Technological Change in Cities and Regions

An Evolutionary Analysis of Knowledge Spaces and Technology Trajectories

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KNOWLEDGE [IN] SPACE

While a substantial literature, i.e. Regional Innovation Systems, Learning Regions, Local Knowledge Economies, promotes the idea that different knowledge economies/learning regions produce various subsets of knowledge, which in turn becomes the source of their competitive advantage, systematic evidence of the production of these different kinds of knowledge over space is lacking.

Little is known about how technological change evolves at specific places over time.

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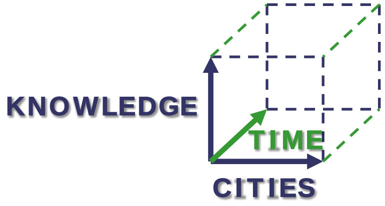

Knowledge Production in an Evolutionary Economic Geography Framework

- **Knowledge production** is a
  - cumulative,
  - path-dependent, and
  - interactive process.

  } **Evolutionary Economic Geography**
  Boschma and Frenken (2006)
  Kogler (RS SI on EEG, 2015)

- **Knowledge [in] space**
  - Knowledge accumulates
  - knowledge relationships

  } **Increasing interest in EG**
  Boschma et al. (2012), Rigby (2012),
  Kogler et al. (2013)

- **Knowledge acquired in the past** provides
  - opportunities, and
  - sets limits.

  } **Entry, Exit and Selection**
  Rigby and Essletzbichler (2000),
  Boschma, Balland & Kogler (2014)

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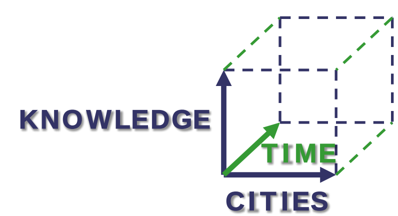
What We Know / What We Want to Know

Novel technology competencies emerge from the recombination of existing competences and knowledge.

(Schumpeter, 1939; Abernathy and Townsend, 1975; Fleming, 2001; Boschma and Frenken, 2011)

Do cities and regions diversify into technologies that are related to their specific knowledge structure and expertise?

If yes, what are the driving forces of this diversification process?



The Technology/Knowledge Space - Objectives

- **Objectives:**

  - Investigate the long-term **evolution** of technology portfolios of European regions over a 30-year time period.

  1. Construct a **knowledge space** that measures the degree of relatedness between distinct technologies

     a) examine the evolution of the European knowledge space

     b) analyse how the knowledge space shifts within different regions

  2. Decompose changes in the technological coherence of individual NUTS regions into the influence of selection (differential growth), entry and exit

  3. Estimate a fixed-effects conditional logit model of technological entry and exit by technology class and region

Kogler D. F., Rigby D. L. & Tucker I. (2013) Mapping Knowledge Space and Technological Relatedness in US Cities, *European Planning Studies* 21(9), 1374-1391.

EPO DATA – 1981 to 2005

- **Patent data is an excellent proxy of inventive output**.

  The advantages of using patents to track knowledge output are clear: long time-series, spatial disaggregation, technological detail and information on inventors, co-inventor relationships and patterns of assignment.

- **EPO patents**
- **Each patent that was developed by at least one <u>EU15</u> inventor**
- **<u>629</u> IPC [technology] subclasses**
- **Timeframe = 1981 to 2005 [priority date]**
  - Five 5-year periods:

1981-1985 →	1
1986-1990 →	2
1991-1995 →	3
1996-2000 →	4
2001-2005 →	5

- **Geography ???**

EPO
Patent Data

Patent Classification

Inventor(s)

Priority Date

Applicant

(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) **EP 2 711 947 A1**

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(21) Application number: **13182981.4**

(22) Date of filing: **04.09.2013**

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Designated Extension States:
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24.09.2012 GB 201216963

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(54) **A power transfer device**

(57) Described is an electrical power transfer device for transferring power between two coaxial relatively rotatable components, comprising: an outer core having a magnetic flux guide, an outer electrical winding and a cavity for receiving an inner core; an inner core located at least partially within the cavity, the inner core having a magnetic flux guide and an inner winding, wherein the inner and outer core are arranged to be movable between a first configuration in which the magnetic flux guides of the inner and outer cores separated by a first distance in which power is transferred in use, and a second configuration in which the inner and outer cores are separated by a second distance, in which relative rotation of the inner and outer cores is possible in the second configuration, wherein in the first configuration the magnetic flux guides of the inner and outer cores abut one another.

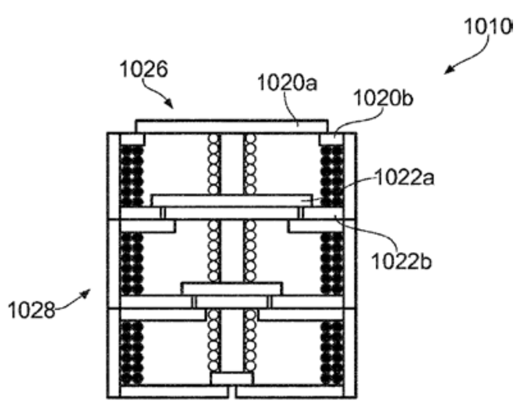
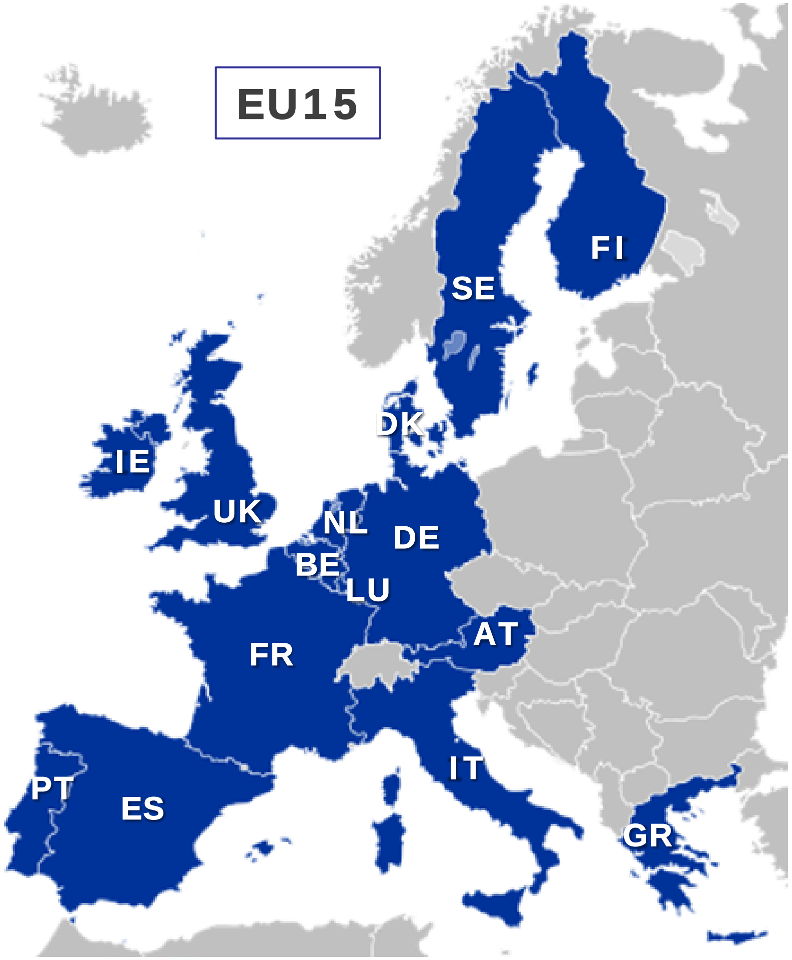
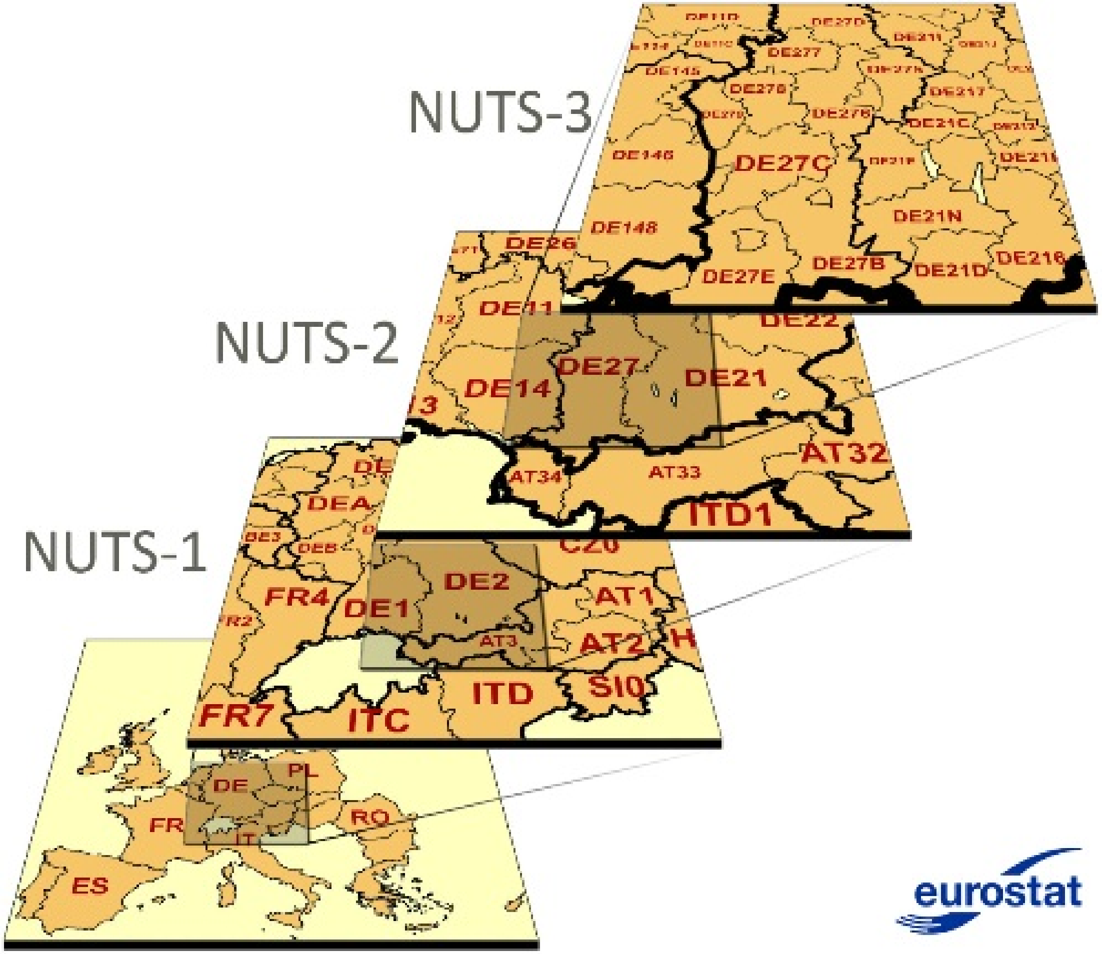


FIG. 10

NUTS Regions (Nomenclature of territorial units for statistics)



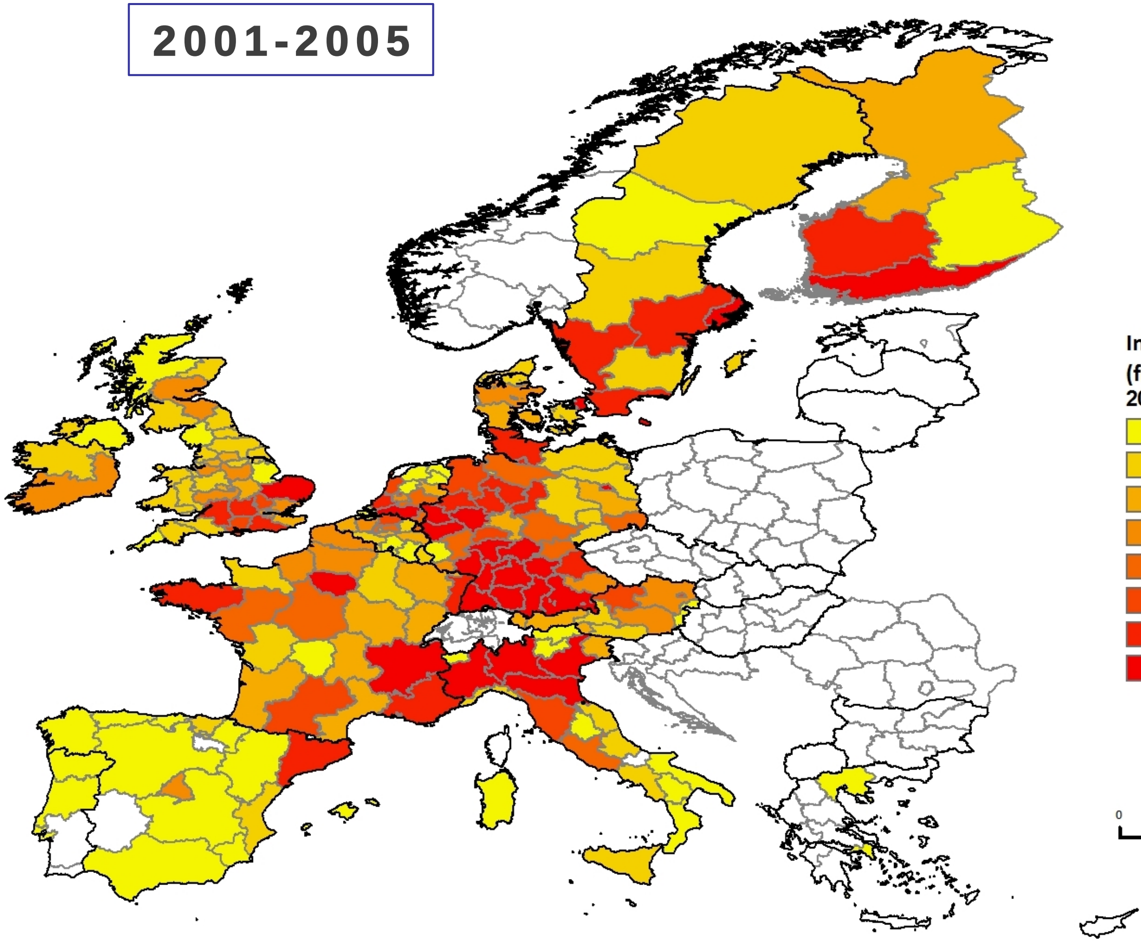
NUTS 2 ...the appropriate level for analyzing regional-national problems...



74 regions at NUTS 1, **216 regions at NUTS 2** and 1090 regions at NUTS 3 level for EU15.

Regional Inventiveness [fractional inventor counts per Patent]

2001-2005



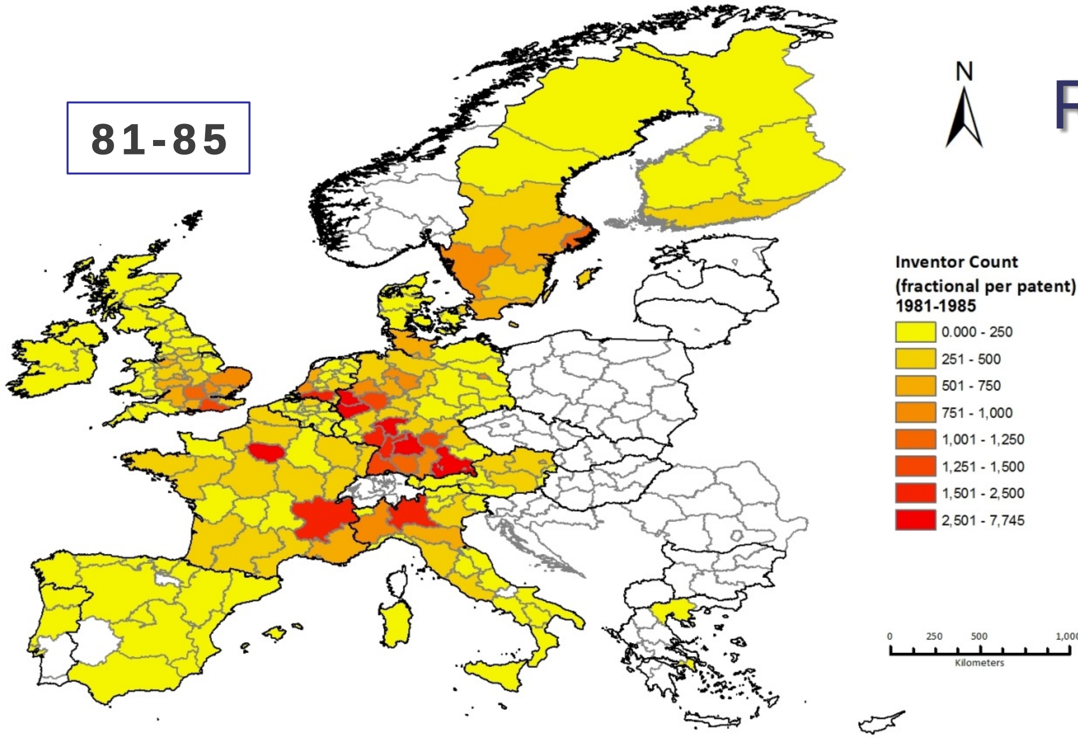
	NUTS 2 Region		01-05
1	FR10	Ile de France	15,312
2	DE11	Stuttgart	13,050
3	DE21	Oberbayern	12,198
4	NL41	Noord-Brabant	9,749
5	DE71	Darmstadt	7,361
6	DEA2	Koln	7,315
7	ITC4	Lombardia	7,032
8	DEA1	Dusseldorf	6,961
9	DE12	Karlsruhe	6,768
10	FR71	Rhone-Alpes	6,510
11	DE13	Freiburg	4,908
12	DE14	Tubingen	4,387
13	DEB3	Rheinhessen-Pfalz	4,211
14	FI18	Etela-Suomi	4,021
15	DE25	Mittelfranken	3,956
16	ITD5	Emilia-Romagna	3,607
17	DEA5	Arnsberg	3,483
18	SE11	Stockholm	3,055
19	DE30	Berlin	2,982
20	DK01	Hovedstaden	2,860

Careful with random ranking exercises!

Kogler (2014) **Intellectual Property and Patents: Knowledge Creation and Diffusion**, forthcoming in the *Handbook of Manufacturing Industries in the World Economy*, Edward Elgar

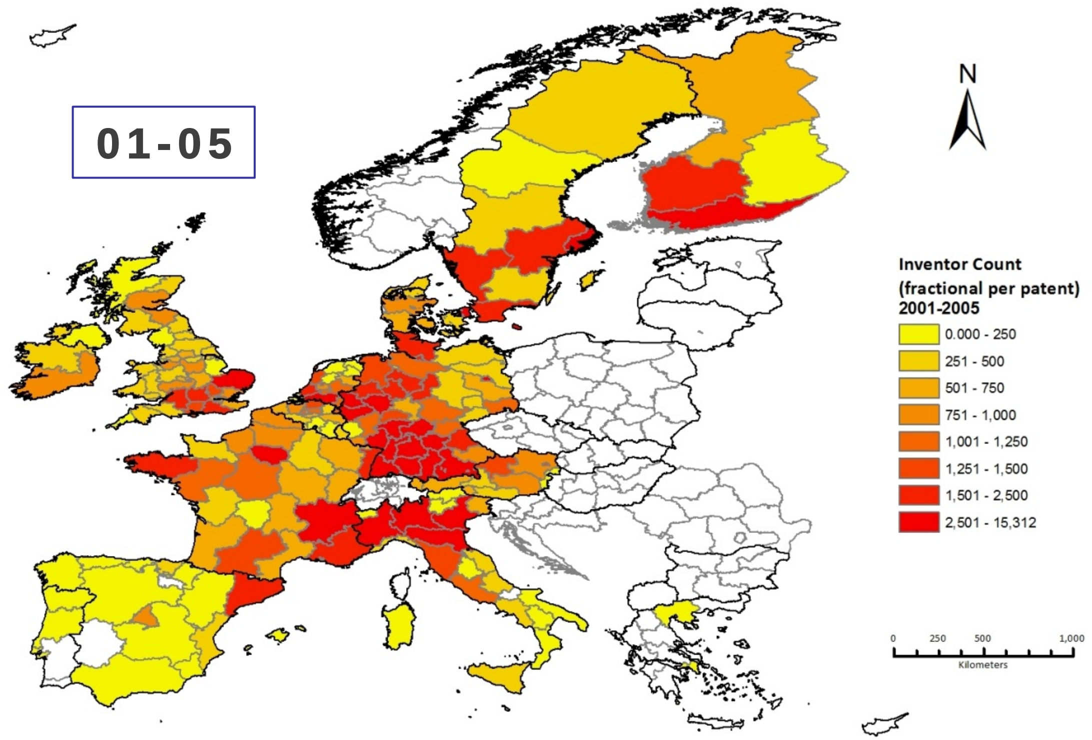
Regional Inventiveness

81-85



	NUTS 2 Region		81-85		NUTS 2 Region		81-85
1	FR10	Ile de France	7,745	11	ITC4	Lombardia	1,912
2	DE21	Oberbayern	4,966	12	DE25	Mittelfranken	1,497
3	DE71	Darmstadt	4,207	13	DE13	Freiburg	1,426
4	DEA1	Dusseldorf	3,741	14	DEA5	Arnsberg	1,296
5	DEA2	Koln	3,714	15	UKJ2	Surrey, E&W Sussex	1,260
6	DE11	Stuttgart	2,981	16	SE11	Stockholm	1,198
7	FR71	Rhone-Alpes	2,226	17	UKJ1	Berks, Bucks & Oxon	1,120
8	DE12	Karlsruhe	2,130	18	DE14	Tubingen	1,003
9	NL41	Noord-Brabant	2,090	19	ITC1	Piemonte	987
10	DEB3	Rheinhessen-Pfalz	2,073	20	UKI2	Outer London	896

01-05



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1	FR10	Ile de France	15,312	11	DE13	Freiburg	4,908
2	DE11	Stuttgart	13,050	12	DE14	Tubingen	4,387
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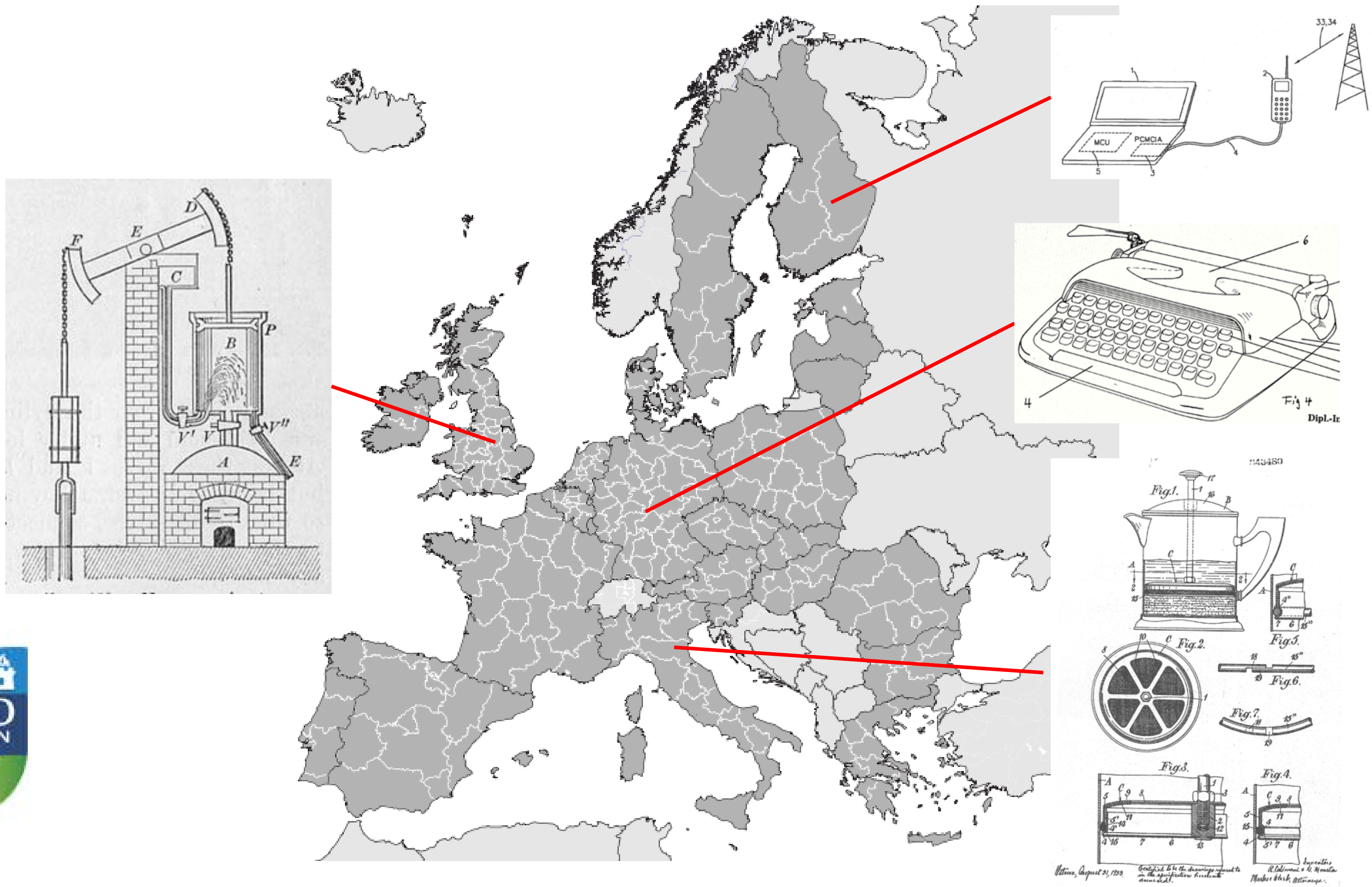
6	DEA2	Koln	7,315	16	ITD5	Emilia-Romagna	3,607
7	ITC4	Lombardia	7,032	17	DEA5	Arnsberg	3,483
8	DEA1	Dusseldorf	6,961	18	SE11	Stockholm	3,055
9	DE12	Karlsruhe	6,768	19	DE30	Berlin	2,982
10	FR71	Rhone-Alpes	6,510	20	DK01	Hovedstaden	2,860

Technological Specialization

We analyze the ***technological diversity/coherence*** *of European NUTS Regions*

(629 patent classes; 229 NUTS 2 regions; 1981 to 2005)



The EU Knowledge Space [co-occurrence of patent classes]

The (629 x 629) symmetric technology class co-occurrence matrix...

The following is a matrix for a patent that makes 5 separate knowledge claims in 2 distinct technology classes, i.e. H02B, H02J.

There are 5 separate knowledge claims, **4 in H02J** and **1 in H02B**, i.e. the patent class field reads: H02J, H02J, H02J, H02J, H02B

	H02A	H02B	H02C	H02D	H02E	H02F	H02G	H02H	H02I	H02J	H02K	H02L
H02A												
H02B										1		
H02C												
H02D												
H02E												
H02F												
H02G												
H02H												
H02I												
H02J										4		
H02K												
H02L												

IPC Class Definition:

Section H = ELECTRICITY

H20 = GENERATION, CONVERSION, OR DISTRIBUTION OF ELECTRIC POWER

H02B = BOARDS, SUBSTATIONS, OR SWITCHING ARRANGEMENTS FOR THE SUPPLY OR DISTRIBUTION OF ELECTRIC POWER

H02J = CIRCUIT ARRANGEMENTS OR SYSTEMS FOR SUPPLYING OR DISTRIBUTING ELECTRIC POWER; SYSTEMS FOR STORING ELECTRIC ENERGY

...the **relatedness** of technology classes in a place determines the technological **competency** or **coherence** of a region...

THE EU KNOWLEDGE SPACE [CO-OCCURRENCE OF PATENT CLASSES]

Measuring the proximity, or knowledge relatedness, between patent technology classes.

F_{ip} = 1 if patent record *p* lists the class code ***i***, otherwise F_{ip} = 0

Then, in a given time period, the total number of patents that list technology class ***i*** is given by: $N_i = \sum_p F_{ip}$

Similar the number of individual patents that list the pair of co-classes ***i*** and ***j*** is identified by the count: $N_{ij} = \sum_p F_{ip} F_{jp}$

Repeating this co-class count for all pairs of 629 patent classes yields the (629 x 629) symmetric technology class co-occurrence matrix ***C*** the elements of which are the co-class counts N_{ij}

Kogler D. F., Rigby D. L. & Tucker I. (2013) Mapping Knowledge Space and Technological Relatedness in US Cities, *European Planning Studies* 21(9), 1374-1391.

The EU Knowledge Space [co-occurrence of patent classes]

The co-class counts measure the technological proximity of all pairs, but they are also influenced by the number of patents found within each individual patent class N_i.

Therefore, the elements of the co-occurrence matrix are standardized by the square root of the product of the number of patents in the row and column classes of each element:

$$S_{ij} = \frac{N_{ij}}{\sqrt{{N_i}^2 * {N_j}^2}}$$

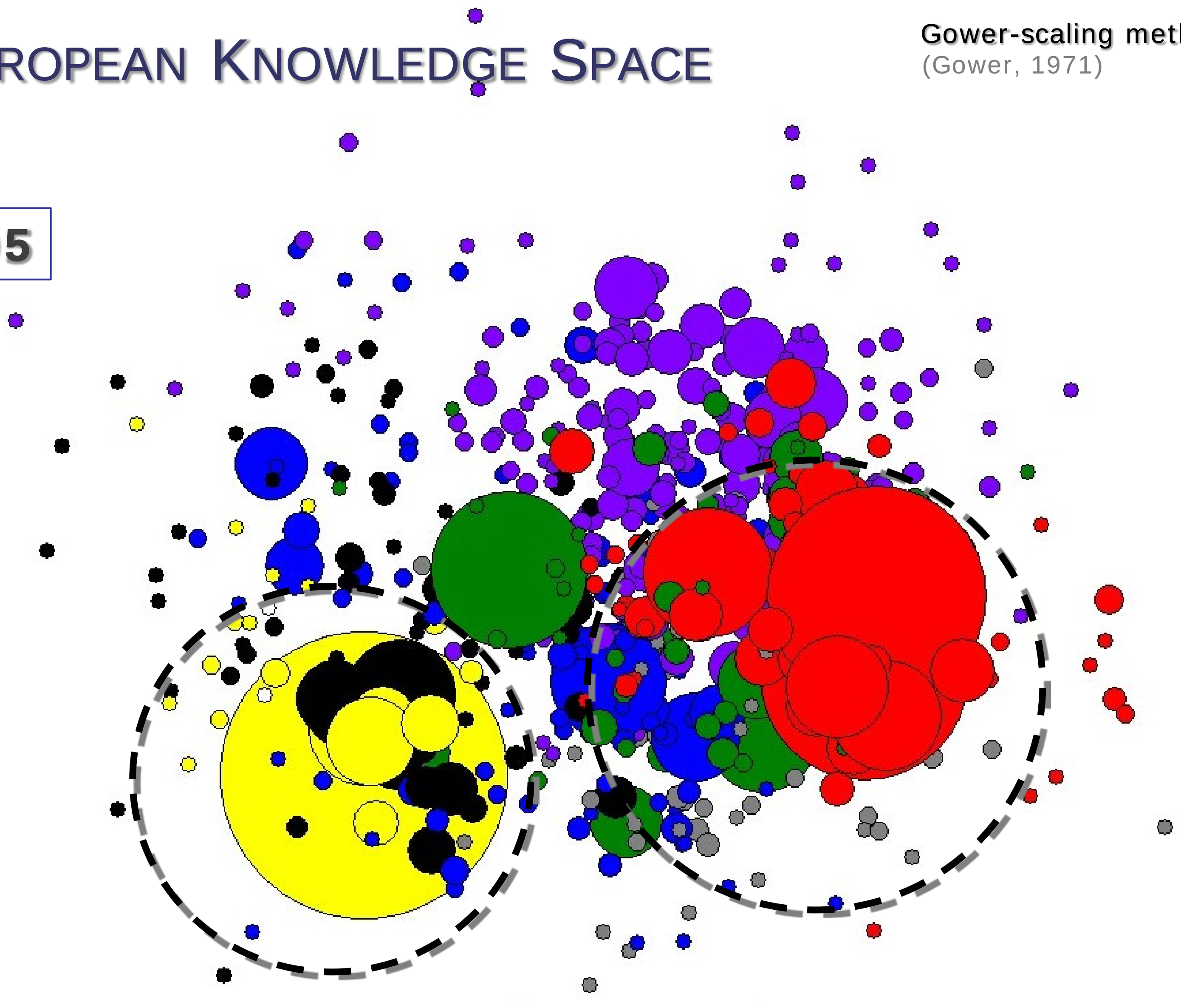
where S_{ij} is an element of the standardized co-occurrence matrix (***S***) that indicates the technological proximity, or knowledge relatedness, between all pairs of patent classes in a given time period

Note: We apply a fractional count of technology classes and also weight by the spatial distribution of co-inventors

THE EUROPEAN KNOWLEDGE SPACE

Gower-scaling method
(Gower, 1971)

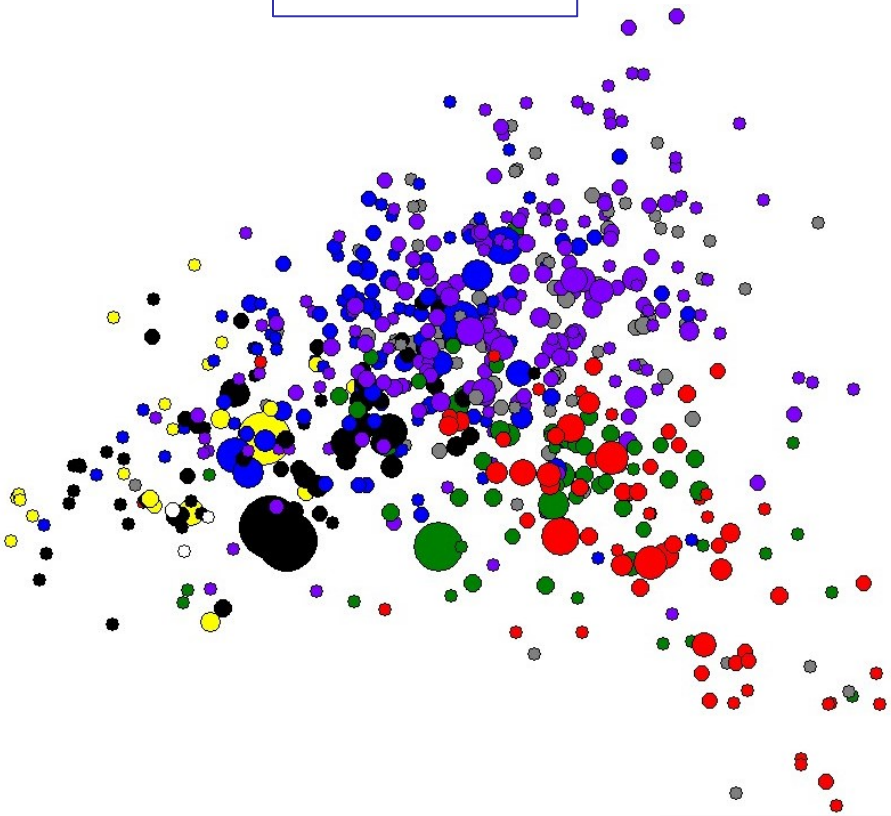
2001-2005



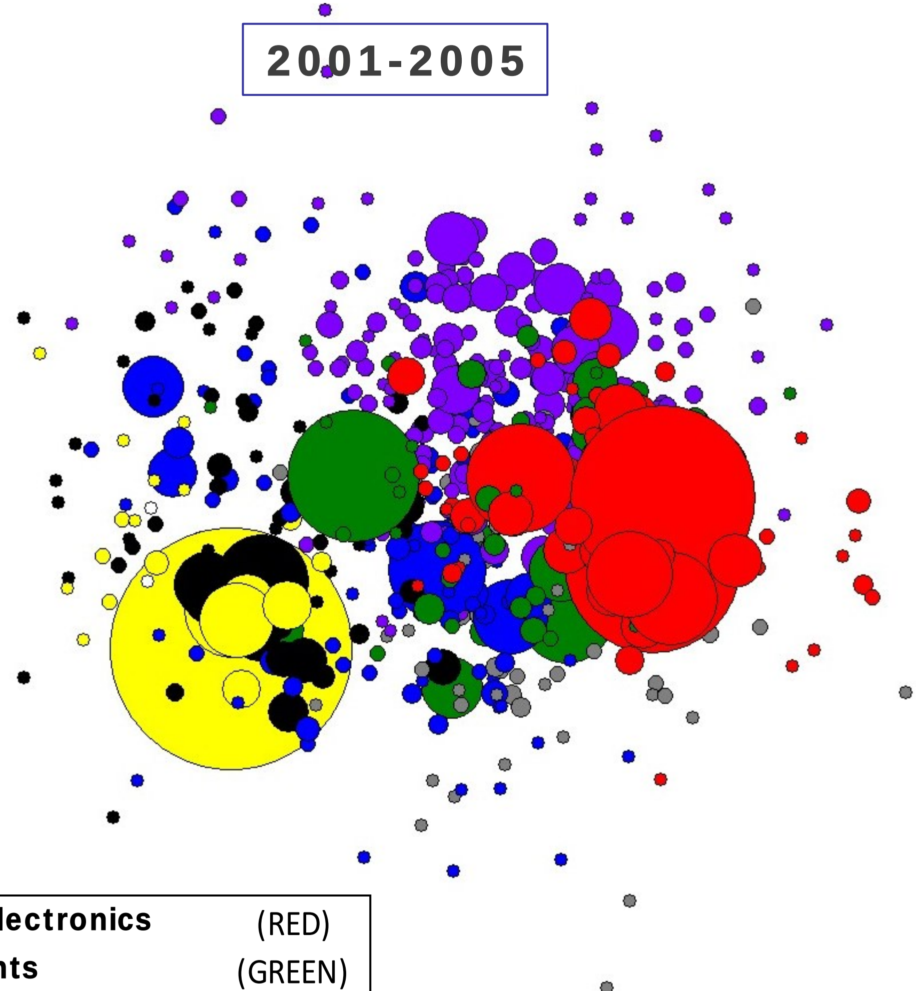
Electrical Eng.; Electronics	(RED)	**Industrial Processes**	(BLUE)
Instruments	(GREEN)	**Mechanical; Machines; Transport**	(PURPLE)
Chemicals; Materials	(BLACK)	**Consumer Goods; Civil Eng.**	(GREY)
Pharmaceuticals; Biotechnology	(YELLOW)		

THE EUROPEAN KNOWLEDGE SPACE

1981-1985



2001-2005



Electrical Eng.; Electronics	(RED)
Instruments	(GREEN)
Chemicals; Materials	(BLACK)
Pharmaceuticals; Biotechnology	(YELLOW)
Industrial Processes	(BLUE)
Mechanical; Machines; Transport	(PURPLE)
Consumer Goods; Civil Eng.	(GREY)

Average Relatedness Overall & by Sector

Overall Avg Relatedness

= steady increase (increasing specialization)

Sectoral Avg Relatedness

= variations in magnitude and direction

Time Period	Overall Average Relatedness
1981-85	0.0095
1986-90	0.0097
1991-95	0.0102
1996-00	0.0115
2001-05	0.0129

Time Period	Electrical Eng. & Electronics	Instru-ments	Chemicals Materials	Pharma-ceuticals Biotech.	Industrial Processes	Mechanical Machines Transport	Consumer Goods & Civil Eng.
	avg ↑	avg ↑	high ↓	high ↑	avg ↔	low ↑	low ↑
1981-85	0.045	0.054	0.078	0.290	0.041	0.017	0.035
1986-90	0.045	0.055	0.072	0.299	0.042	0.018	0.038
1991-95	0.047	0.054	0.069	0.336	0.044	0.018	0.039
1996-00	0.059	0.060	0.063	0.350	0.043	0.020	0.040
2001-05	0.071	0.065	0.067	0.347	0.043	0.020	0.042

Regional Average Relatedness

The average relatedness value for a region ***r*** in time period ***t*** is calculated as:

$$AR^{rt} = \frac{\sum_j s_{ij}^{t} * D_j^{rt}}{N^{rt}}$$

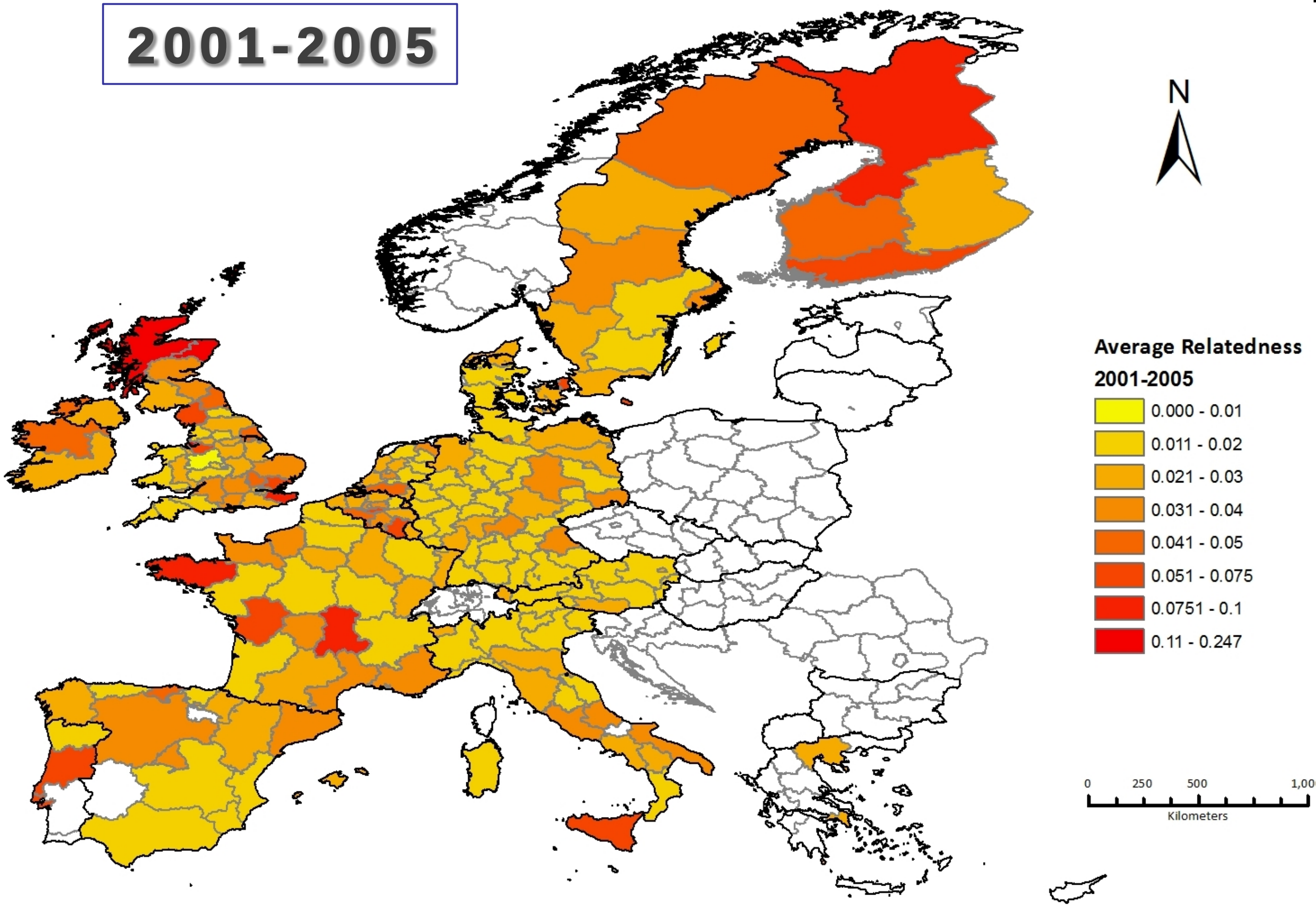
$\boldsymbol{S_{ij}^{t}}$ represents the (row or column) vector of the standardized co-occurrence matrix noted previously

$\boldsymbol{D_j^{rt}}$ is the count of the number of patents in technology class ***j*** in NUTS2 region ***r*** in year ***t***

$\boldsymbol{N^{rt}}$ is a count of the total number of patents in region ***r*** in year ***t***

Note: We apply a fractional count of technology classes and also weight by the spatial distribution of co-inventors

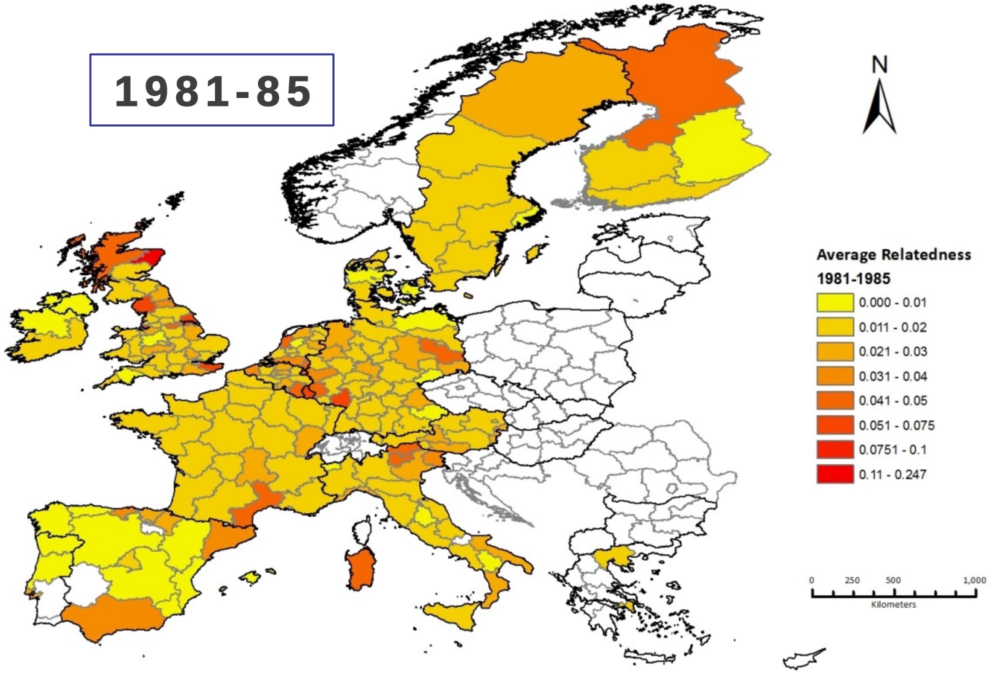
Regional Average Relatedness



	NUTS 2 Region		2001 - 2005 arltdn	2001 - 2005 inv
1	UKM5	NE Scotland	0.137	282
2	UKD5	Merseyside	0.120	396
3	UKM6	Highlands and Isl.	0.119	74
4	FI1A	Pohjois-Suomi	0.085	522
5	UKJ4	Kent	0.080	696
6	FR72	Auvergne	0.078	653
7	FR52	Bretagne	0.075	1,721
8	UKH3	Essex	0.074	929
9	UKD2	Cheshire	0.071	789
10	BE34	Prov. Luxemb. (B)	0.070	124
:	:	- : -		:
180	DE93	Luneburg	0.012	1,186
181	ITD3	Veneto	0.012	2,777
182	DE22	Niederbayern	0.012	962
183	ITE3	Marche	0.011	435
184	UKK3	Cornwall & Isl. of S.	0.011	98
185	DEA5	Arnsberg	0.011	3,483
186	ITC1	Piemonte	0.011	2,783
187	FR51	Pays de la Loire	0.011	1,050
188	DE27	Schwaben	0.010	2,848
189	UKG2	Shropshire and Sfd	0.010	388

Regional Avg Rltd

1981-85



	NUTS 2 Region		1981 - 1986 arltdn	1981 - 1986 inv
1	UKM5	NE Scotland	0.127	68
2	UKD5	Merseyside	0.083	247
3	UKE1	E. Yorkshire & N. Lincs	0.069	148
4	UKD1	Cumbria	0.069	63
5	LU00	Luxemb. (Gr.-Duche)	0.059	167
6	UKJ4	Kent	0.056	390
7	DEB3	Rheinhessen-Pfalz	0.054	2,073
8	UKM6	Highlands and Isl.	0.049	5
9	UKE3	South Yorkshire	0.048	167
10	FR81	Languedoc-Roussillon	0.047	250

2001-05

	NUTS 2 Region		2001 - 2005 arltdn	2001 - 2005 inv
1	UKM5	NE Scotland	0.137	282
2	UKD5	Merseyside	0.120	396
3	UKM6	Highlands and Isl.	0.119	74
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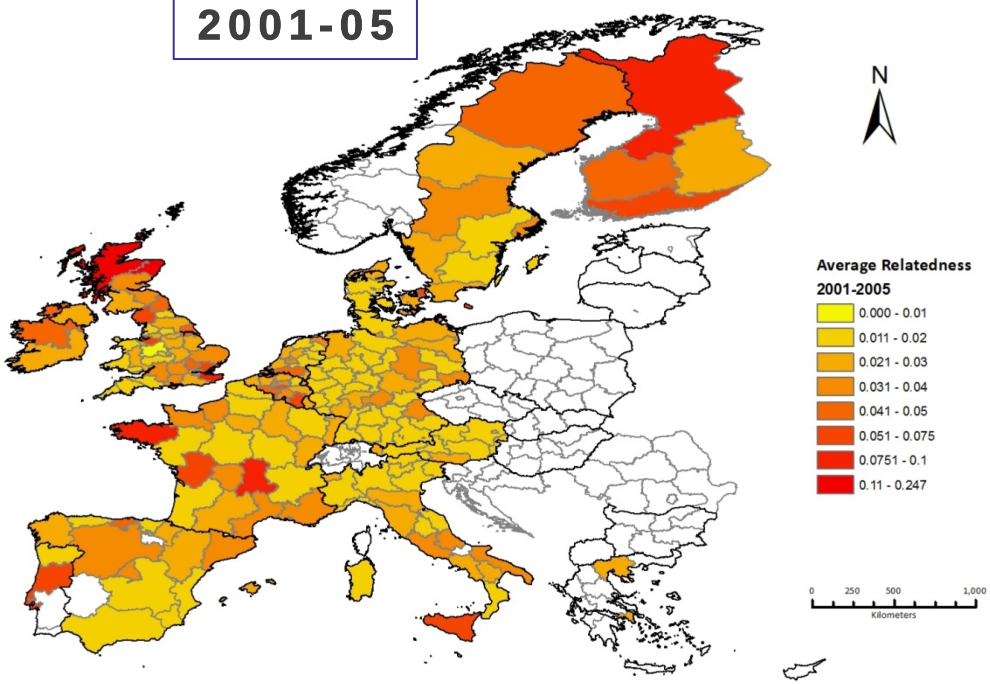

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Decomposing Regional Changes in Technological Specialization

- According to our theory of knowledge and technology evolution:
  - The process of technological diversification and abandonment is shaped by the region's technological structure at the beginning of the period.

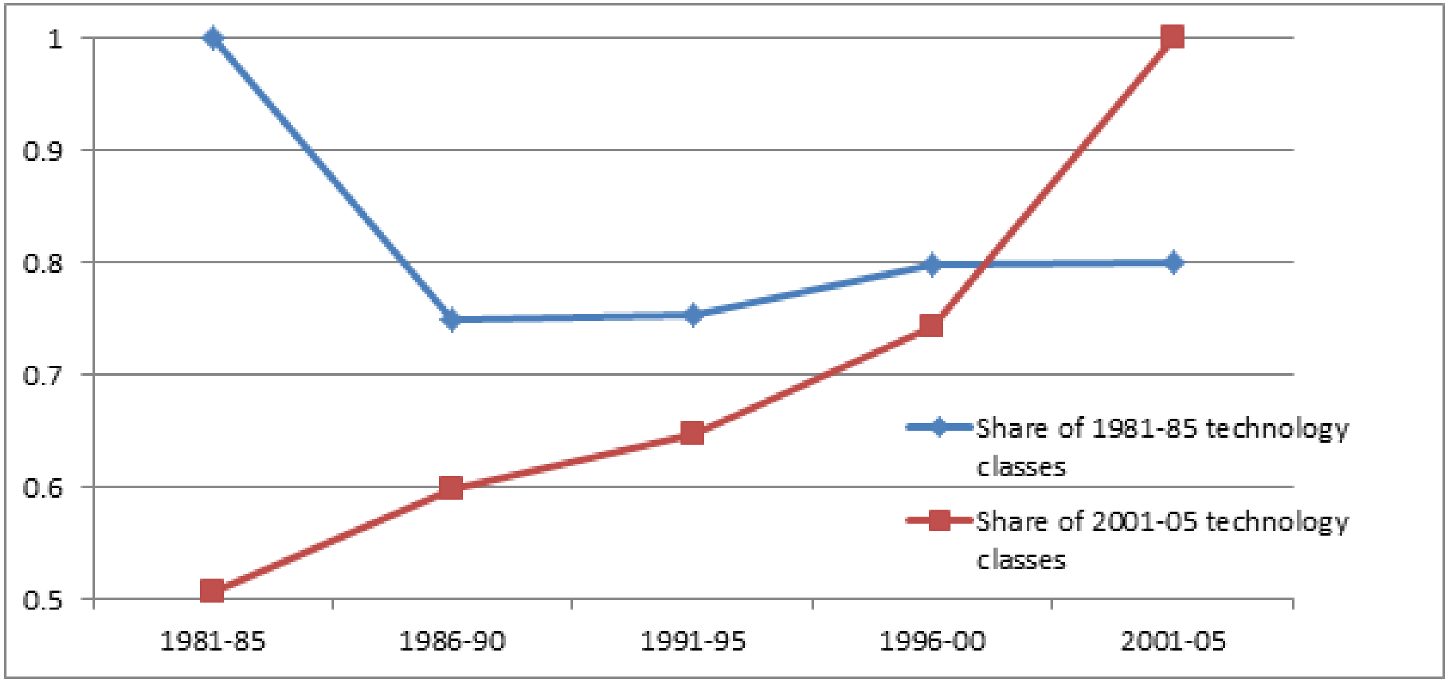
  ➡ How do regions become more or less technologically cohesive (related)?

- **The need to examine:**
  - the impact of changes in technology classes present in a region (**incumbent technologies**)
  - technologies added to the regional portfolio (**entry**); and
  - abandoned technologies (**exit**).

Regional Technological Diversification and Abandonment

Out of a total of 133,977 (213x629) possible region-technology classes, 34,005 (25.4%) existed in the period 1981-1985, increasing to 53,606 (40%) by 2001-05.

In other words, regions started to fill a lot of empty technology niches over the period examined.



Decomposing Regional Changes

Following the literature on productivity decomposition (FOSTER *et al.*, 1998), the change in technological cohesion in region r and between times t and $t+1$ can then be decomposed as follows

$$C_r^{t+1} - C_r^t = \sum_{ij \in INC} (p_{ijr}^{t+1} - p_{ijr}^t) s_{ijr}^t + \sum_{ij \in INC} (s_{ijr}^{t+1} - s_{ijr}^t)(p_{ijr}^t - C_r^t)$$

$$\sum_{ij \in INC} (SC_{ir}^{t+1} - SC_{ir}^t)(s_{ir}^{t+1} - s_{ir}^t) + \sum_{ij \in N} (p_{ijr}^{t+1} - C_r^t) s_{ijr}^{t+1} - \sum_{ij \in X} (p_{ijr}^t - C_{ijr}^t) s_{ijr}^t$$

where the subscript ***INC*** denotes incumbent links, i.e. links between patents in technology classes that exist in year t and $t+1$,

N represent new links to entering technology classes that exist in $t+1$ but were not part of the regional portfolio in year t, and

X denotes abandoned links to technology classes that leave the region between t and $t+1$

Decomposing Regional Changes

$$C_r^{t+1} - C_r^t = \sum_{ij \in INC} (p_{ijr}^{t+1} - p_{ijr}^t) s_{ijr}^t + \sum_{ij \in INC} (s_{ijr}^{t+1} - s_{ijr}^t)(p_{ijr}^t - C_r^t)$$

$$\sum_{ij \in INC} (SC_{ir}^{t+1} - SC_{ir}^t)(s_{ir}^{t+1} - s_{ir}^t) + \sum_{ij \in N} (p_{ijr}^{t+1} - C_r^t) s_{ijr}^{t+1} - \sum_{ij \in X} (p_{ijr}^t - C_{ijr}^t) s_{ijr}^t$$

Incumbent classes (*INC*)

1. Change in relatedness values among incumbent classes assuming that the shares of those links on the total number of links remains const.
2. Selection effect – positive if classes with relatedness values higher than average reg. relatedness expand their patent shares relative to those links with lower than avg. values.
3. Covariance term – positive if tech. classes that have become more related also expand market shares.

Entry (*N*) – positive if entering tech. classes are more closely related to the reg. tech. portfolio than average

Exit (*X*) – negative if technology classes less closely related to the reg. portfolio than avg. relatedness exit the region

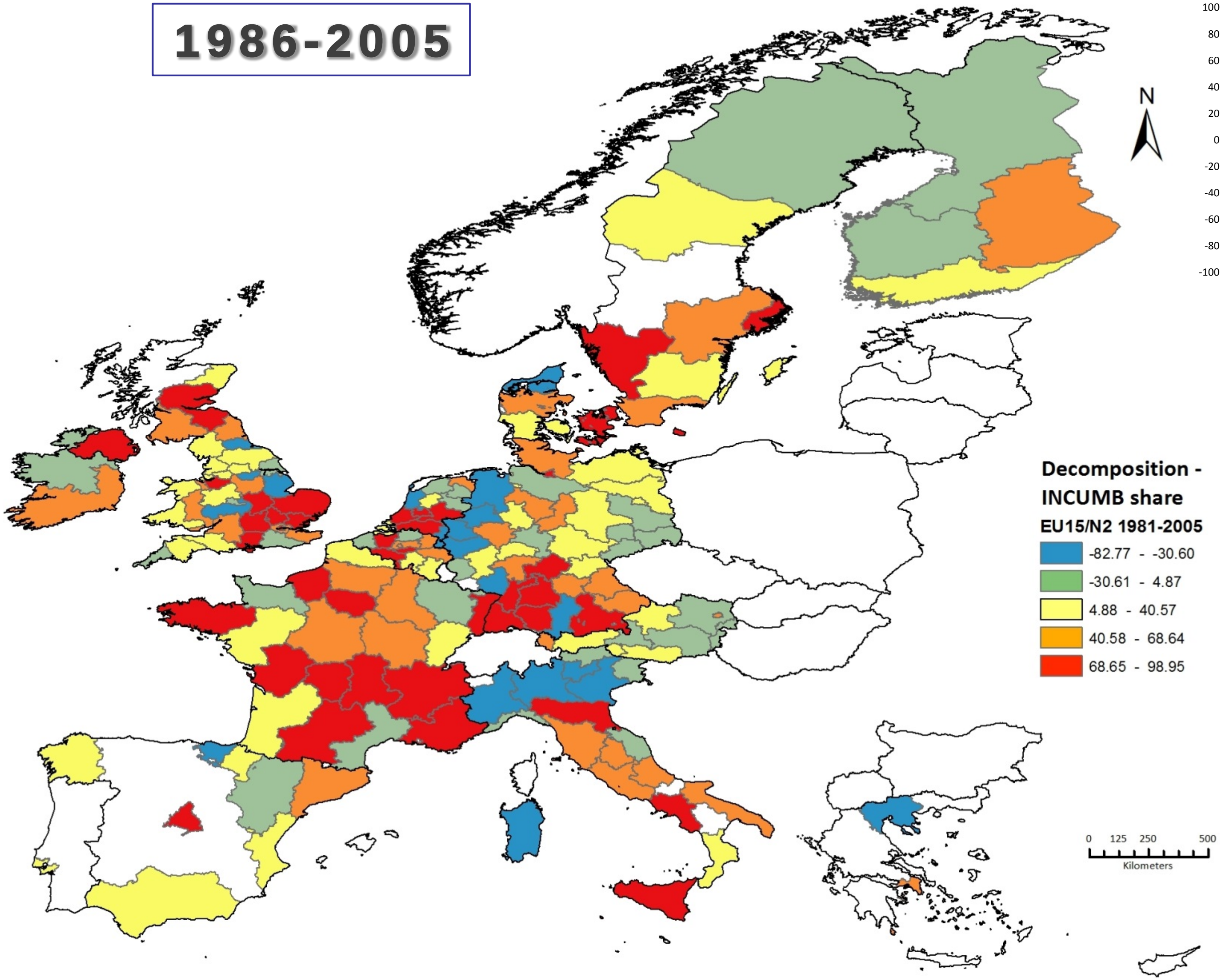
Components of Change in Regional Technological Specialization

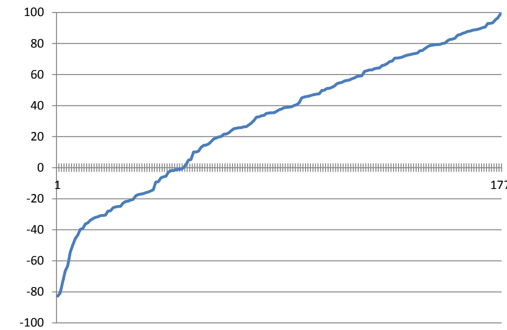
Period	Regional change · Avg. Relatedness	Incumbent, Selection, Covariance	Entry	Exit
1981/90	-0.00003	0.00053	-0.00247	-0.00191
	%	10.8	-50.3	-38.9
1986/95	0.00177	0.00185	-0.00191	-0.00183
	%	33.1	-34.2	-32.7
1991/00	0.00232	0.00289	-0.00216	-0.00159
	%	43.5	-32.5	-23.9
1996/05	0.00103	0.00109	-0.00176	-0.00169
	%	24.0	-38.8	-37.2)

Note: The values are weighted means for all regions with more than 50 patents. The weights are the number of patents at the beginning of each period. The percentages reflect the share of each component divided by the sum of their absolute values.

DECOMPOSITION – SHARE OF INCUMBENT, SELECTION AND COVARIANCE

1986-2005

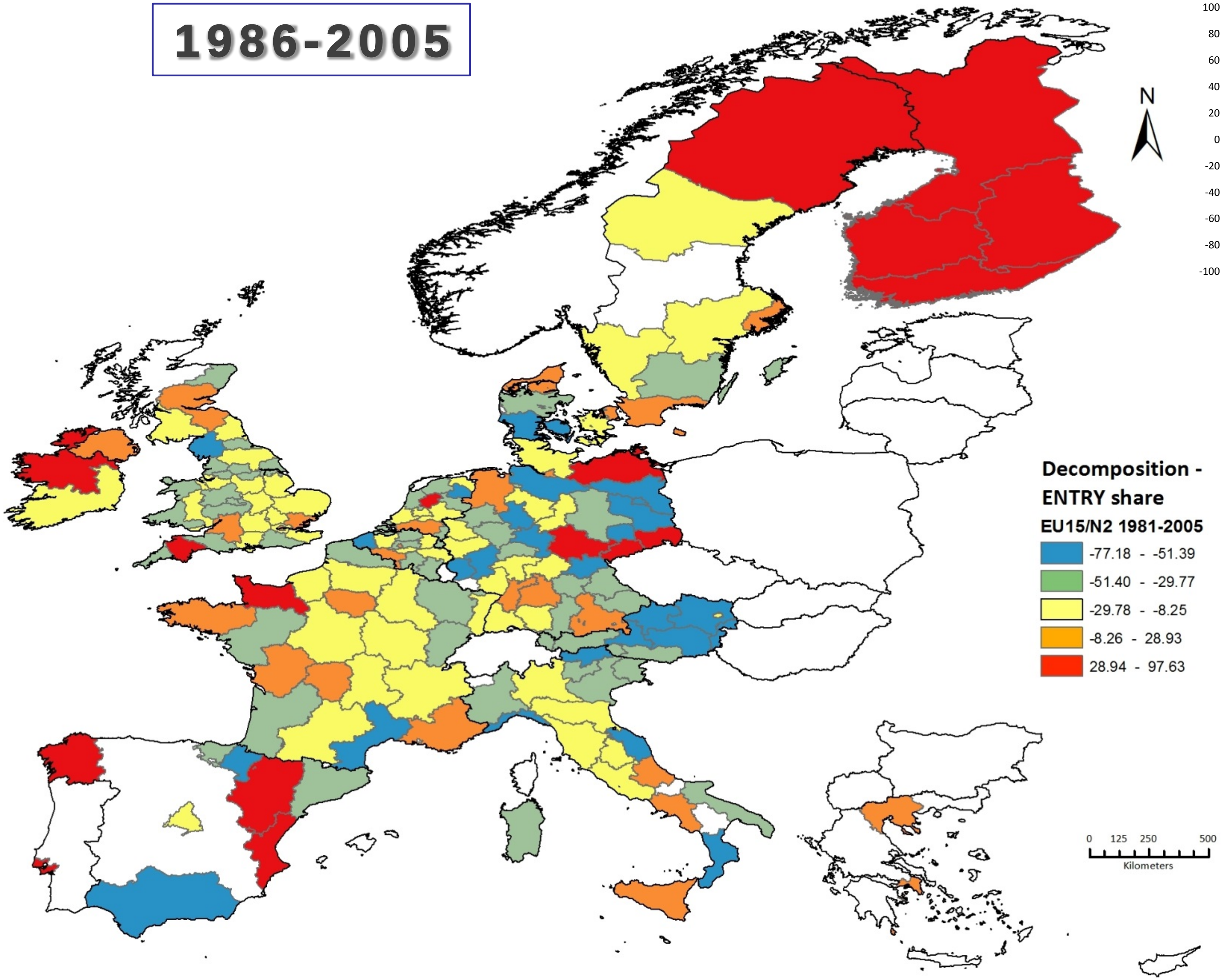


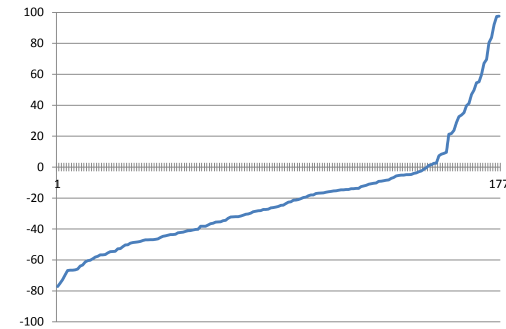


Rank	ID	NUTS Region	ISC %
1	FR10	Ile de France	98.947
2	SE11	Stockholm	96.532
3	DE11	Stuttgart	95.220
4	FR52	Bretagne	93.378
5	DE21	Oberbayern	92.952
:	:	- : -	:
173	DEA1	Dusseldorf	-63.331
174	DE94	Weser-Ems	-66.496
175	ITC4	Lombardia	-73.523
176	DEA2	Koln	-80.768
177	DEB3	Rheinh.-Pfalz	-82.769

In about 2/3 of all regions incumbents increase technological cohesion

Decomposition – Share of Entry



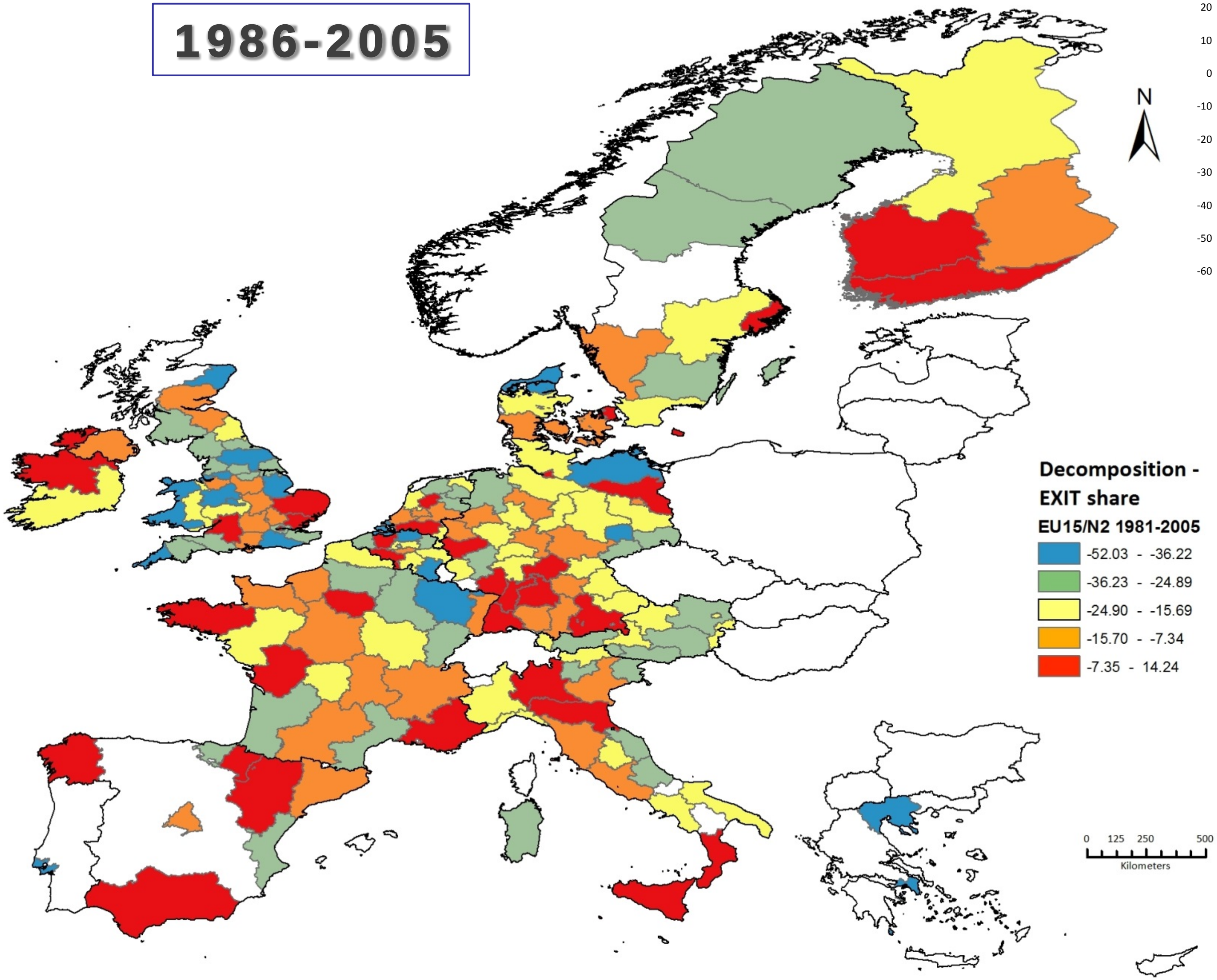


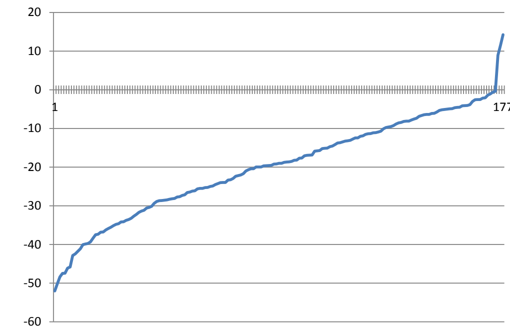
Rank	ID	NUTS Region	ENTRY %
1	IE01	Border, Midl.	97.624
2	ES24	Aragon	97.330
3	FI19	Lansi-Suomi	92.057
4	FR25	Basse-Normand.	83.697
5	ES11	Galicia	80.398
:	:	- : -	:
173	ES22	Com. Foral d.N.	-66.856
174	AT22	Steiermark	-69.652
175	AT11	Burgenland (A)	-72.726
176	DE93	Luneburg	-75.075
177	ES61	Andalucia	-77.179

In all, but 29 regions, entry lowers technological cohesion
→ Does this contradict the theory?

Decomposition – Share of Exit

1986-2005

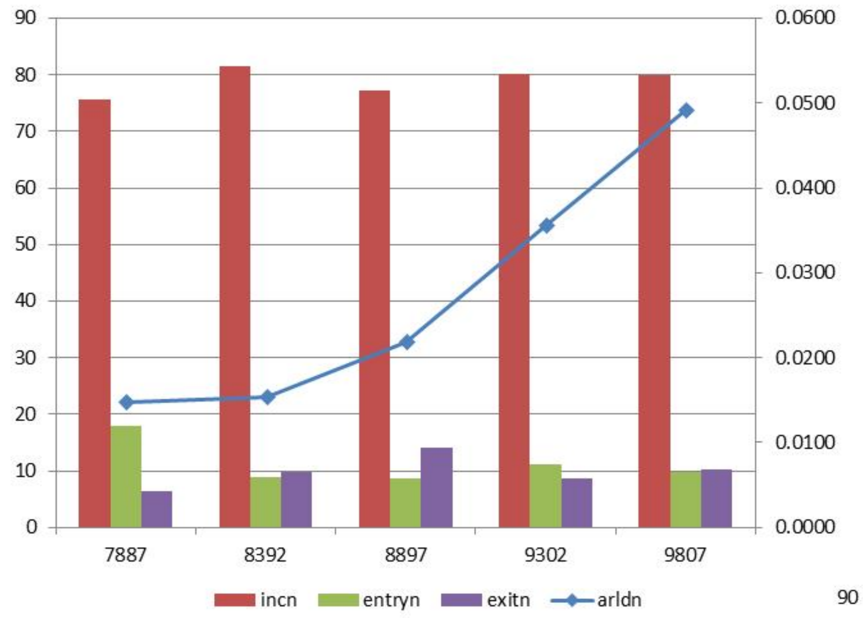




Rank	ID	NUTS Region	EXIT %
1	ITF6	Calabria	14.238
2	ES22	Com. Foral d.N.	11.465
3	ES11	Galicia	8.930
4	IE01	Border, Midl.	-0.376
5	FR10	Ile de France	-0.612
:	:	- : -	:
173	UKG3	West Midlands	-47.432
174	UKG2	Shrop. & Staff.	-47.457
175	BE21	Prov. Antwerpen	-48.361
176	UKJ2	Surrey, E&W SX	-50.143
177	GR12	Kentriki Maked.	-52.030

In all regions, other than 3, exit increase tech. specialization

Change in Regional Technological Coherence

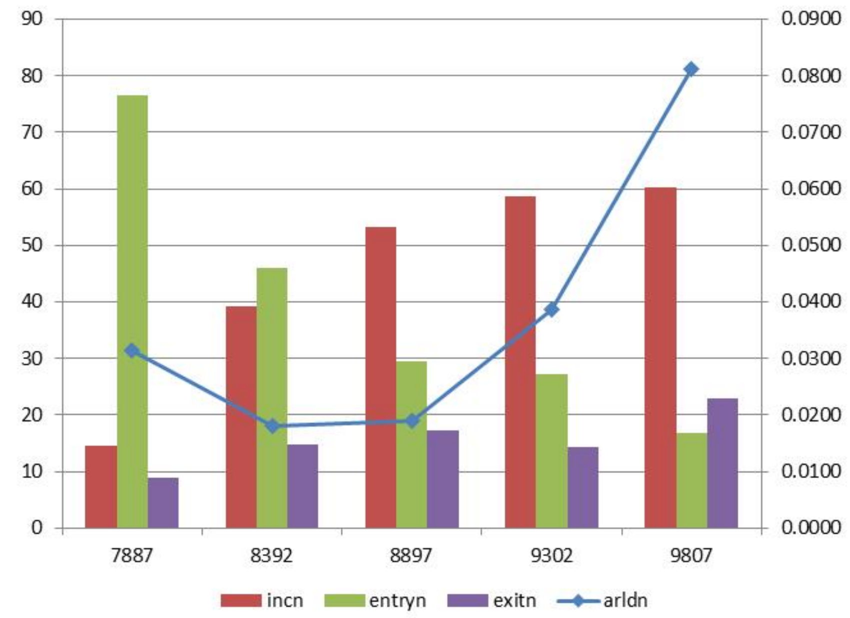


FR10 – Ile de France

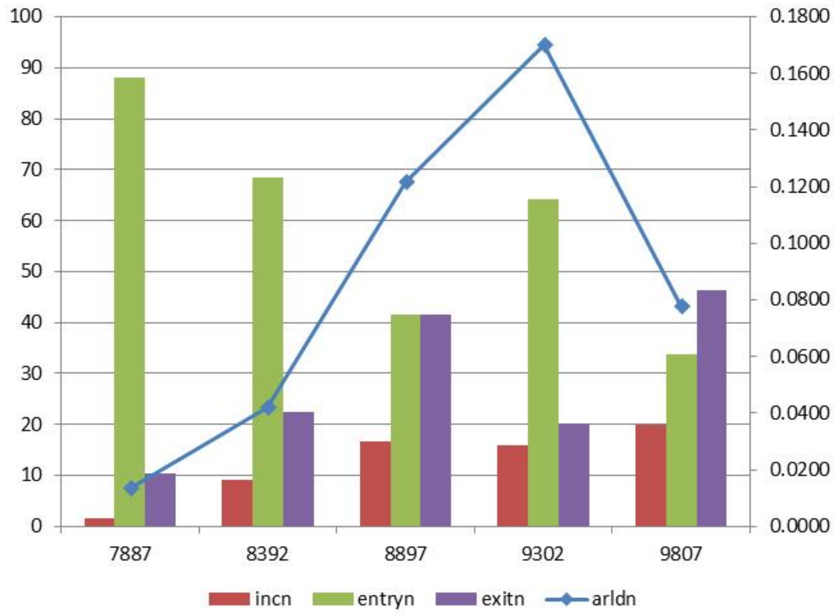
	78-82	83-87	88-92	93-97	98-02	03-07
patents	5,942	8,595	10,735	11,147	14,655	15,647
firms	1,100	1,592	1,838	1,862	2,241	2,332
classes	527	563	560	543	551	550
r_pat	1	1	1	1	1	1
r_arltdn	171	187	187	168	130	136

FI18 – Etela-Suomi

	78-82	83-87	88-92	93-97	98-02	03-07
patents	193	615	1,249	2,313	3,945	3,827
firms	72	207	322	494	709	730
classes	155	305	383	415	450	433
r_pat	75	43	26	16	12	16
r_arltdn	57	154	171	97	41	39



CHANGE IN REGIONAL TECHNOLOGICAL COHERENCE

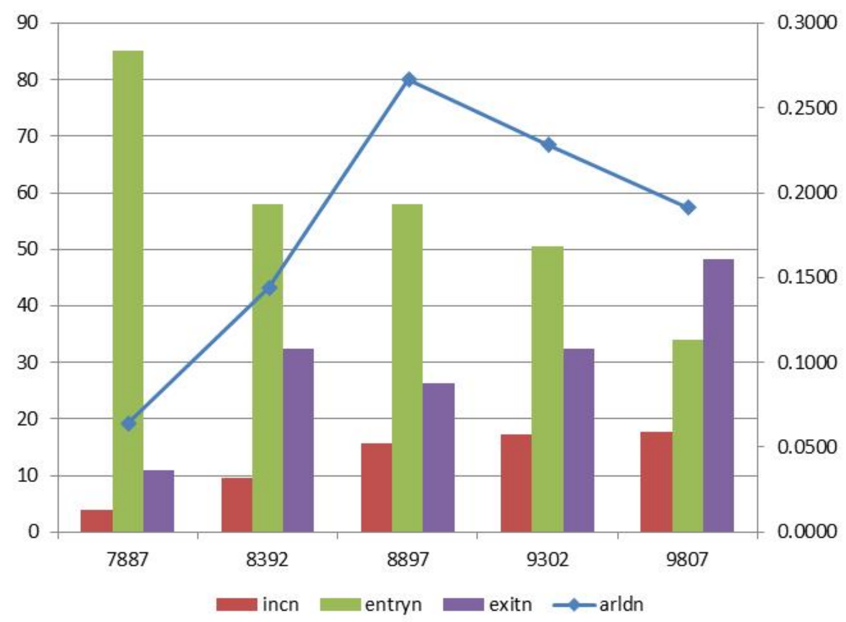


ITG1 – Sicilia

	78-82	83-87	88-92	93-97	98-02	03-07
patents	22	62	123	212	337	340
firms	6	26	41	35	70	105
classes	27	74	116	116	173	156
r_pat	151	141	133	128	129	134
r_arltdn	50	24	7	7	20	33

UKM5 – North Eastern Scotland

	78-82	83-87	88-92	93-97	98-02	03-07
patents	29	86	123	212	324	340
firms	20	55	78	116	139	142
classes	29	71	90	119	139	123
r_pat	145	132	132	126	134	135
r_arltdn	11	6	3	3	4	2



UCD DUBLIN

Entry & Exit of Technologies in Regions

$$\tilde{Y}_i^{rt} = \alpha + \beta_1 \tilde{T}echProx_i^{rt-1} + \beta_2 \tilde{G}eogProx_i^{rt-1} + \beta_3 \tilde{S}ocialProx_i^{rt-1} + \boldsymbol{\beta \widetilde{C}ov_i^{rt-1}} + \boldsymbol{\beta T} + \tilde{\varepsilon}_i^{rt}$$

where the binary dependent variable assumes the value 0 or 1, and represents the probability of region *r* in year *t* exhibiting relative technological specialization in technology class *i*.

TechProx is the time-lagged value of the total distance (in units of technological relatedness) between each technology class *i* and all other technology classes where the city exhibits relative technological specialization.

GeogProx is a time-lagged and spatially weighted measure of knowledge flows to region *r* from all NUTS2 regions that have relative technological specialization in technology class *i*.

SocialProx is a time-lagged measure of the strength of co-inventor linkages between a region and its neighbors within each technology class.

Cov is a matrix of region and time specific covariates and **T** is a time fixed effect.

The final term is an error assumed to possess the usual properties. The ~ indicates that each of the variables have been demeaned with respect to time. The fixed effects specification has the advantage of eliminating unobserved fixed effects that are swept out of the model, along with other fixed effects (region and technology class).

Boschma R., Balland P.-A. & Kogler D. F. (2014) Relatedness and technological change in cities: The rise and fall of technological knowledge in U.S. metropolitan areas from 1981 to 2010, *Industrial and Corporate Change*, doi: 10.1093/icc/dtu012.

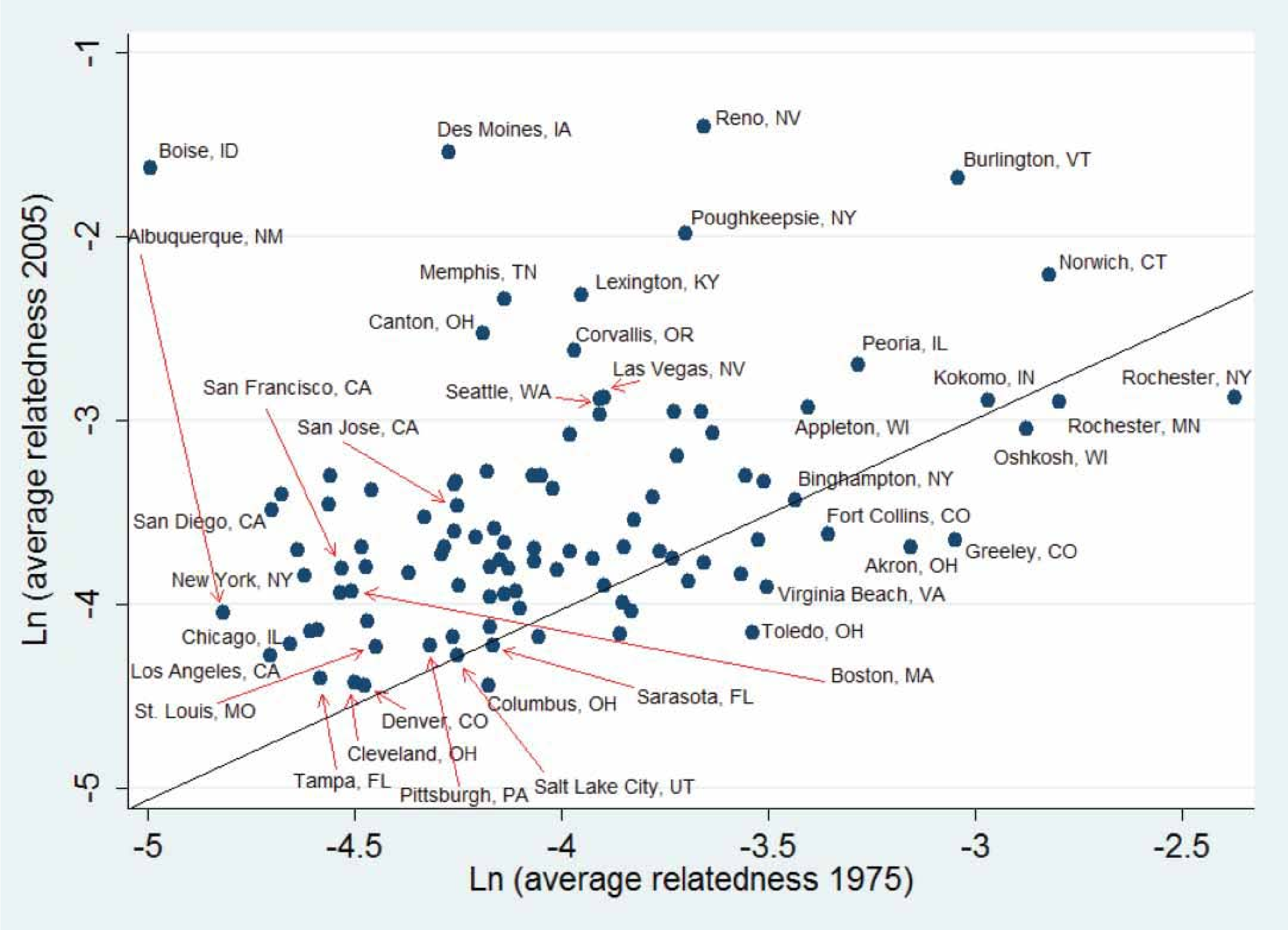
Entry & Exit of Technologies in Regions
(Technological, Social & Spatial Proximity)

	ENTRY		EXIT	
Independent Variables	**FE Logit**	**FE Logit**	**FE Logit**	**FE Logit**
L. Tech Proximity	2.5180*** (0.0969)	2.3278*** (0.0978)	-1.5073*** (0.1310)	-1.1095*** (0.1340)
L. Geog Proximity		0.0670*** (0.0027)		-0.0990*** (0.0055)
L. Social Proximity		0.0405*** (0.008)		0.0041 (0.0063)
L. Inventor Count	0.0039 (0.0047)	-0.0031 (0.0046)	-0.0650*** (0.0071)	-0.0647*** (0.0077)
No. observations LL	88,449	88,449	31,360	31,360

Notes: FE is fixed effects. * represents significant at the 0.1 level, ** significant at the 0.05 level, *** significant at the 0.01 level. The L prefix shows that the independent variables are lagged one time period.

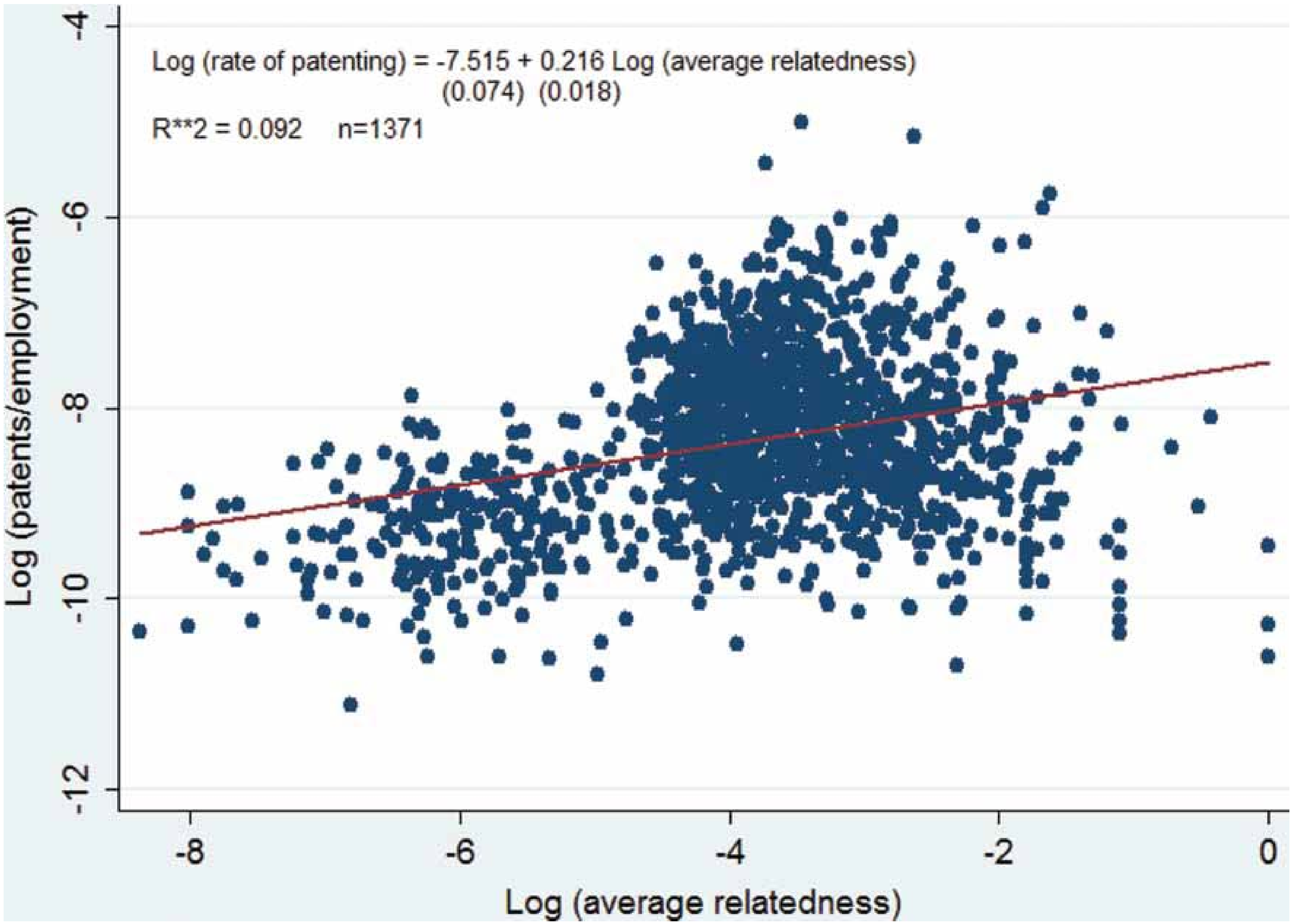
AVERAGE RELATEDNESS IN US CITIES, 1975 AND 2005

Mean knowledge relatedness value in 1975 = 0.0207, and in 2005 = 0.0391
Variance among metro relatedness values was three times greater in 2005 than 1975

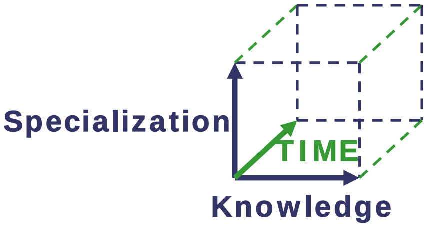


DOES SPECIALIZATION IMPACT THE PRODUCTION OF KNOWLEDGE ACROSS US CITIES?

The estimated slope coefficient suggests that doubling a city's relatedness score, cetris paribus, will increase the rate of patenting by approximately 22%



SUMMARY - CONCLUSIONS



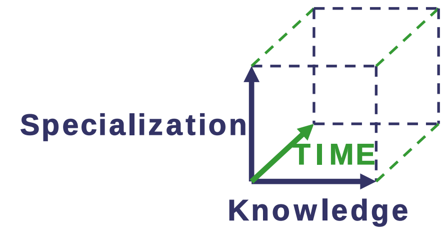
- The European and US **Knowledge Space** is evolving

- **Average Relatedness** values increase overall, but vary substantially between technology sectors and regions

- **Changes in the technological coherence** (specialization/diversification) of individual regions and cities are **driven by entry, exit, and differential growth**; the patterns point to specific regional technology trajectories

- The **entry and exit** of regional technological knowledge is conditioned by technological and spatial proximity to existing knowledge cores, and to some extent also by social proximity and the number of inventors in a specific technology class.

Policy Implications – Follow-Up



- **The Smart Specialisation Thesis** - weak empirical basis so far; the present research project should provide further insights.

- **Interpreting Results** – difficult at times, e.g. entry decreases average relatedness, but on a second look the new technology classes that actually enter a place are closer to the regional knowledge space than the ones that don't.

- **Follow-up and Next Steps** – further analysis of the 'actors' (inventors/firms) of change, the 'type' of change (incremental/radical, and branching processes), and the link to policy initiatives, i.e. attracting vs. home grown.

  Potential Avenue – drawing upon Ireland as a 'laboratory' to gain further insight into the evolutionary processes that potentially drive technological change/upgrading.

T H A N K Y O U !

Q E S T I O N S ?

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The research presented is joined work with:

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For further information and papers please visit:
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https://ucd.academia.edu/DieterFranzKogler

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