Sectoral and Geographical Specificities in the Spatial Structure of Economic Activities*

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Preliminaries: Research Fields

- Agent-Based Computational Economics (ACE)
  - Methodology: Empirical validation in ACE models
  - Applications: ACE models and policy

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  - Firm locational choices and the geography of industrial agglomeration
  - Firm size and growth dynamics: the role of financial constraints

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  - Firm size and growth dynamics: the role of financial constraints
- Statistical Properties of Micro/Macro Economic Dynamics
  - Statistical properties of household consumption patterns
  - Statistical properties of country-output growth (w/ Mauro Napoletano)

Home-Page

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Outline

- Motivations
  - Geographical distribution of economic activities
  - Are economic activities geographically clustered?
  - If so, which are the determinants of geographical agglomeration?
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- A Dynamic Model of Firm Locational Choice
  - Boundedly-rational firms
  - Repeated locational choices under dynamic increasing returns
  - Predictions in terms of probability distributions
  - Empirically-testable model
  - Results and future extensions

Introduction

- A trivial observation…
  - Economic activities seem to be quite concentrated in geographical space

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- A trivial observation…
  - Economic activities seem to be quite concentrated in geographical space
- … and some related questions
  - Is that true? Is geographical concentration higher than what a random-allocation model would predict?
  - Is geographical concentration high *in all* industrial sectors?
  - Are there industrial sectors that are more geographically clustered than others?
  - And, if so, which are the determinants of this uneven geographical concentration across sectors?
  - Are these determinants more related to “locations” or “sectors”?
  - In other words, are they more related to “technological factors” or to the “comparative advantage” of different areas?

Some Empirical Evidence: Areas

- Data from Italian Statistical Office (Year: 1996)
  - Industrial agglomeration profiles
    - Share of firms belonging to sector *s* located in area *h* (normalized by the size of sector *s*)
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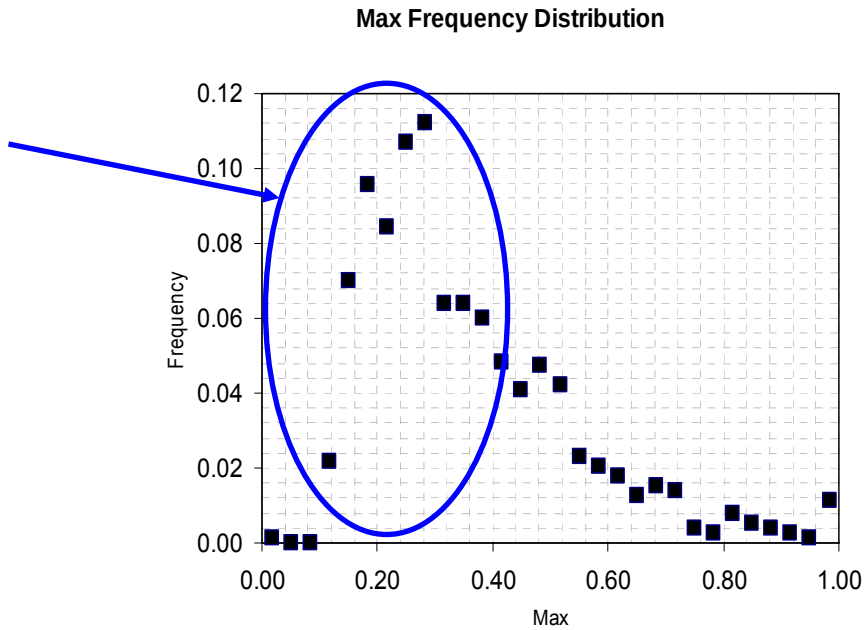
  - Frequency distribution
    - Areas containing firms from all sectors



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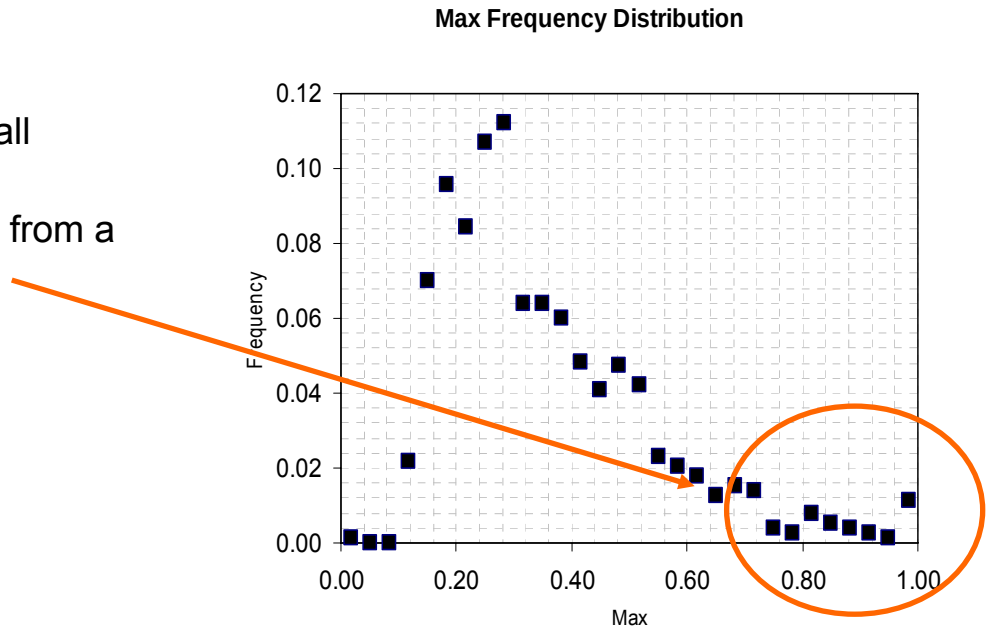

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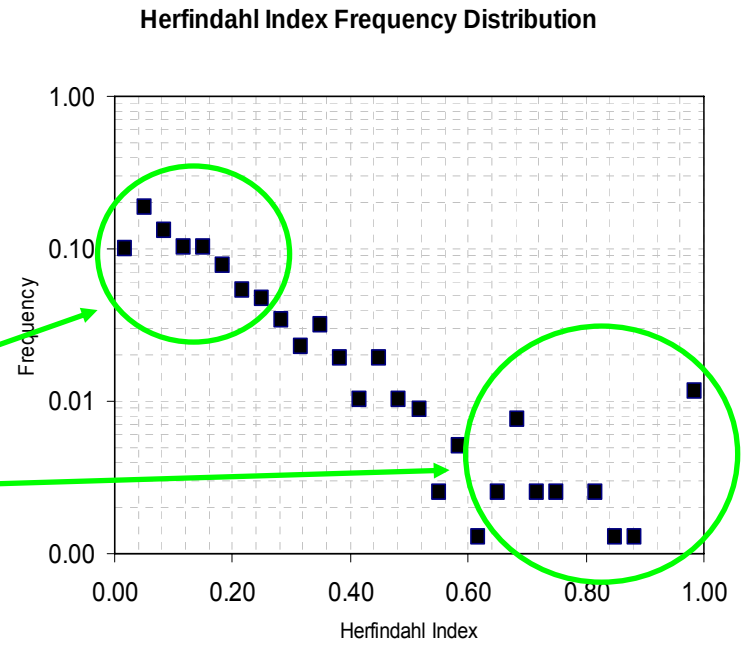
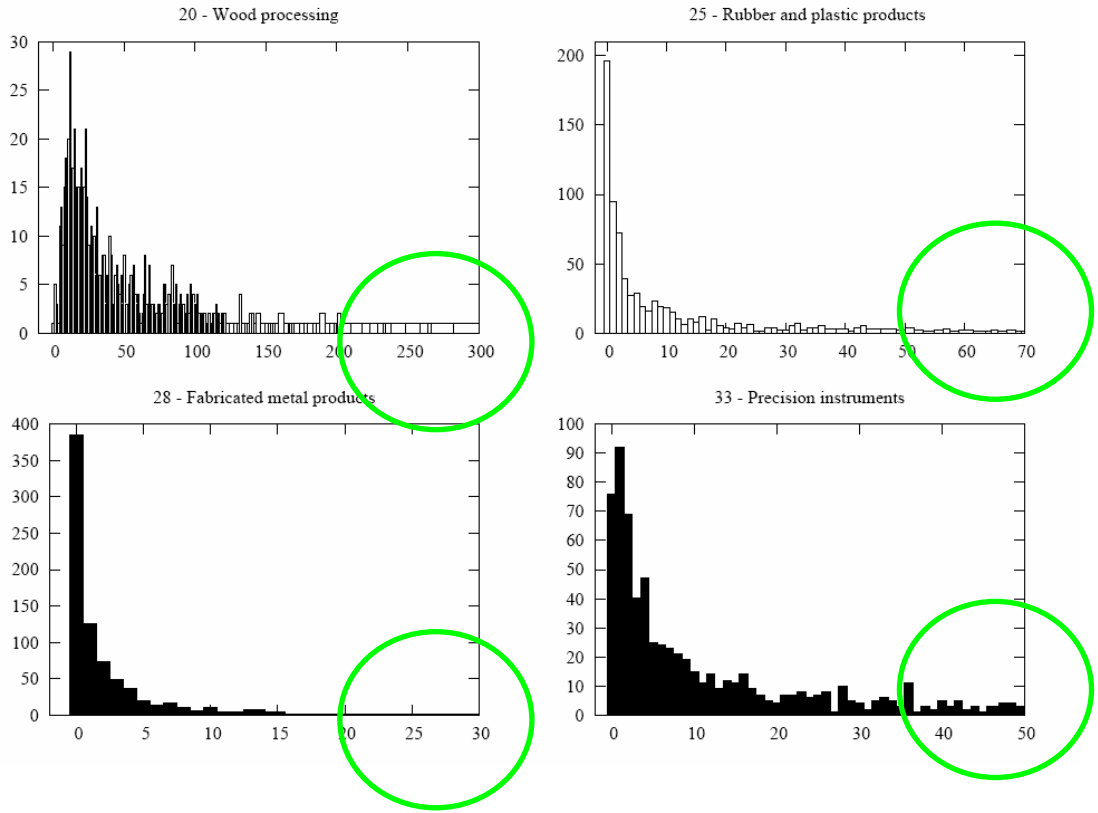
  - Frequency distribution
    - Areas containing firms from all sectors
    - Areas that only contain firms from a few sectors
    - Areas with:
      - Low concentration
      - High concentration



Some Empirical Evidence: Sectors



Frequency distribution of occupancy profiles in different industries. X-axis: Number of firms in a given location; Y-axis: Number of locations that host a given number of firms

- **Very Strong Sector Heterogeneity**
  - Shape and Range

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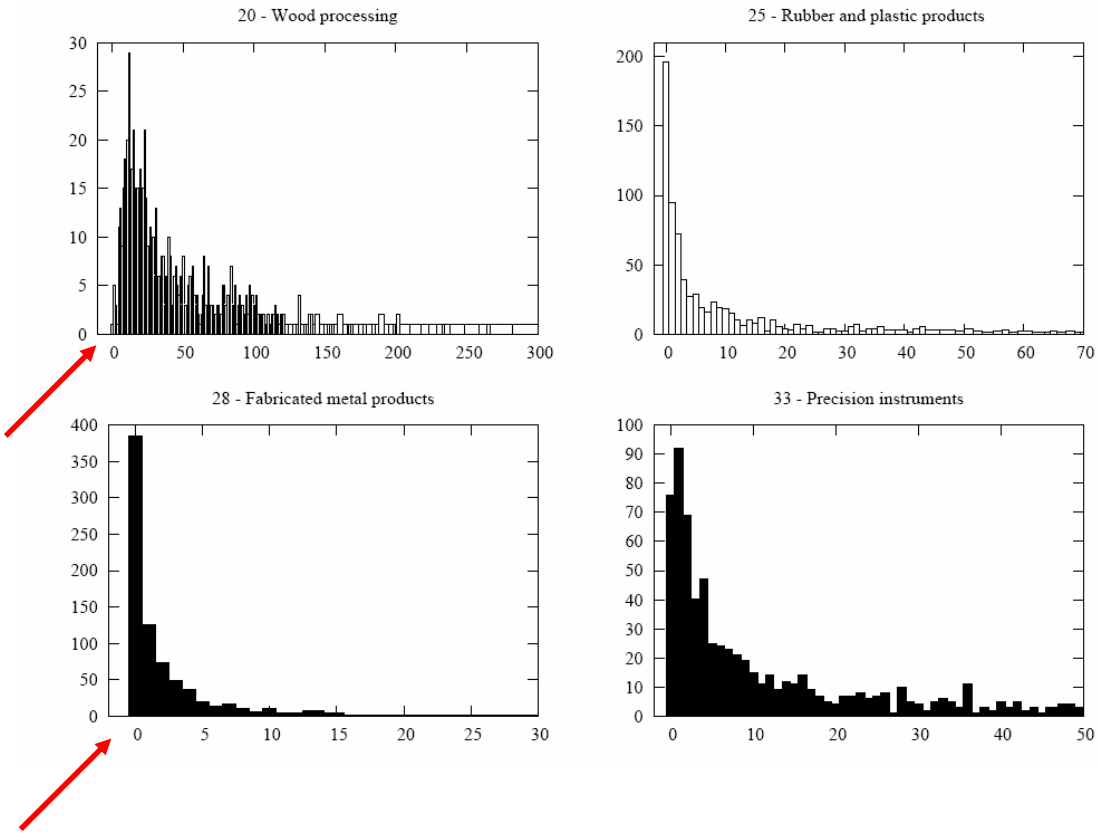

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  - Number of empty locations

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- Traditional Story: Comparative Advantage Theories
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    - Congestion and pollution
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  - Centrifugal forces
    - Increasing input costs (labor, land)
    - Congestion and pollution
    - Transportation costs
  - Agglomeration patterns defined as equilibria between these forces
    - Von Thunen (1826), Christaller (1933), Isard (1956)
    - Fujita (1988), Papageorgiou & Smith (1983)

Theory (2/4)

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  - Goal: Explaining geographical concentration as the outcome of:
    - Optimal choices made by fully-rational agents
    - Centrifugal forces:
      - Firms try to meet demand across space, while avoiding as much as possible local competition
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      - Firms try to meet demand across space, while avoiding as much as possible local competition
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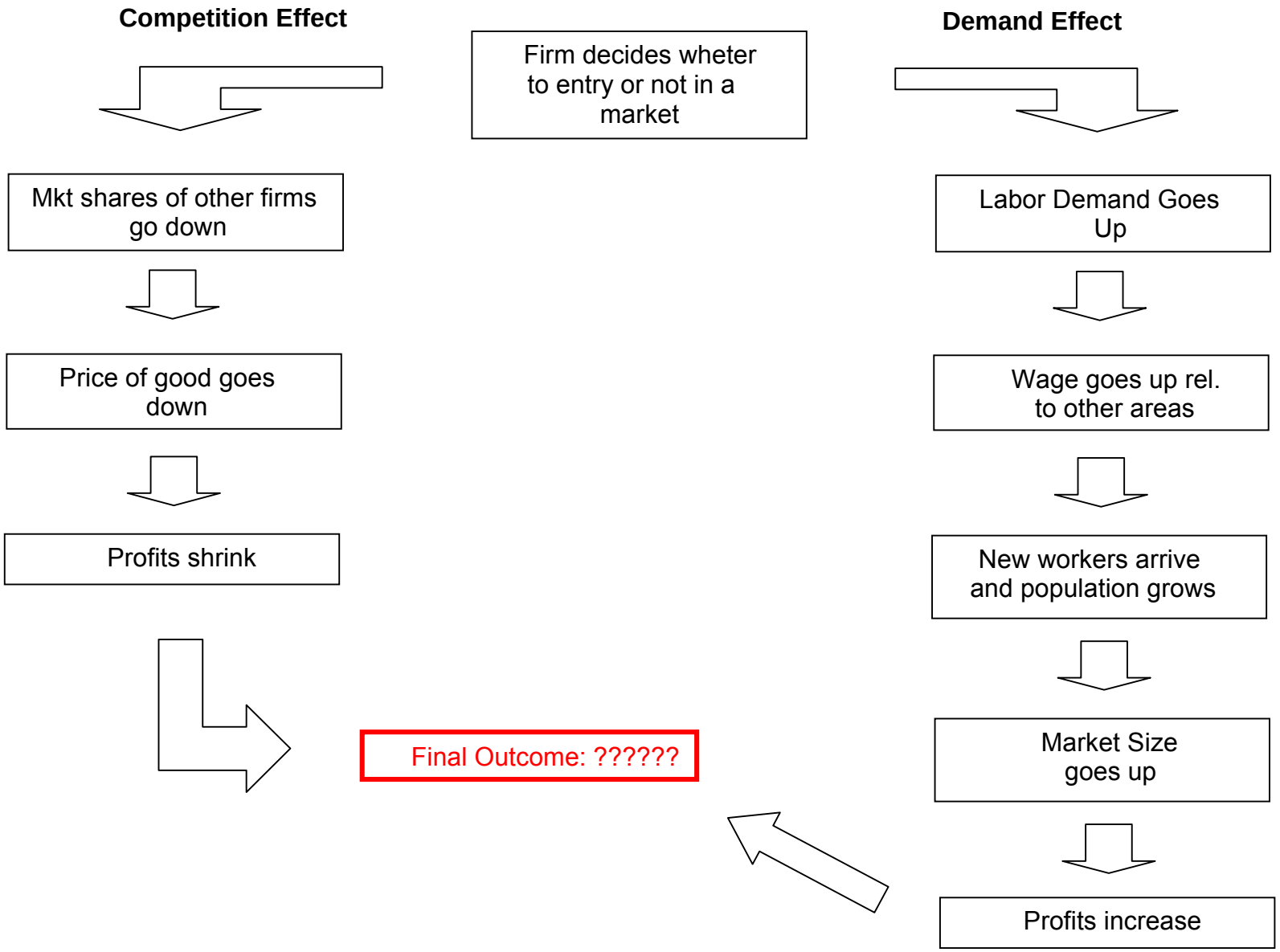
      - Increasing returns to concentration; more efficient consumer markets
  - Main ingredients
    - **Increasing returns**: Expected profits from choosing to locate in a given area are increasing in the number of firms already present there
    - **Transportation costs**: Bring firms close to areas where there are big markets and cheap inputs
    - **Migration flows**: Bring workers close to areas with high employment rates and large local markets

New Economic Geography



Theory (3/4)

- "Episode II": Dartboard Approach vs. New Economic Geography
  - Questions
    - Is the starting point of NEG really true?
    - Are industry-specific spatial agglomeration indices really larger than those we would have expected from a random allocation?
    - How many (and which) are the industries characterized by a low (high) spatial agglomeration index?

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    - Are industry-specific spatial agglomeration indices really larger than those we would have expected from a random allocation?
    - How many (and which) are the industries characterized by a low (high) spatial agglomeration index?
  - Stylized model (Ellison and Glaeser, 1997)
    - Space ("dartboard") where firms ("darts") of different colors ("sectors" are thrown
    - Probability that an area receives a dart depends
      - Ex-ante natural advantage
      - Local technological spillover (extreme: advantage= zero vs. infinity)
      - Size distribution of firm sector
    - In equilibrium: testable relation linking
      - Spatial agglomeration index for each sector
      - Concentration index for each sector
    - Spatial agglomeration index does not allow to separate geographical vs. technological determinants

Theory (4/4)

- Result #1
  - Spatial concentration indices are larger than what a random model would predict in 97% of all cases (US States, 4-digits sectors)

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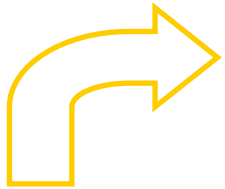
- Problems
  - Model does not generate implications about the spatial agglomeration distribution (I.e. number of firms in each area / industry): Implications only link spatial concentration index to concentration index of firm size in each given sector
  - It is not possible to disentangle geographic vs. technological factors: spatial concentration index involves in non-linear ways both comparative-advantage and technological-spillover effects

Geographical vs. Technological Determinants



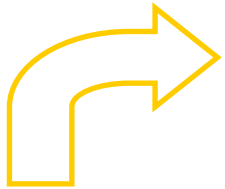
Observed Spatial Agglomeration

Geographical Determinants

- Resources and/or localization
- Aggregate Activities
- Urbanization

Common initial conditions
(not necessarily *industry-specific*)

Geographical vs. Technological Determinants



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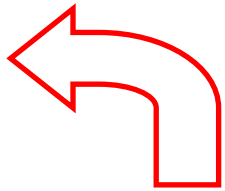

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Technological Determinants

- Local spillovers
- Labor market and infrastructure
- Local knowledge and spin-offs

Dynamic Increasing Returns
(*industry-specific* in each area)

An Alternative Model

- References

  - **Bottazzi, Dosi and Fagiolo (2002)**, "On the Ubiquitous Nature of the Agglomeration Economies and their Diverse Determinants: Some Notes", in Quadrio Curzio, A. and Fortis, M. (Eds.), *Complexity and Industrial Clusters: Dynamics and Models in Theory and Practice*, Heidelberg, Physica-Verlag, p.167-191.

  - **Bottazzi, Dosi and Fagiolo (2004)**, "On Sectoral Specificities in the Geography of Corporate Location", in Breschi, S. and Malerba, F. (Eds.), *Clusters, networks and innovation*, Oxford, U.K., Oxford University Press.

  - **Bottazzi, Dosi, Fagiolo and Secchi (2006)**, "Sectoral Specificities in the Spatial Structure of Economic Activities", LEM WP, 2004/21 (SCED, under review).

  - **Bottazzi, Dosi, Fagiolo and Secchi (2007)**, "Modeling Industrial Evolution in Geographical Space", LEM WP, 2007/06 (JEG, under review).

Background: Polya-Urn Models (Arthur, 1994)

- The economy
  - Potentially infinite population of agents
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- Results
  - Under mild hypotheses, as $t \to \infty$ the systems locks-in with p=1
  - That is: The system converges a.s. to some frequency pattern (x,1-x) of A- and B-adopters
  - If there is multiplicity of lock-in frequencies, which one will be selected depends in unpredictable ways on both initial conditions and (path-dependently) the history of the process

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- Time $t = 0,1, \ldots$
- Time-t system state $\underline{n}_t = (n_{1t}, n_{2t}, \ldots, n_{Lt})$

n_{ht} = # firms in area h at time t

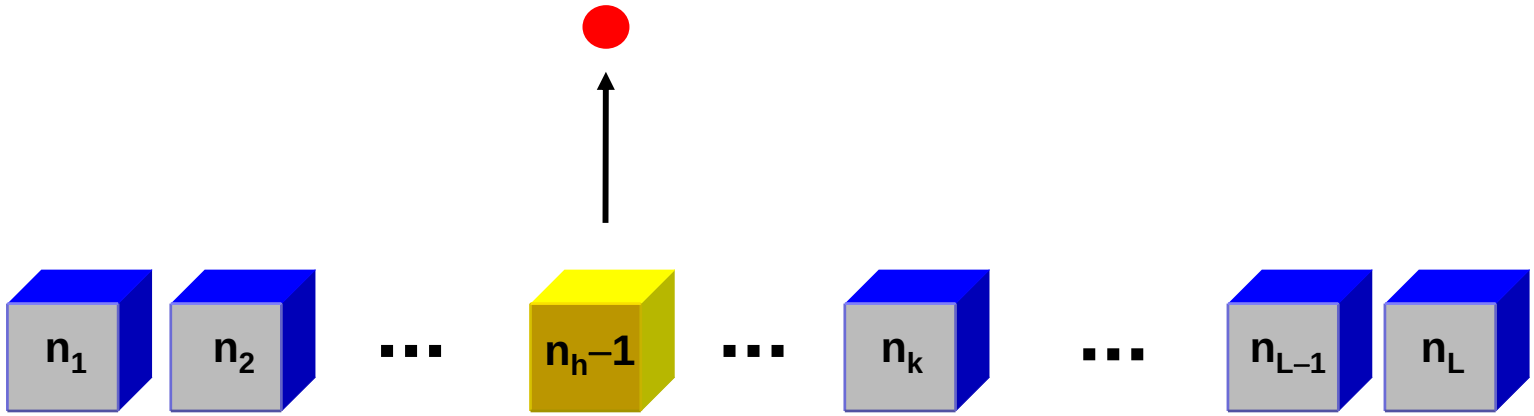
Dynamics: Step #1

- At time t a configuration $\underline{n}_t = (n_1 , n_2 , \ldots , n_L)$ is given

Dynamics: Step #2

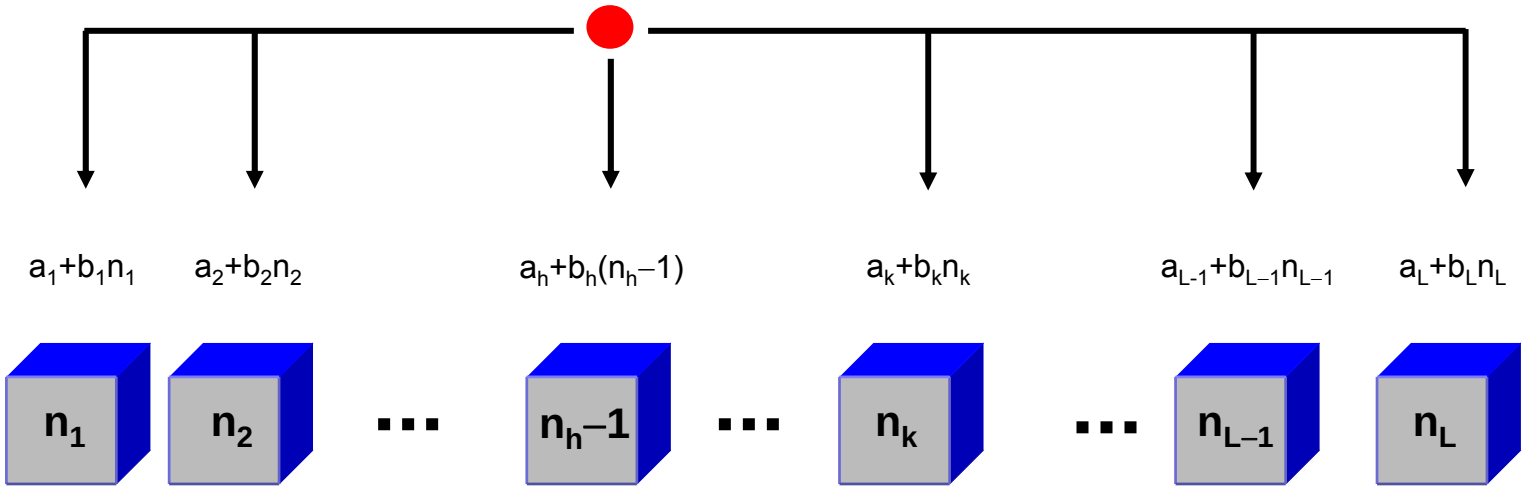
- An area (box) is chosen at random…

Dynamics: Step #3



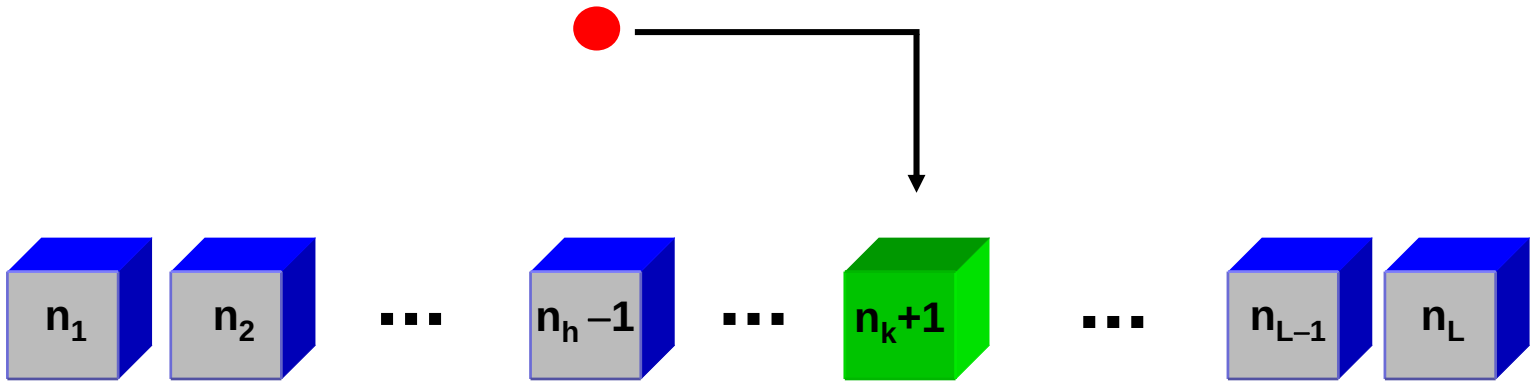
- A firm (ball) is drawn (exit / death / reallocation)

Dynamics: Step #4



- A new firm (or the one that just exited) chooses a new location
- It chooses area h with probability proportional to: $a_h+b_h\, n^*_h$

Dynamics: Step #5



- The chosen area increases the number of firms (balls) it contains by one unit

Dynamics: Step #6

- A new configuration is ready for time t+1
- The process goes on…

Analysis and Testable Implications

- Dynamics governed by a Markov Chain
  - Predictions in terms of ergodic distributions
  - We obtain analytical solutions for
    - Probability of finding $(n_1, n_2, \ldots, n_L)$ firms in the L areas
    - Probability that a given area contains *n* firms
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- Testable Implications
  - Estimation of parameter vectors ($\underline{a}$,$\underline{b}$)
  - Parameter estimation can be done in such a way to disentangle
    - Geographical determinants ($\underline{a}$)
    - Technological determinants ($\underline{b}$)

We estimate three alternative sub-models

Model	Hypothesis	Parameters
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2	Heterogeneous Areas with Urbanization Effects Homogeneous Agglomeration Effects	$a_h > 0$ $b_h = b > 0$

Ergodic Distributions

Model	Probability of finding a profile n in the L areas **$\pi(\underline{\mathbf{n}} ; \underline{\mathbf{a}}, \underline{\mathbf{b}})$**	Marginal probability of finding *n* firms in a given area **$\mathbf{p(n ; \cdot)}$**
0	$\frac{N}{L^N}\prod_{l=1}^{L}\frac{1}{n_l!}$	$\binom{N}{n}\left(\frac{1}{L}\right)^n\left(1-\frac{1}{L}\right)^{N-n}$

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2	$\frac{N!\Gamma(A/b)}{\Gamma(A/b+N)}\prod_{l=1}^{L'}\frac{1}{n_l!}\frac{\Gamma(a_l/b+n_l)}{\Gamma(a_l/b)}$	$\binom{N}{n}\frac{\Gamma(A/b)}{\Gamma(A/b+N)}\frac{\Gamma(a/b+n)}{\Gamma(a/b)}\frac{\Gamma((A-a)/b+N-n)}{\Gamma((A-a)/b)}$

Data and Estimation Procedure

- Italian Census of Production Activities
  - N ≈ 500000 firms (business units)
  - L=784 areas (Local Systems of Labor Mobility, LSLM)
  - M=23 industrial sectors (manufacturing, 2 digits)
  - Years: 1991, **1996**, 2001

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- Estimation Procedure
  - Take a given model: 0, 1, 2
  - For each sector:
    - Fit theoretical distribution $p_j(n)$ to empirical $f_j(n)$
    - Estimate free parameters by minimizing Chi-Squared test (provided that test is not rejected)

Results: A Sneak-in Preview (1/2)

- Model 0: Random Agglomeration
  - The model is always rejected: space matters in all sectors
  - Observed concentration higher than expected in a model with homogeneous area without spillovers (as in Ellison + Glaser, 1997)

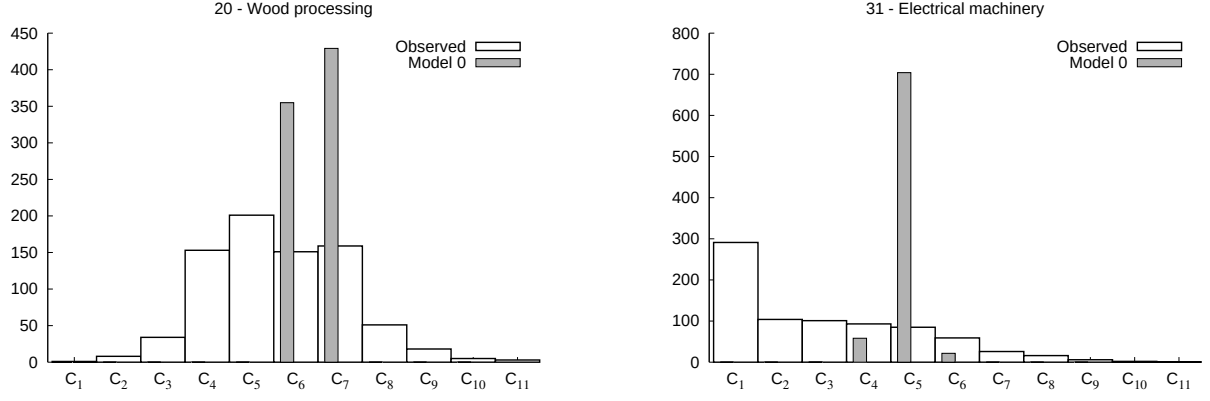

Figure 4: Occupancy class frequencies computed on observed data (white bars) and estimated using Model 0 (gray bars).

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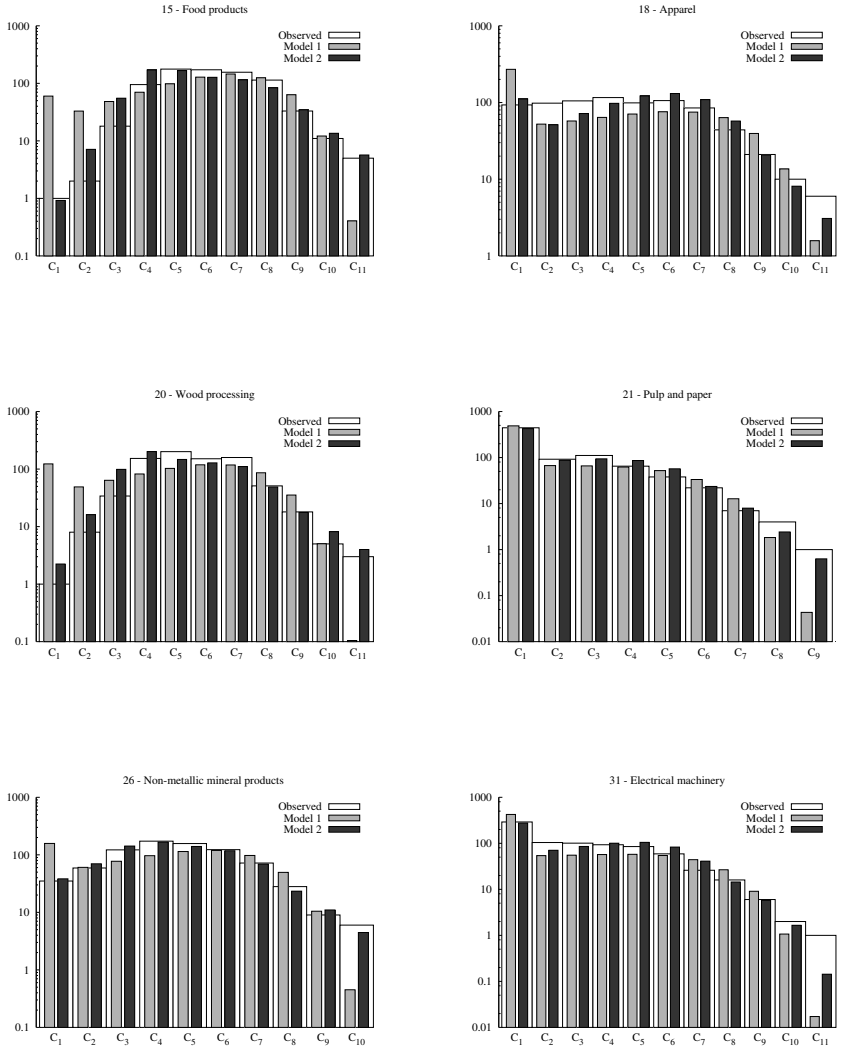

Figure 5: Occupancy class frequencies computed on observed data (white bars) and estimated using Model 1 (gray bars) and Model 2 (black bars).

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- Interpretation
  - Geographic attractiveness *a(j,l)* measures also exogenous geographical and infrastructural factors, demand-induced externalities, etc.
  - Parameter $\beta(j)$ measures overall pull exerted by all business units from all other sectors
  - Sectors with high $\beta(j)$: overall installed base of all production units brings a stronger attractive strength

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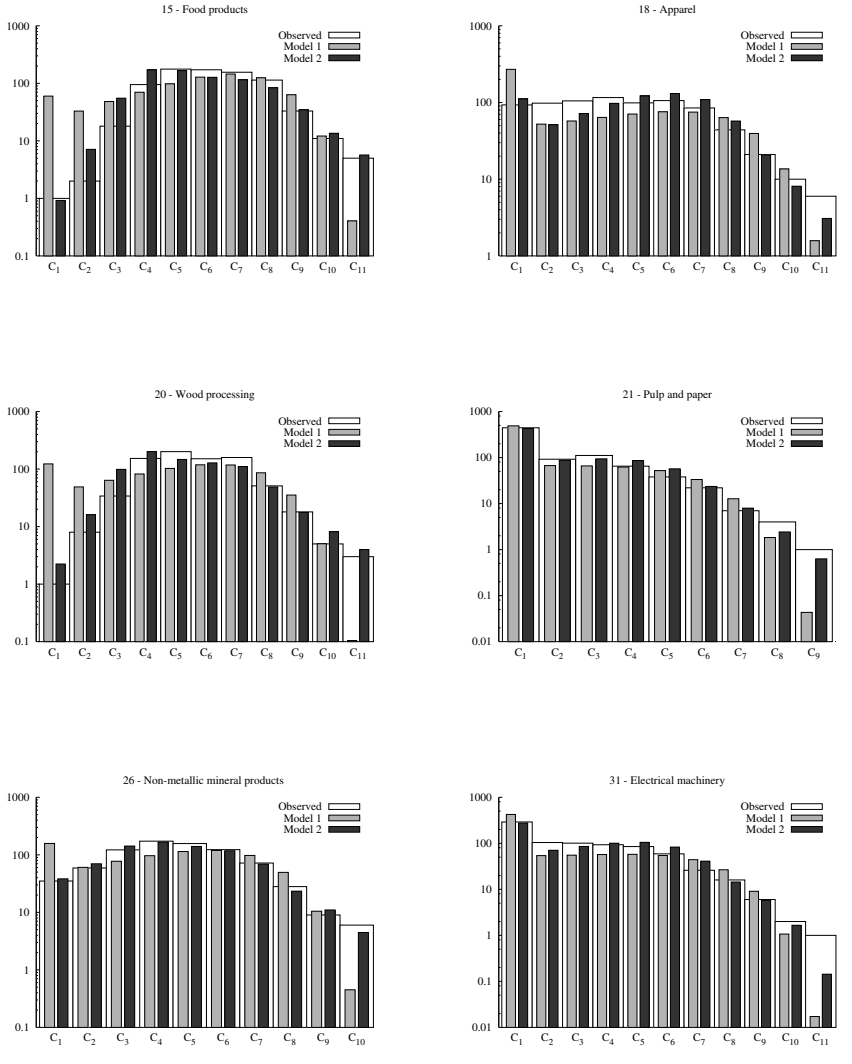

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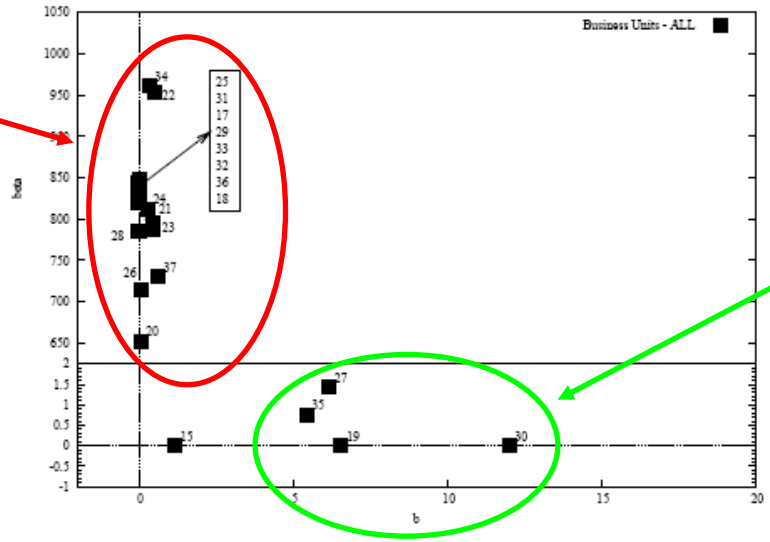

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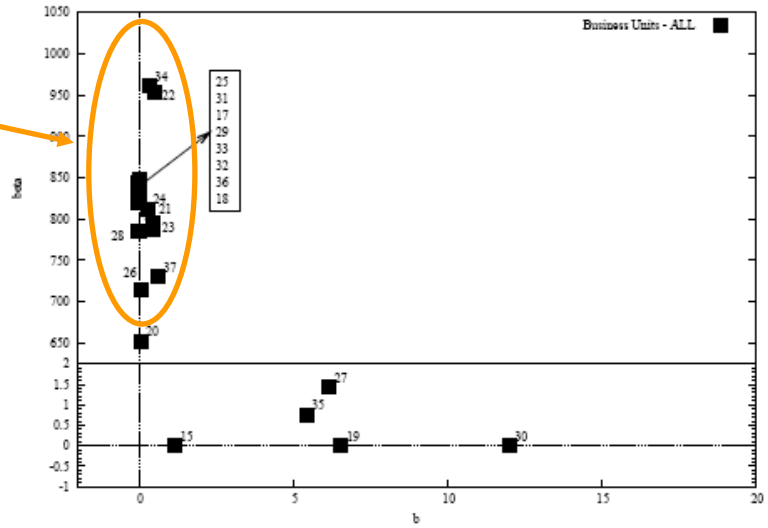
Include
Textiles (17) and Apparel (18)
Why??



Model 2: Additional Results (1/2)

- Re-estimating the model without metropolitan areas
  - Metropolitan areas: 11 over 784 (around biggest cities)
    - They tend to exert a “more-of-everything” effect that is not entirely captured by urbanization effects
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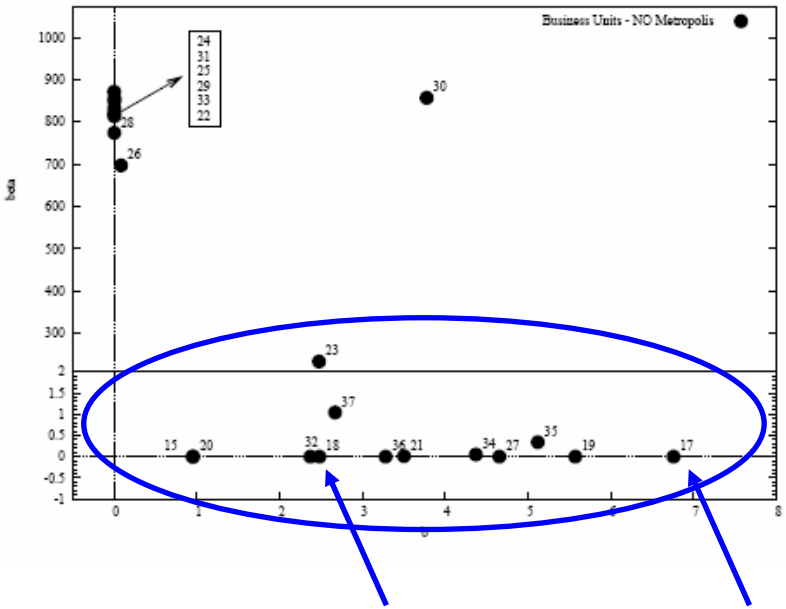

- Picture significantly changes
- Leather and apparel are now characterized by a low urbanization parameter (β)
- Agglomeration effects are mostly of a sector-specific nature
- Even when urbanization effect is present, it only explains a small part of inter-location variation in locational intensities, that is the “urbanization assumption” is not that supported by the data

Model 2: Additional Results (2/2)

- What about firm- and sector-size effects?
  - Our estimates in terms of “number of firms”
    - We treat differently the case of (1 firm, 10000 employees) vs. (100 firms, 100 employees each). What about: Increasing returns? Internalization?
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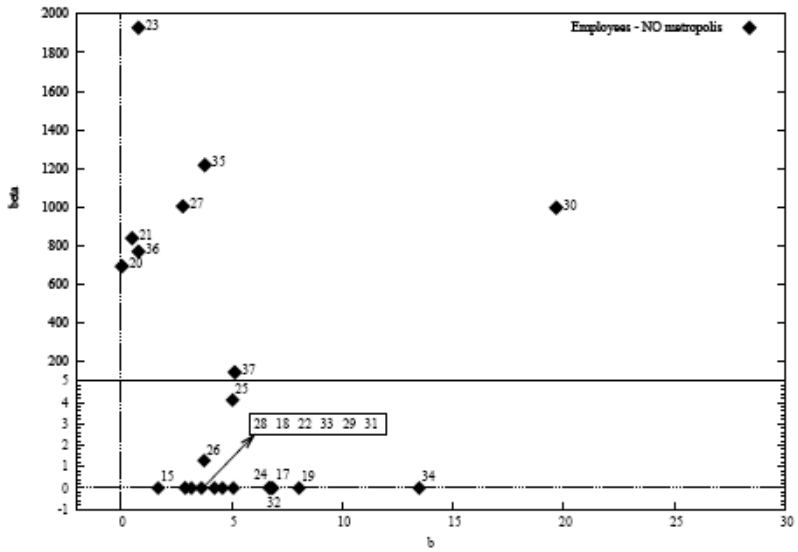

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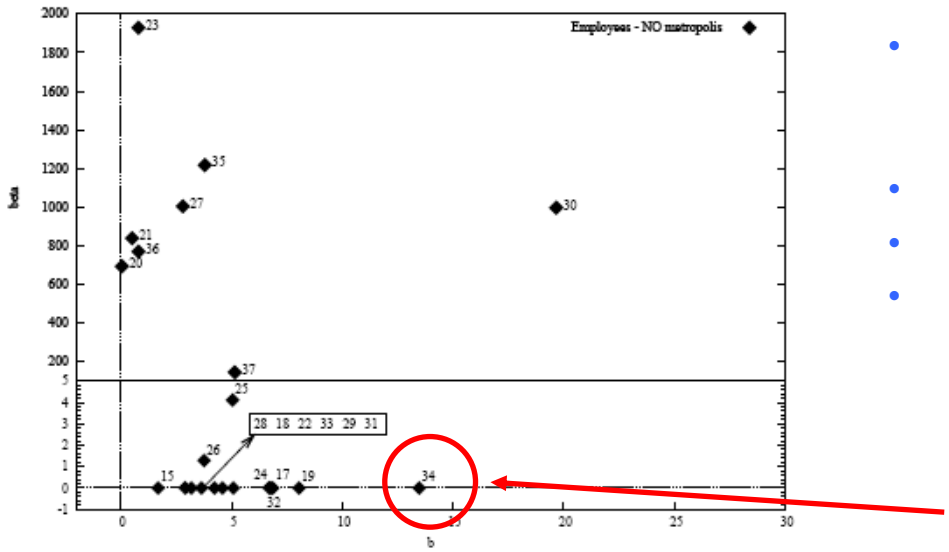

- After having taken away metropolitan areas, results seem to be confirmed
- Relatively high heterogeneity
- Sector-specific effects dominate
- We are able to capture effects of location patterns of industries composed of few but very large firms
  - Motor vehicles (34) are characterized by a very large agglomeration coefficient

Results: A Sneak-in Preview (2/2)

- Which interpretation for ex-post cross-sector heterogeneity in technological determinants to agglomeration?
  - Do sectoral specificities (technological and organizational learning) map onto different spatial agglomeration strengths?
  - Is it possible to taxonomize industrial sectors with respect to their net weight of the technological determinant in spatial agglomeration processes?

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  - Is it possible to taxonomize industrial sectors with respect to their net weight of the technological determinant in spatial agglomeration processes?

- Yes. According to Pavitt taxonomy:
  - Sectors belonging to different macro-classes display statistically significant and interpretable agglomeration strength (i.e. *b* coefficients in Model 2)

Sector	Example	Agglomeration Economies	Why?
Scale Intensive	Transport Equipment	Higher	• Hierarchical relations among firms • "Oligopolistic core" • Subcontracting networks
Supplier Dominated	Leather		• Italian Districts • Inter-firm division of labor • Knowledge complementarities • District-specific institutional arrangements
Science-Based	Electronics	Intermediate	• Expected higher -- “Silicon Valley” effects • In Italy: Weaker
Info-Intensive	Financial Intermediation	Lower	• “Monopolistic competition” strategies of branch location near customers

Conclusions

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- What we are doing now, and what do we plan for future research
  - Deeper understanding of Pavitt-like taxonomic exercises
  - Robustness of results to alternative
    - Time-spans
    - Countries and databases
  - More micro-founded version of the model
    - Inter-sectoral spillovers and geographical distances