate of the probability) of drawing the same region twice
- A high value of this index suggests that this industry is highly concentrated in a few regions

EG Coagglomeration Index Intuition

- To measure coagglomeration, we look at the probability of drawing, say, region 1 for both industry i and industry j (so two separate draws for each industry). This probability is

$$s_{1i}s_{1j}$$

- If we are interested in drawing the any region twice for each industry, we look at

$$\sum_{m=1}^{M} s_{mi}s_{mj}$$

- A high value of this index suggests that industry i and industry j like to produce together across regions

EG Coagglomeration Index Intuition

$$\sum_{m=1}^{M} s_{mi} s_{mj}$$

- Regions that have more people in it are likely to also have the i and j coagglomerated, even though the two industries do not necessarily benefit from coagglomeration.
- Thus, we must control for size of each region m:

$$\sum_{m=1}^{M} (s_{mi} - x_m)(s_{mj} - x_m)$$

- x_m is the share of national employment that's in region m
- Related to covariance of region-industry employment shares in the two industry

EG Coagglomeration Index Intuition

- Account for overall geographic concentration of employment nationally

$$\frac{\sum_{m=1}^{M}(s_{mi} - x_m)(s_{mj} - x_m)}{1 - \sum_{m=1}^{M} x_m}$$