Geography of Innovation and the Location of MNEs R&D Activities

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Outline

- Innovation is clustered in a few places in the world ('local buzz' argument)

- These few places need to be connected to each other ('global pipeline' argument)

- MNEs are privileged actors to build these pipelines, but they need to internationalise their R&D activities in geographically dispersed locations

- What are the factors that drive the location of R&D by MNEs?
  - In particular, to what extent
    - Geographic distance is an obstacle to internationalisation of R&D
    - The location of production activities constraints the location of R&D

Main references

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- Castellani D., Zanfei A. (2006) *Multinational Firms, Innovation and Productivity*, Edward Elgar

- Castellani, D., Jimenez, A., & Zanfei, A. (2013). How remote are R&D labs? Distance factors and international innovative activities. *Journal of International Business Studies*, 44(7), 649-675.

- Castellani D., Lavoratori K. (2017) The Lab and the Plant. Offshored R&D and co-location with manufacturing activities, *mimeo*.

Geography of innovation

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- EG perspective
  - Innovation activities tend to cluster to allow more effective transfer of (mostly) tacit knowledge
    - the importance of 'being there' (Gertler, 2003)
  - Local buzz and global pipelines (Bathelt, Malberg and Maskell, 2004)

    'Local buzz' generates opportunities for the transmission of sticky, non-articulated, tacit forms of knowledge between firms located there

    - Innovation becomes **more clustered over time** as a result of local buzz, but eventually it needs to be **integrated with knowledge external** to the cluster

    'Global pipelines' can 'pump' information about markets and technologies into the cluster, making the 'buzz' more dynamic

      - Pipelines can be created by firms and organisation, or through personal networks (Lorenzen and Mudambi, 2013)
  - But how (and how much) knowledge is transferred in these global pipelines? How can the obstacles of 'not being there' be overcome? (Gertler, 2003, 2008)
  - The literature on MNEs innovation activities can help

Geography of innovation

- IB perspective
  - MNEs typically produce knowledge in their home R&D labs, and exploit it through their network of subsidiaries
  - Increasingly MNEs use their network to leverage geographically dispersed knowledge (Cantwell and Mudambi, 2005)
  - MNEs are becoming orchestrators of knowledge
    - **tap into diverse knowledge clusters** and have the ability to **de-contextualise tacit knowledge** and **transfer it** within the MNE and across space (Meyer et al., 2011; Castellani and Zanfei, 2006, Cantwell and Santangelo, 1999)
    - create institutional proximity that allows **connections between knowledge sources** and share tacit knowledge across locations **despite of geographical distance** (Cano-Kollmann et al., 2016; Gertler, 2003)
  - They are privileged actors to build global pipelines between clusters

Geography of innovation

- In order to act as conduits of knowledge between clusters MNEs need to locate R&D in dispersed locations

  - How **far** are MNEs willing to go with their R&D in order to be **close** to knowledge cluster?

  - **Disperse** R&D geographically to tap into clusters **or co-locate** R&D with production?

Distance and the location of R&D

Castellani, Jimenez, Zanfei (2013)

① Firms may need to cover long distances to gain access to knowledge clusters

- Knowledge is concentrated in (relatively) **few and specialized clusters** where MNC *'need to go'*
- The **location choice set is more limited** than in the case, for example, of manufacturing activities

② MNCs are well placed in the transfer of (codified and tacit) knowledge across clusters even over long distances

- Through corporate culture and routines they facilitate transfer of knowledge within the MNE

③ The international dispersion of MNC's R&D activities is hindered more by socio-institutional distance (that affects information and communication costs) than by geographic distance

- Unfamiliar locations increase information and communication costs that are crucial for effectiveness of foreign R&D labs

→ Geographic distance between cluster is less of an obstacle when MNEs decide where to locate their R&D

The Lab and the Plant

Castellani and Lavoratori (2017)

Why MNEs may locate **their** R&D close to **their** production activities?

- previous investments reduce information costs and uncertainty
- economies of scale and scope
- inter-functional linkages within firm
  - tacit knowledge transfers
  - coordination and control

The Lab and the Plant

Castellani and Lavoratori (2017)

Why MNEs may **not** want to locate their R&D close to their production/R&D activities?

- production and R&D are attracted by different factors (e.g. cheap labour and proximity to markets vs. quality of human capital and local innovation system)
  - geographical dispersion in search for the best external location factors, or
  - concentration of activities along the value chain in a same location, to preserve intra-firm linkages.

The Lab and the Plant

Castellani and Lavoratori (2017)

- The need/advantage from co-location can be very heterogeneous across firms
  - across sectors
    - e.g. degree of modularity of technologies, engineering-intensive R&D vs separable R&D/production processes
  - based on firm sensitivity to coordination and control costs
    - e.g. large vs. small firms and more vs. less internationalised firms
  - based on the importance of tacit vs. codified knowledge

Evidence on the changing geography of inventive activity

Data

- OECD Regional Innovation Dataset
  - 39 countries, 1482 regions (TL2 or TL3) and 32 years (1980-2011)
  - Patent Cooperation Treaty (PCT) Applications, fractional count by inventor and priority year
    - Number of applications
    - Number of patents with co-applicants
    - Share of co-applicants within the region, the country, foreign
  - Population
  - Source: http://stats.oecd.org

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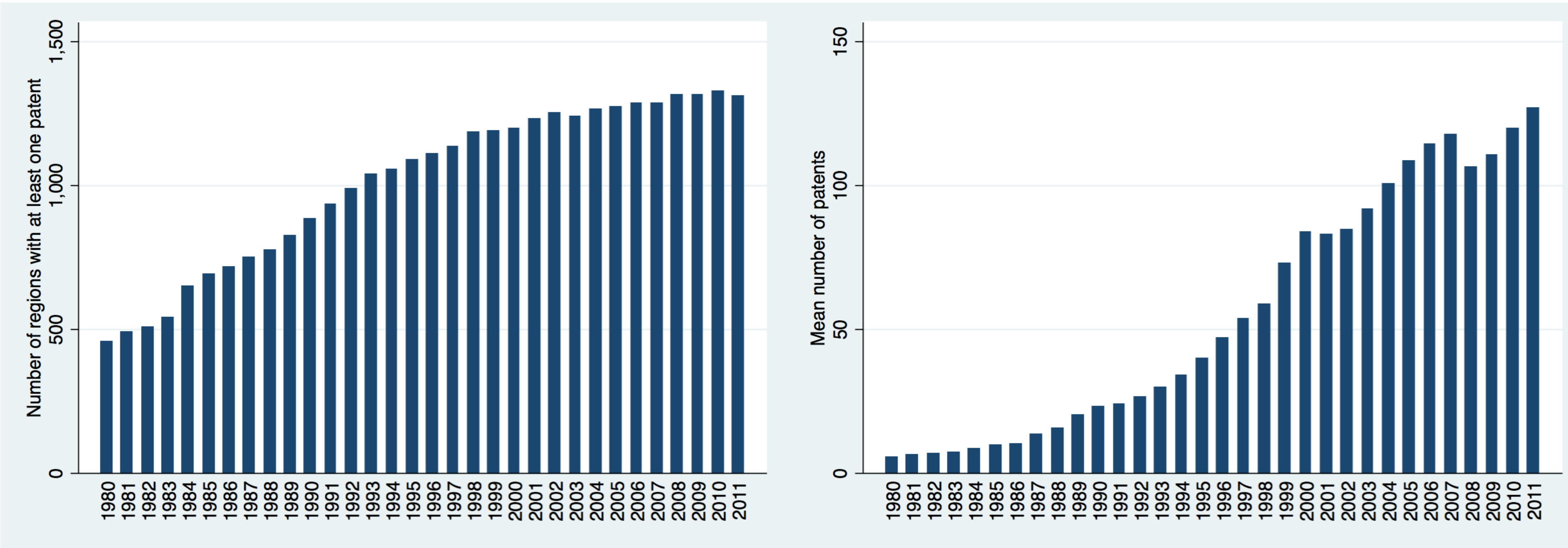
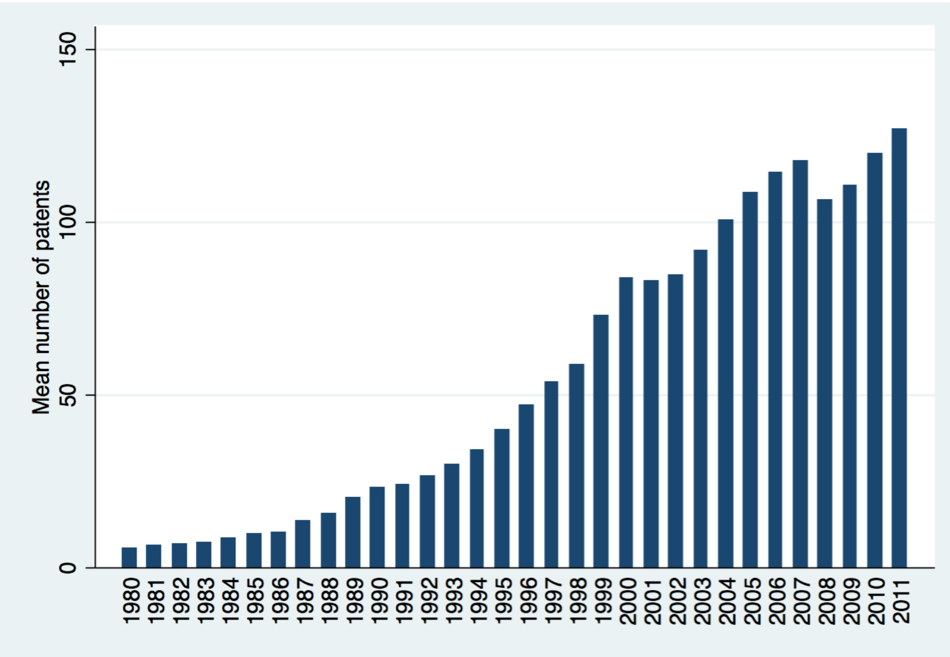
		# Regions (%)	# Patents (%)	# Patents (median)	Population (median)	Patents per million inhabitants (median)
TL2		13.3	7.9%	4	2,621,091	1
TL3 - intermediate		27.21	23.7%	10	511,840	22
TL3 - rural		3.51	0.1%	2	144,751	17
TL3 - close to a city		22.53	11.4%	8	392,842	20
TL3 - remote		10.58	1.4%	3	180,787	19
TL3 - urban		**22.87**	**55.4%**	22	841,717	**32**
Total		100.0% (1,482)	100.0% (2,124,022)	9	503,407	19
USA	TL3	12.1%	35.4%	17	668,486	24
JPN	TL3	3.2%	14.7%	29	1,723,006	17
DEU	TL3	6.5%	12.5%	29	615,003	44
GBR	TL3	9.3%	4.9%	10	298,243	34
FRA	TL3	6.5%	4.7%	9	495,900	21
KOR	TL3	1.1%	3.3%	36	1855,040	17
CHN	TL2	2.1%	3.1%	9	34,911,028	0.2
SWE	TL3	1.4%	2.5%	28	260,197	102
NLD	TL3	0.8%	2.4%	25	1041,552	43
ITA	TL3	7.4%	2.0%	5	355,929	13
…						

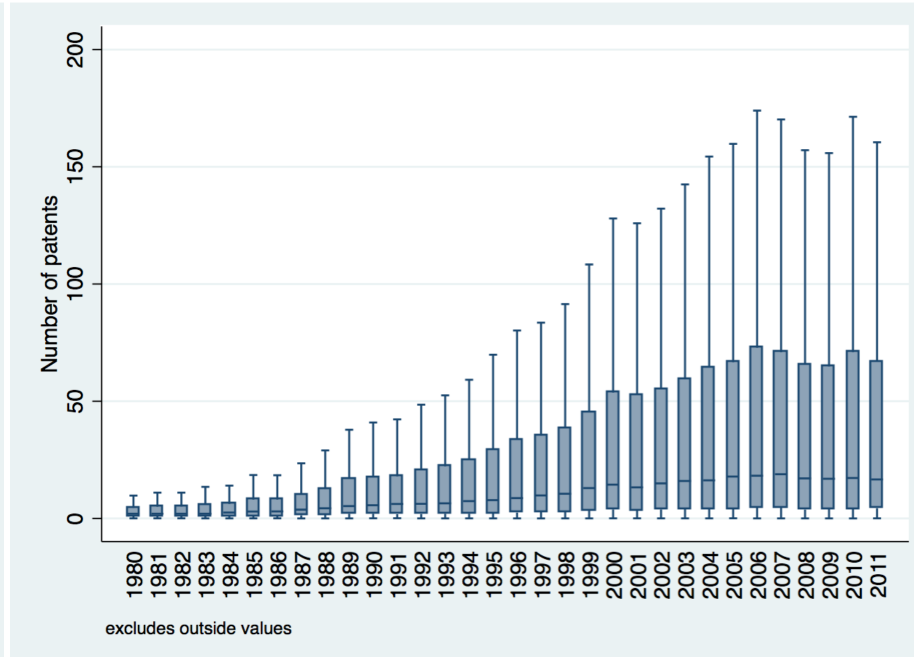
The changing geography of patenting



- The number of regions engaged in patenting has increased threefold
- The average number of patents per region has increased by 2 orders of magnitude

The changing geography of patenting





- The increase in the mean patents is the result of a very skewed distribution
- The median increased relatively little, but there are a number of regions which have significantly increased their patenting

The changing geography of patenting

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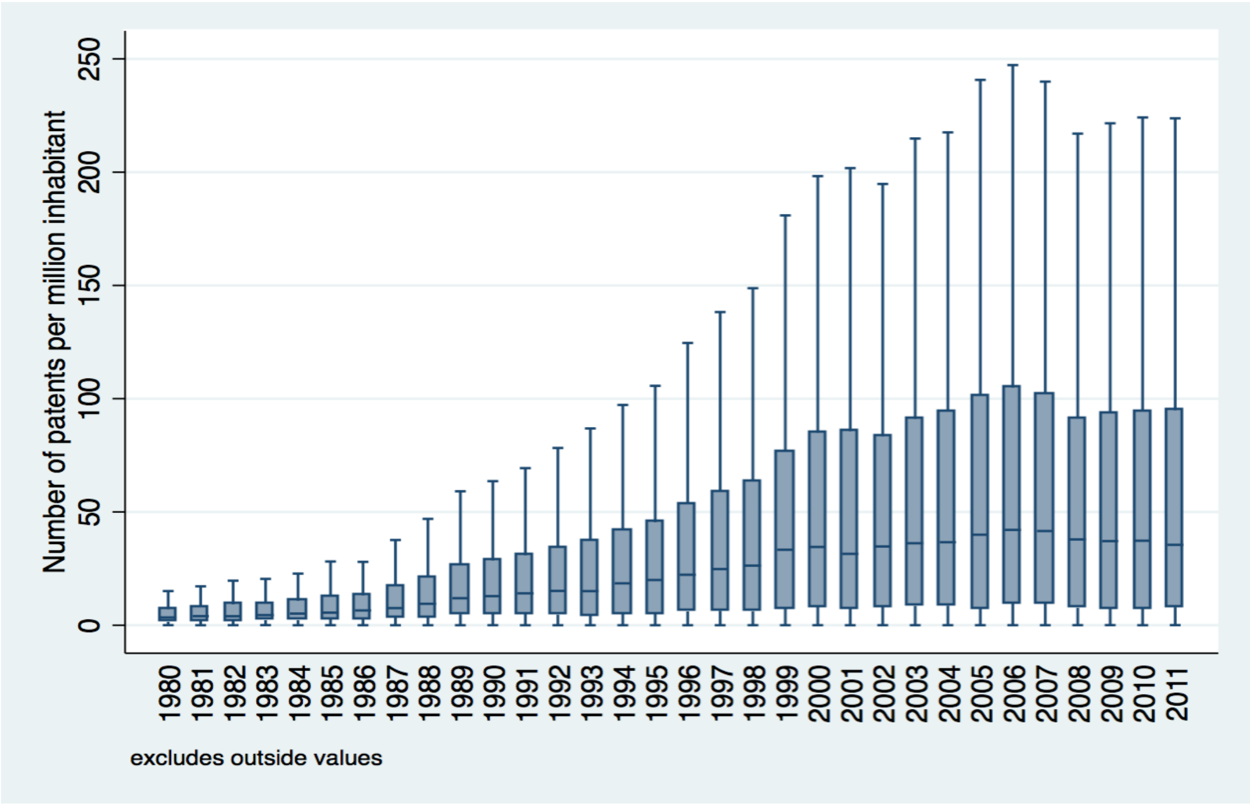

- A similar pattern is observed when we normalise by population
  - Patenting is not driven by increased size of the region!

The changing geography of patenting

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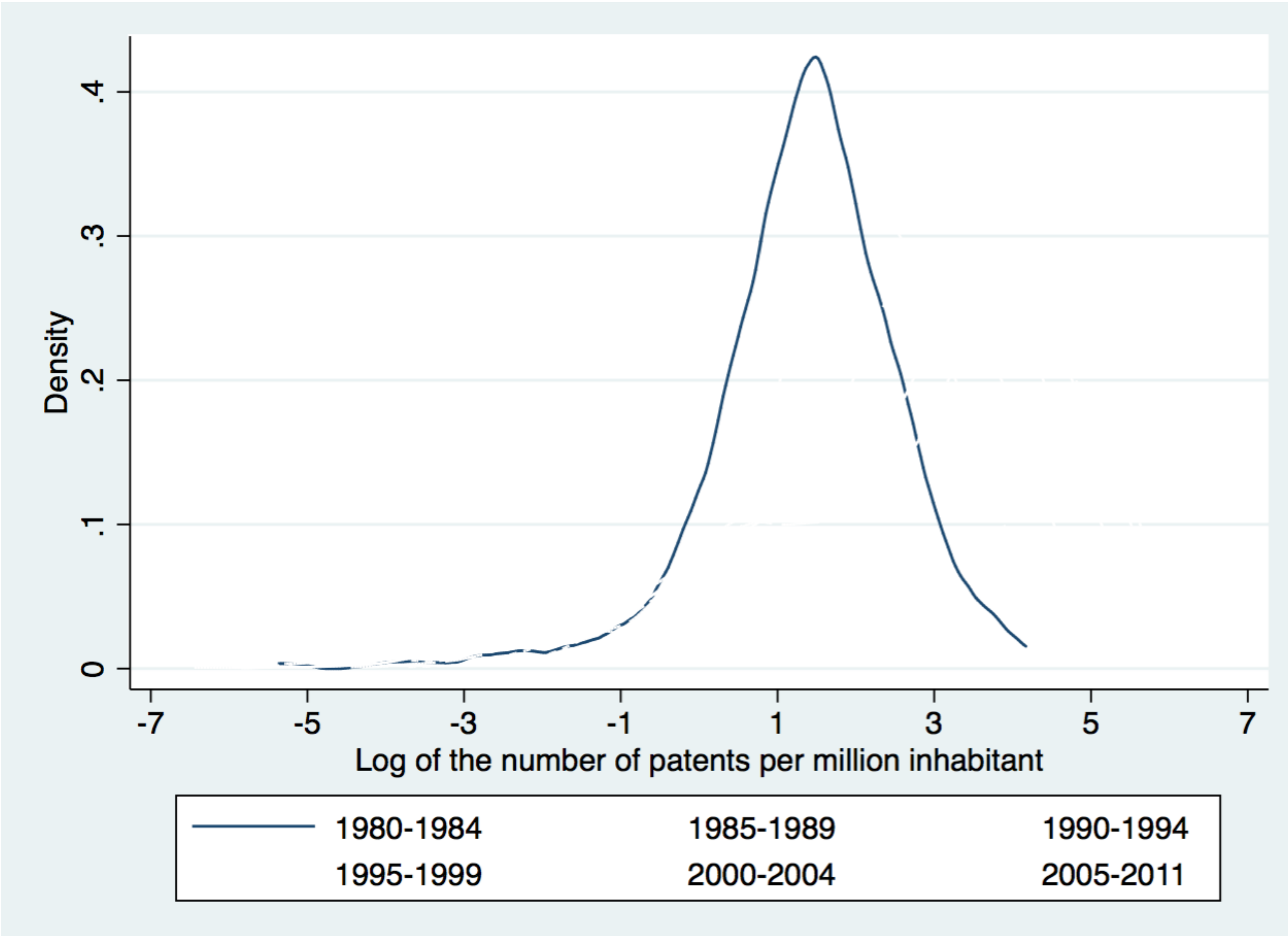
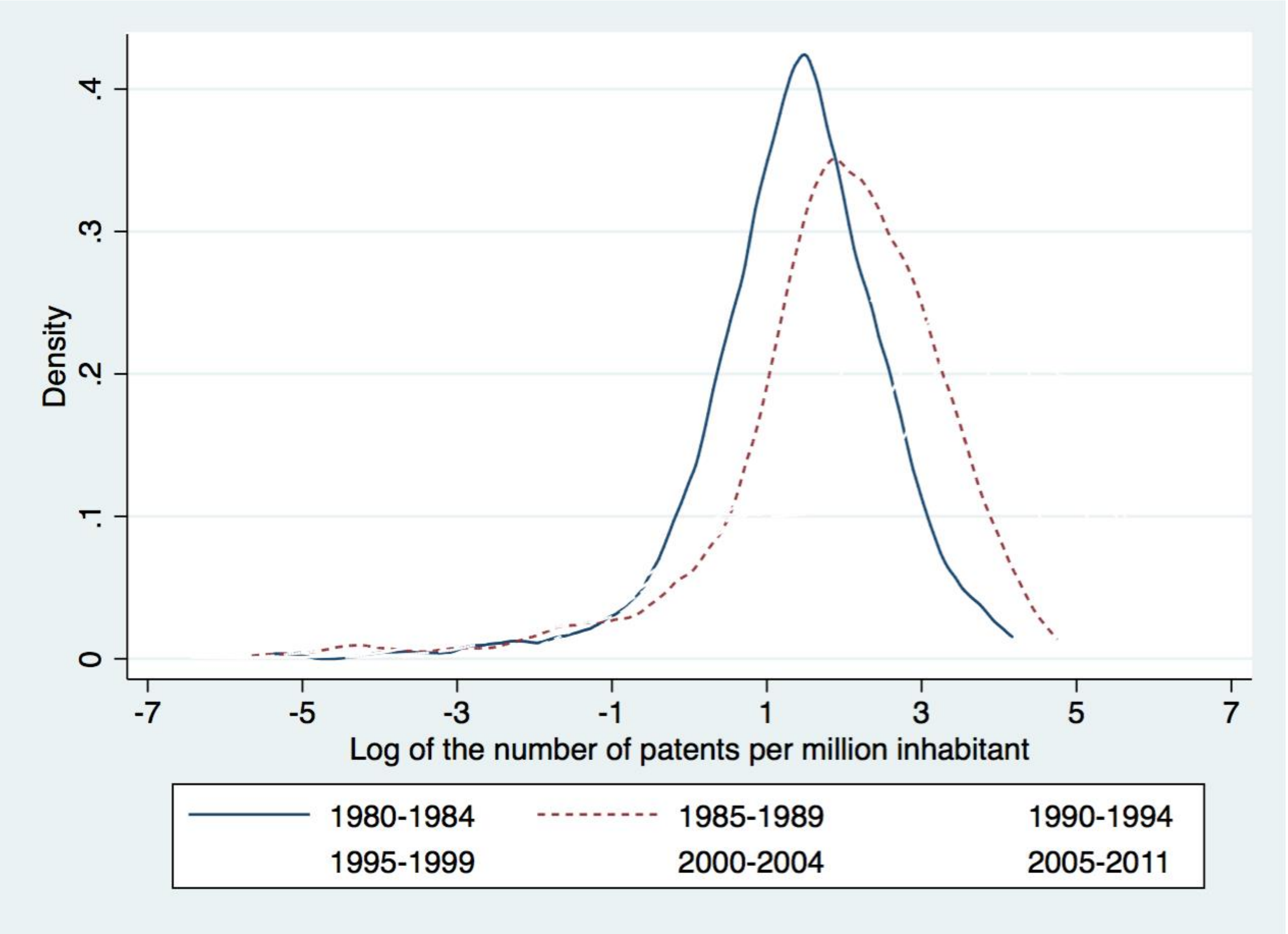


The changing geography of patenting



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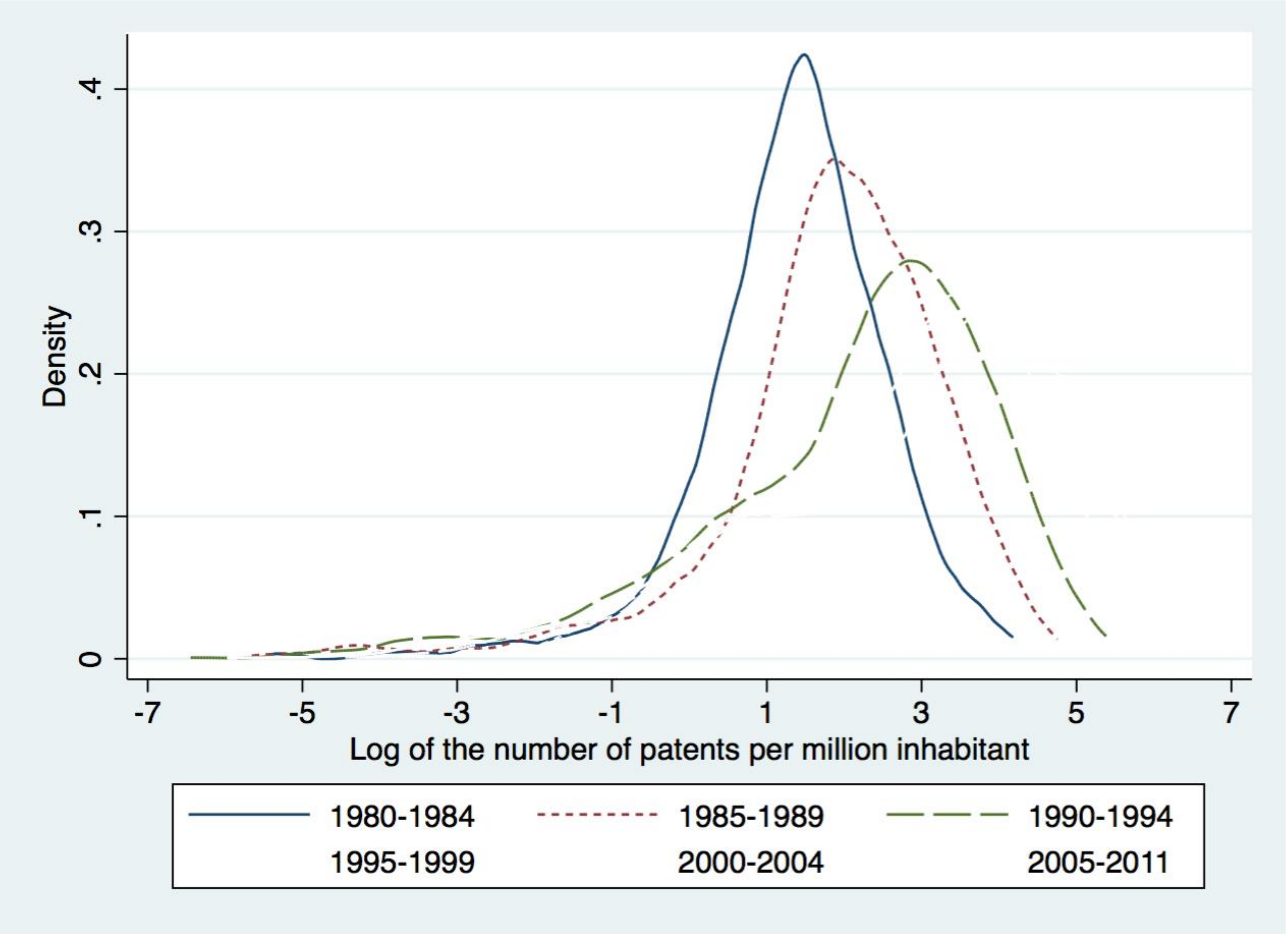

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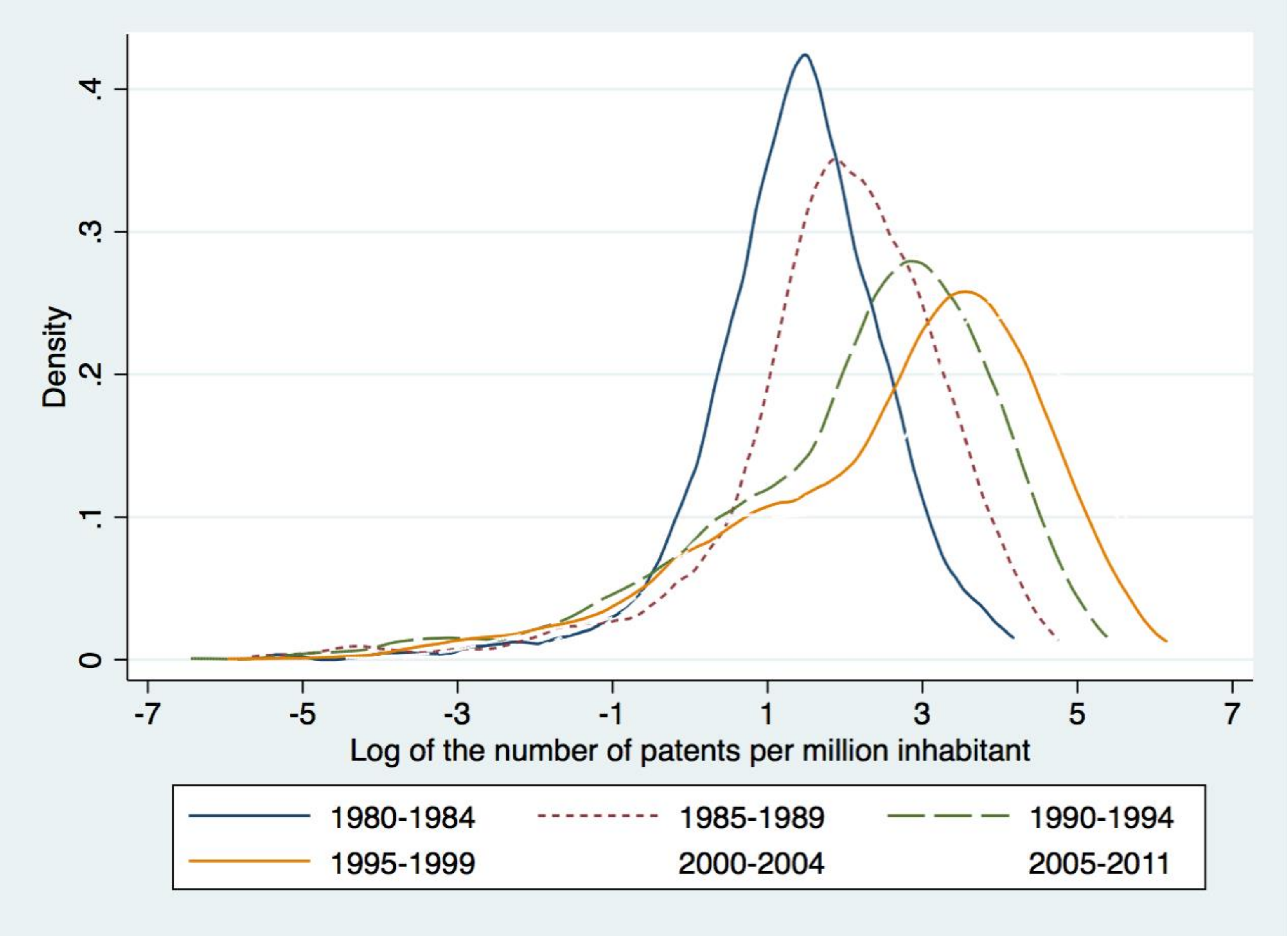

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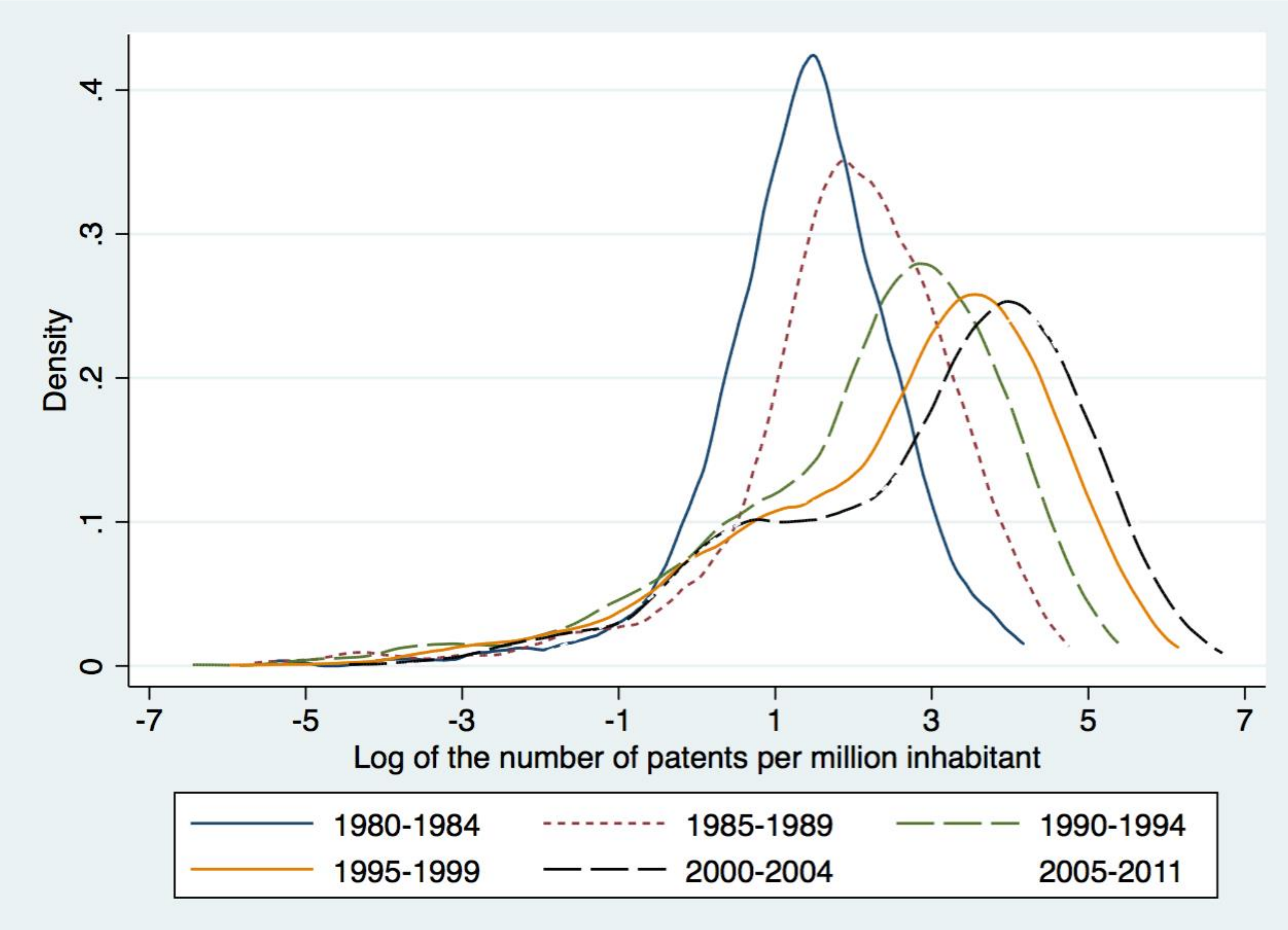
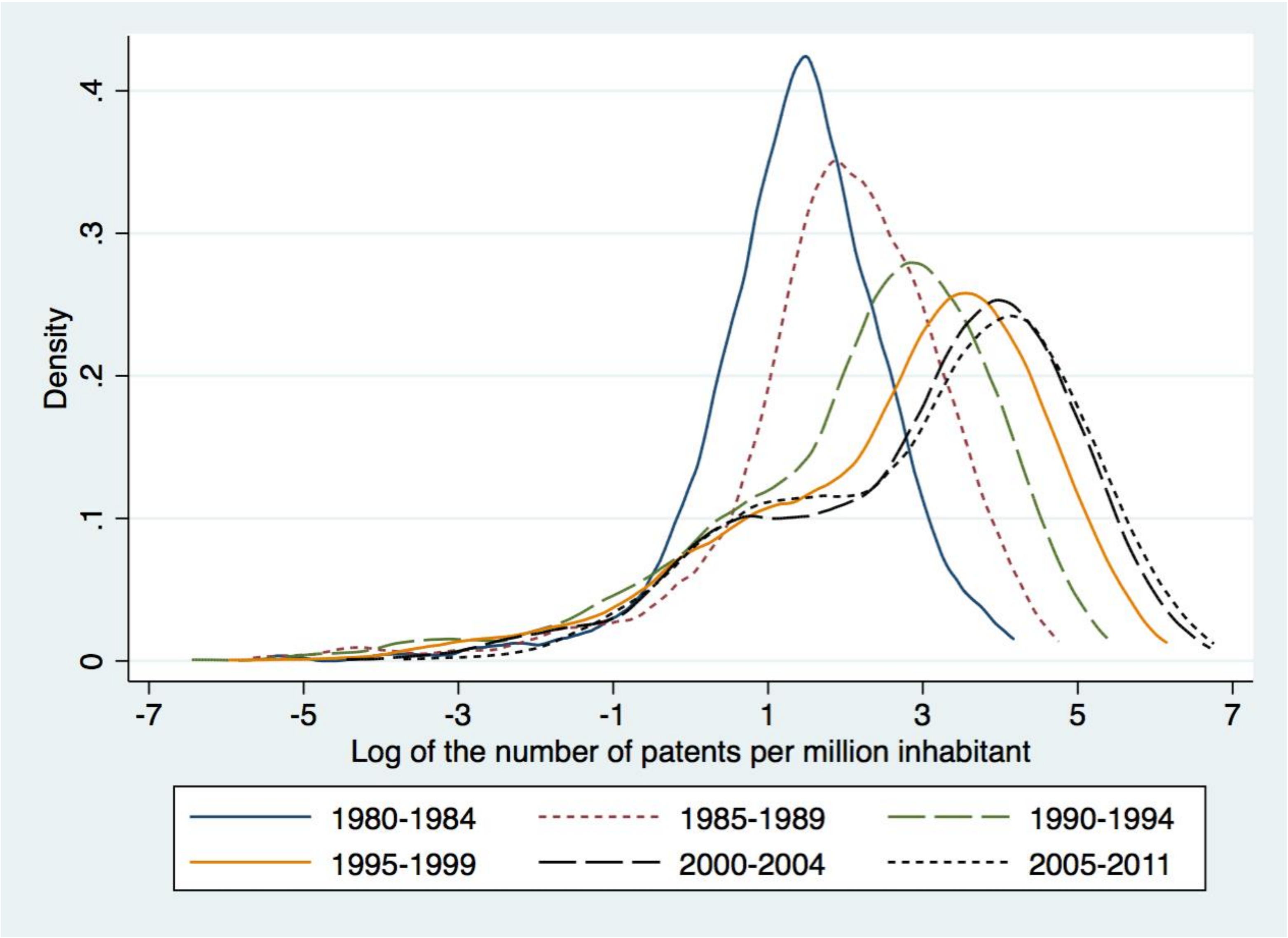
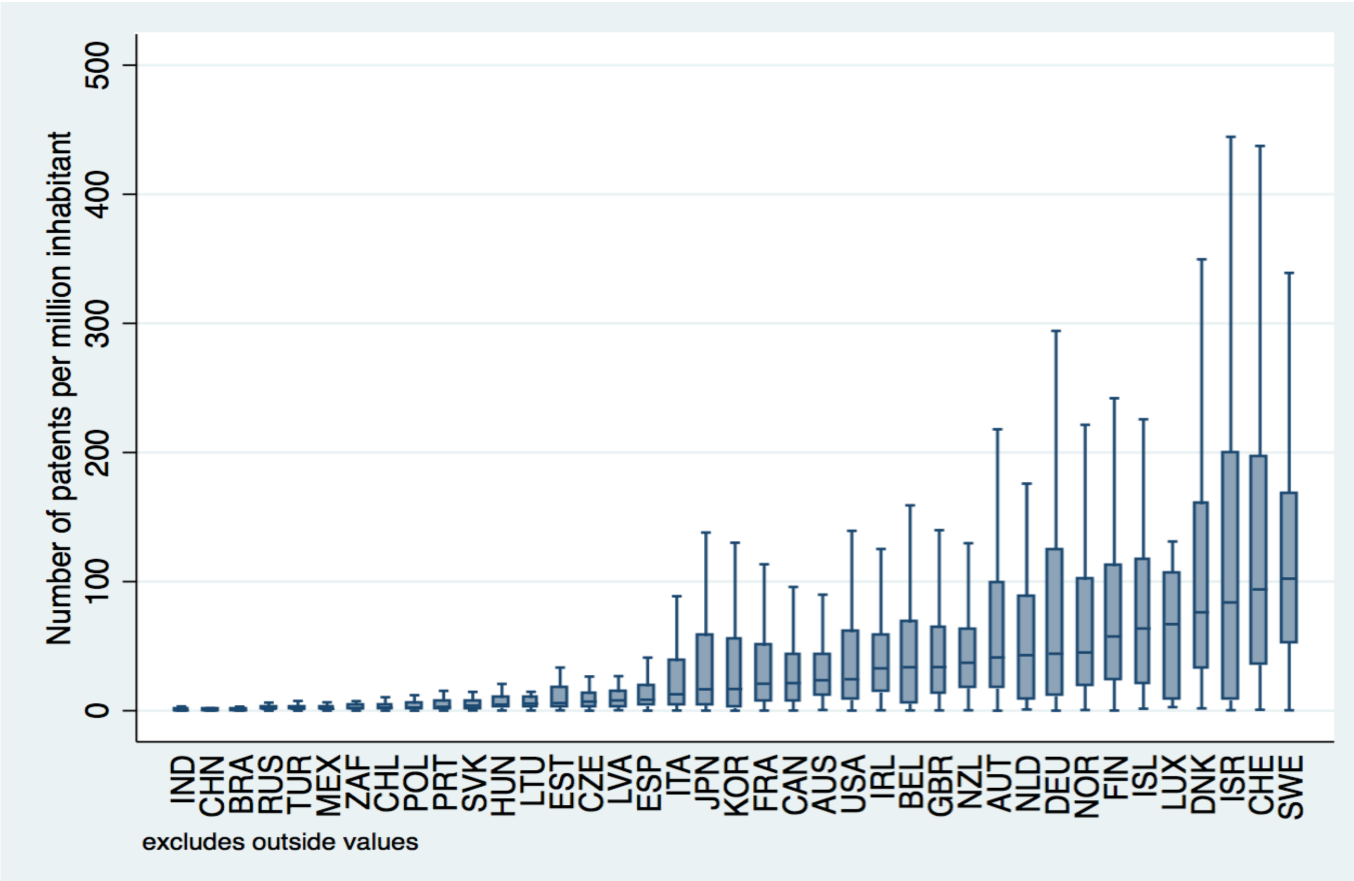


The changing geography of patenting



The changing geography of patenting



- High variance is a feature of most countries!

The changing geography of patenting

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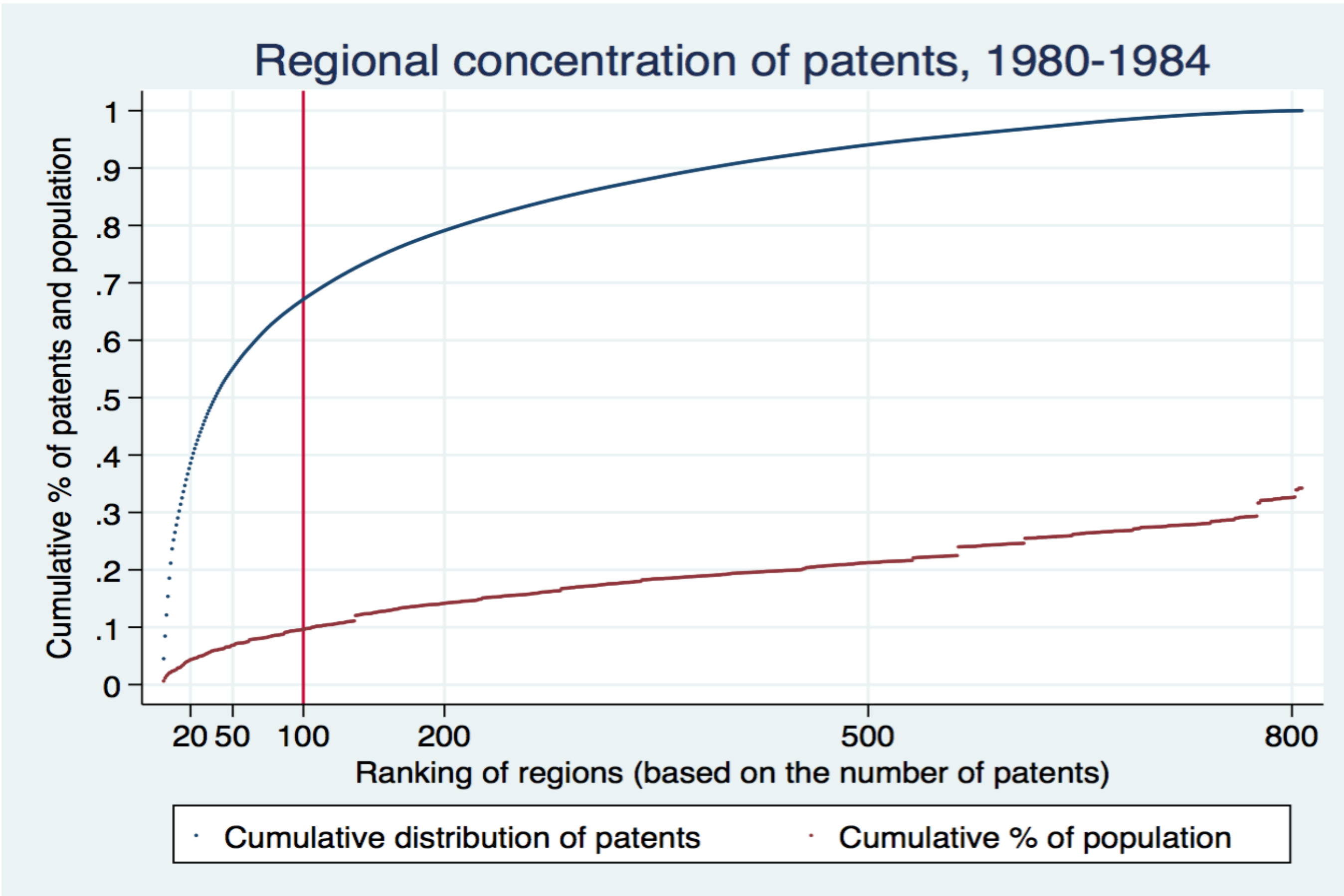
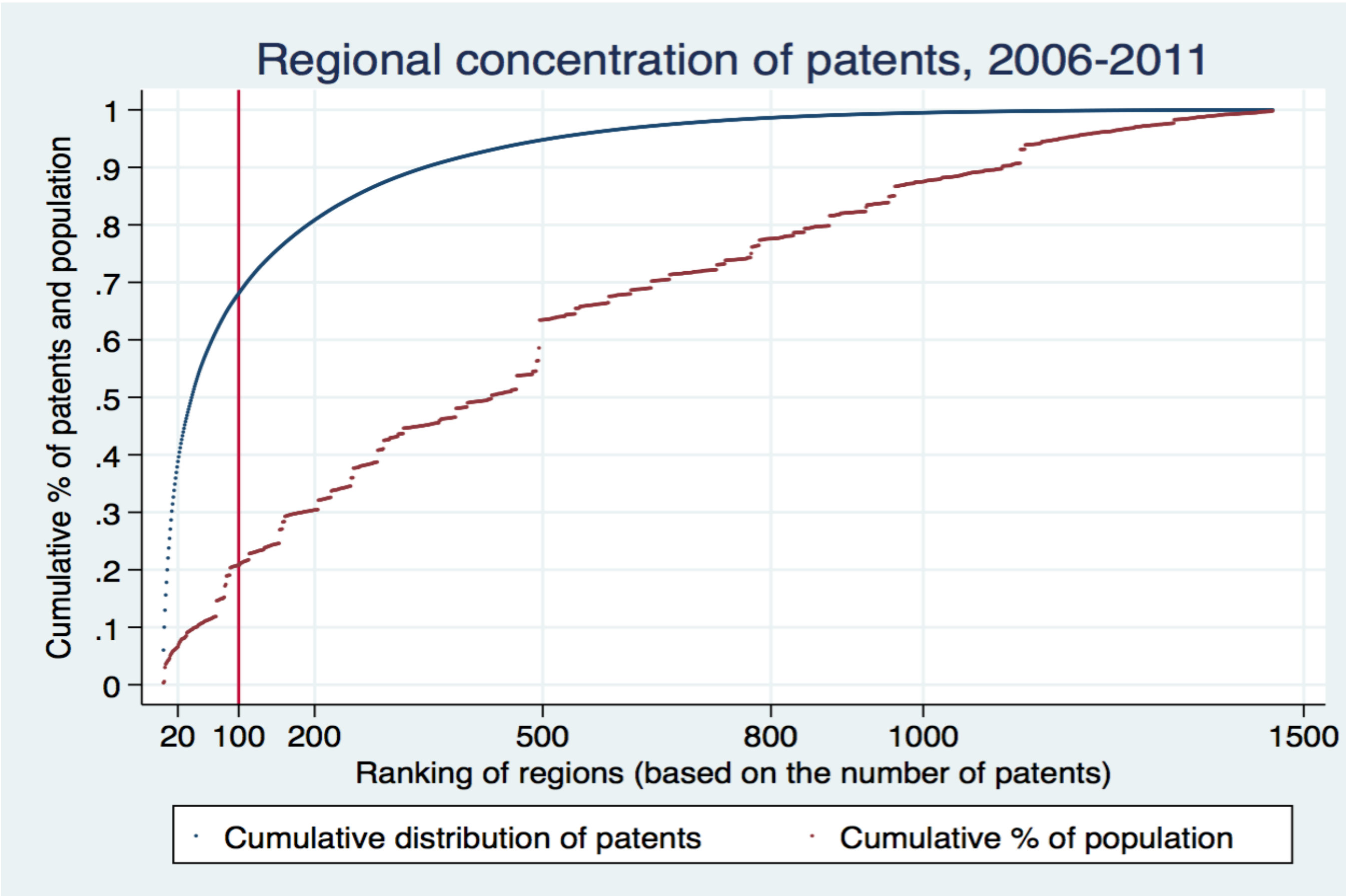


- High concentration of patenting. In 1980-84,
  - just 100 regions account for 70% of patents (and only 10% of population)
  - 70% of world's population is in non-patenting regions

The changing geography of patenting



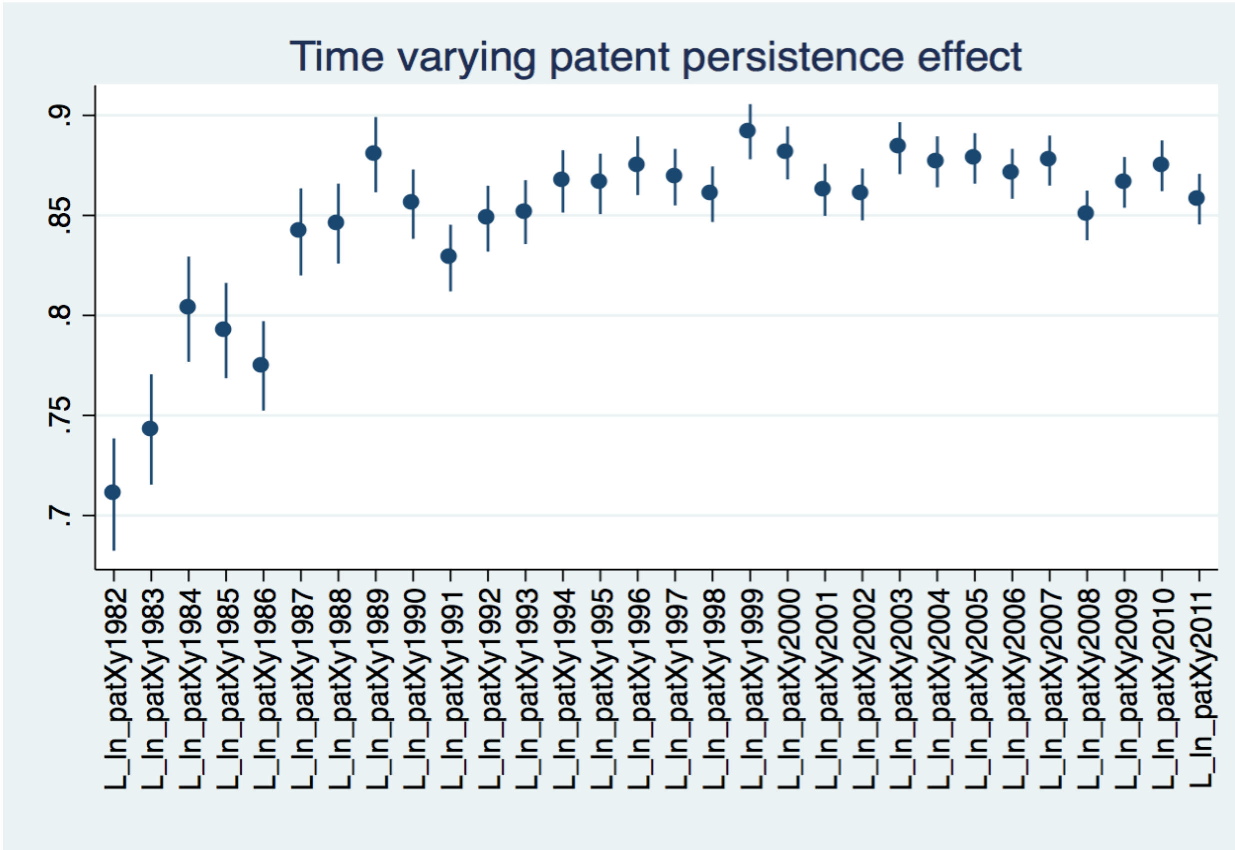
- In 2006-2011,
  - Still 100 regions account for 70% of patents (but they now account for 20% of population)
  - Virtually all regions do some inventive activity

The changing geography of patenting

		Quintiles of the number of patents per million inhabitants at time t (5-year period)					
		1st	2nd	3rd	4th	5th	Total
Quintiles of the number of patents per million inhabitants at time t-1 (5-year period)	1st	**69.58**	20.87	6.48	2.10	0.98	100
	2nd	22.42	**65.50**	11.88	0.21	0.00	100
	3rd	1.86	13.23	**63.45**	20.03	1.43	100
	4th	0.48	0.54	21.40	**60.87**	16.71	100
	5th	0.34	0.07	1.70	17.13	**80.76**	100

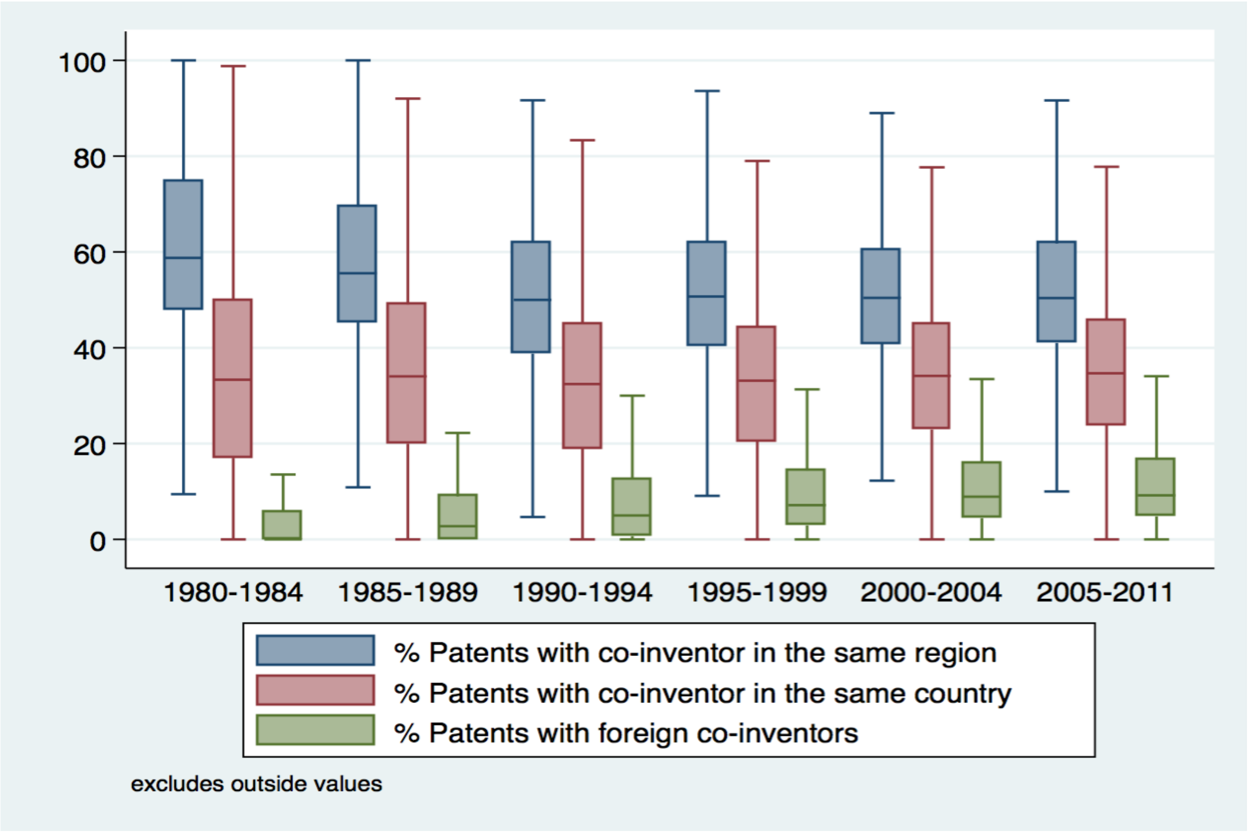
- High persistency in patenting

The changing geography of patenting



$$p_{it} = \alpha + \beta p_{i,t-1} + \sum_{l=1}^{L} \gamma_l (p_{it-1} \times D_l) + \delta X_{it} + \mu_j + \theta_t + \varepsilon_{it}$$

The changing geography of patenting: global pipelines

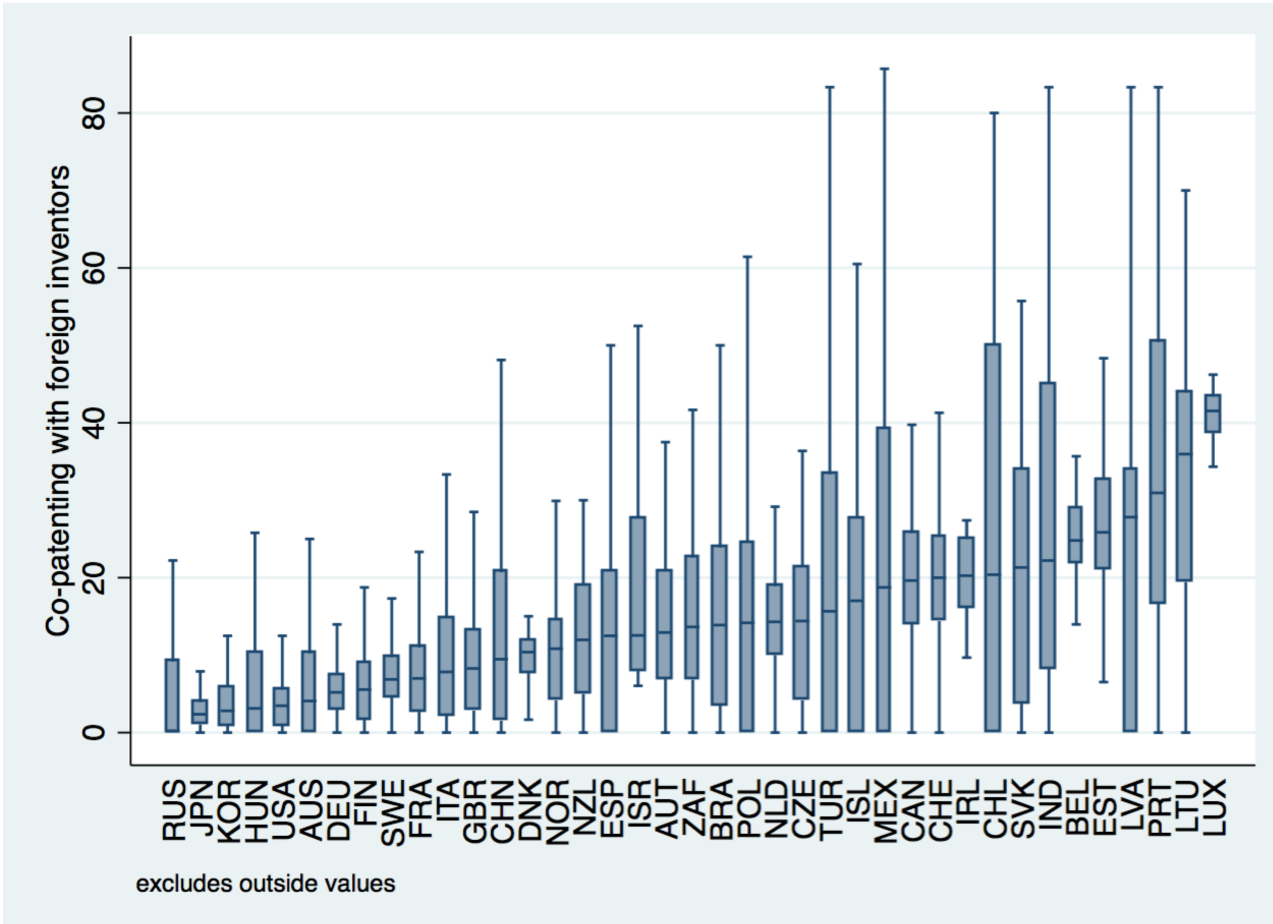


- Local co-invention is predominant (proximity matters), but with large heterogeneity
- Co-patenting with foreign inventors is becoming more important

The changing geography of patenting: global pipelines

- Co-patenting with foreign inventors is becoming more important

The changing geography of patenting: global pipelines



- Heterogeneous behaviour in co-patenting with foreign inventors is common in most countries

Evidence on internationalisation of MNEs R&D

Data

- Cross-border greenfield investments from FT's *fDi Markets* over 2003-2014
  - For each project we know
    - **Name** of the investing company and its parent
    - **City** where the investment take place and city of parent (with geographical coordinates)
    - Main **business activity** involved (e.g. production, R&D, sales & marketing, HQ, logistics, business services, …)
    - **Industry**

Distance and the location of R&D

Castellani and Santangelo (2016)

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Table 2 – Average distance between city of origin and city of destination

	Global Cities	Metro area of global cities	Moderate global cities	Peripheral cities	Total
Coordination	7,839	6,709	6,617	6,538	7,316
R&D-related	**8,312**	**7,363**	**8,605**	**6,601**	**7,771**
Production	6,481	5,948	5,769	5,494	5,707
Support Svcs.	7,153	5,833	6,227	5,214	6,033
Advanced Svcs.	7,024	6,130	5,886	5,193	6,489
Total	7,122	6,198	6,223	5,484	6,347

Coordination: Headquarters

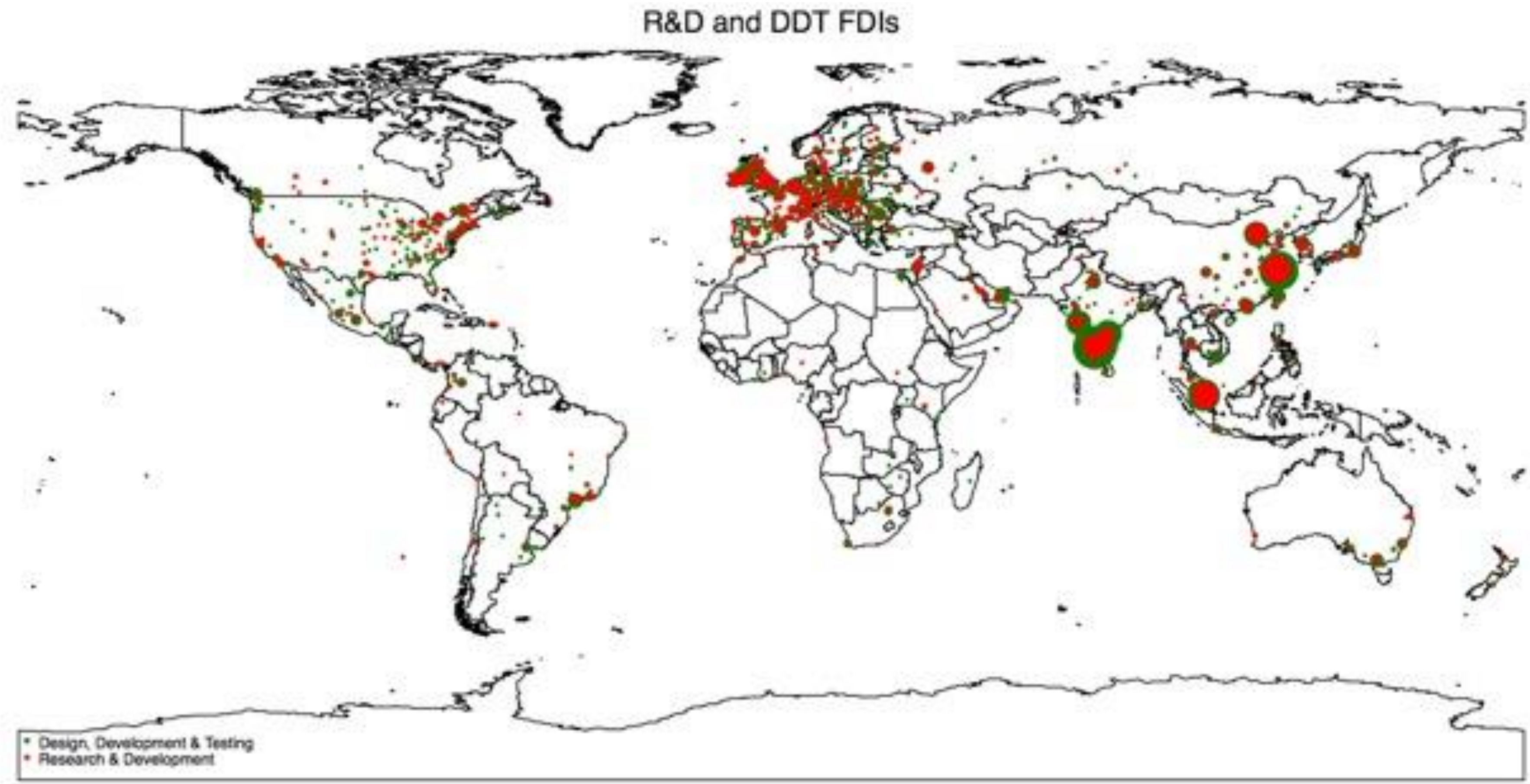
Support svcs: Customer centers, Logistics, Maintenance, Technical support

R&D-related: R&D, Design, Development and Testing

Production: Manufacturing, Construction, Extraction

Advanced svcs: Business svcs, Sales and Marketing

Data



6,235 projects in R&D or Design, Development and Testing in **1,421 cities** worldwide

Probability of locating R&D in a city

Mixed logit results

Table 3: Results of Mixed Logit Model	All firms	Large firms	Small	High-tech	Low-tech
Mean					
Internal factors					
Previous Production (firm-city)	**1.460*** **	0.011	**21.622** **	**0.103**	**4.838*** **
Previous Other Activities (firm-city)	1.143***	0.866***	13.760**	1.694***	-1.620***
External factors					
Main Global City	-0.451***	0.049	-0.7254***	-0.373***	-0.814***
Secondary Global City	0.276***	0.316***	0.227***	0.332***	-0.094
City within 100 km from GC	0.144***	0.183***	0.118**	0.137***	0.163
Agglomeration R&D (log) (city)	0.284***	0.043	0.390***	0.357***	-0.166**
Agglomeration Production (log) (city)	0.032*	0.122***	-0.010	0.009	0.185***
Agglomeration Other Activities (log) (city)	0.600***	0.554***	0.635***	0.566***	0.773***
Distance (log)	0.072***	0.175***	0.016	0.059***	0.157***
Standard Deviation					
Previous Prod (firm-city)	9.072***	7.230***	34.660**	9.758***	12.173***
Previous Other (firm-city)	6.766***	4.648***	43.506**	5.591***	-23.148***
R&D (log) (city)	0.340***	-0.251***	0.374***	0.315***	0.411***
Prod. (log) (city)	-0.003	-0.029	0.004	-0.011	0.019
Other (log) (city)	-0.002	-0.0213	-0.004	-0.003	-0.006
Distance (log)	-0.002	0.048	-0.008	-0.006	0.008
No. obs	8,849,957	3,525,500	5,324,457	7,613,705	1,236,252
No. Projects	6,235	2,481	3,754	5,362	873
No. Cities	1,421	1,421	1,421	1,421	1,421

Probability of locating R&D in a city

Mixed logit results

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	Pharma/Biotech	Chemicals	Semiconductors	Automotive
	Low modularity		High modularity	
Mean				
Previous Prod (firm-city)	**3.995*** **	**11.247*** **	**-0.858**	**0.184**
Previous Other (firm-city)	3.427*	7.220***	1.826***	-0.407
External factors				
Main Global City	-0.160	0.1037	0.034	-0.329
Secondary Global City	0.379**	0.1877	0.527**	0.202
City within 100 km from GC	0.734***	0.5822***	0.209	0.357**
Agglomeration R&D (log) (city)	0.137*	-0.0651	0.829***	0.421***
Agglomeration Prod. (log) (city)	0.023	0.3916***	-0.105	0.198**
Agglomeration Other (log) (city)	0.733***	0.5061***	0.368***	0.214**
Distance (log)	0.002	0.1331*	0.0957	0.042
Standard Deviation				
Previous Prod (firm-city)	10.977**	25.602***	7.160***	6.728***
Previous Other (firm-city)	15.867***	29.870***	6.504***	8.243***
R&D (log) (city)	0.344***	-0.426***	0.218	0.065
Prod. (log) (city)	0.018	0.012	0.300***	-0.083
Other (log) (city)	-0.001	0.040	0.009	0.027
Distance (log)	-0.015	0.141	0.110	0.069
No. obs	851,179	565,556	545,664	575,503
No. Projects	599	398	384	406
No. Cities	1,421	1,421	1,421	1,421

Concluding remarks

- In order to thrive, clusters need 'local buzz' and 'global pipelines'
- Evidence based on the evolution of patenting across OECD regions in the last 30 years suggest that
  - Despite that more regions have started to patent, strong clustering have emerged (consistent with 'local buzz' effect)
    - the top regions are patenting more and more
  - A number of regions have increased their propensity to co-patent with foreign inventors (consistent with 'global pipeline' argument)
    - It may be due to a combination of laggard regions starting to patent more and established regions seeking to renew their knowledge base
- MNE can play a key role in building pipelines that connect clusters
  - They seem able to overcome the difficulties of doing R&D far from home and transfer knowledge across space
  - Dispersion of R&D is somewhat constrained by the need to keep R&D close to production