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The space of interregional knowledge flows in Europe

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Overview

- Introduction
- Methods and data
- Results
- Conclusions

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Introduction

Introduction

- Knowledge exchange is an information based interaction necessarily accompanying research and development in the creative segments of economy.
- More innovative and technologically advanced economic systems were identified better performing than those less creative.
- The position in knowledge exchange networks in spatial perspective appears to be related with regional economic development level and growth.

Introduction

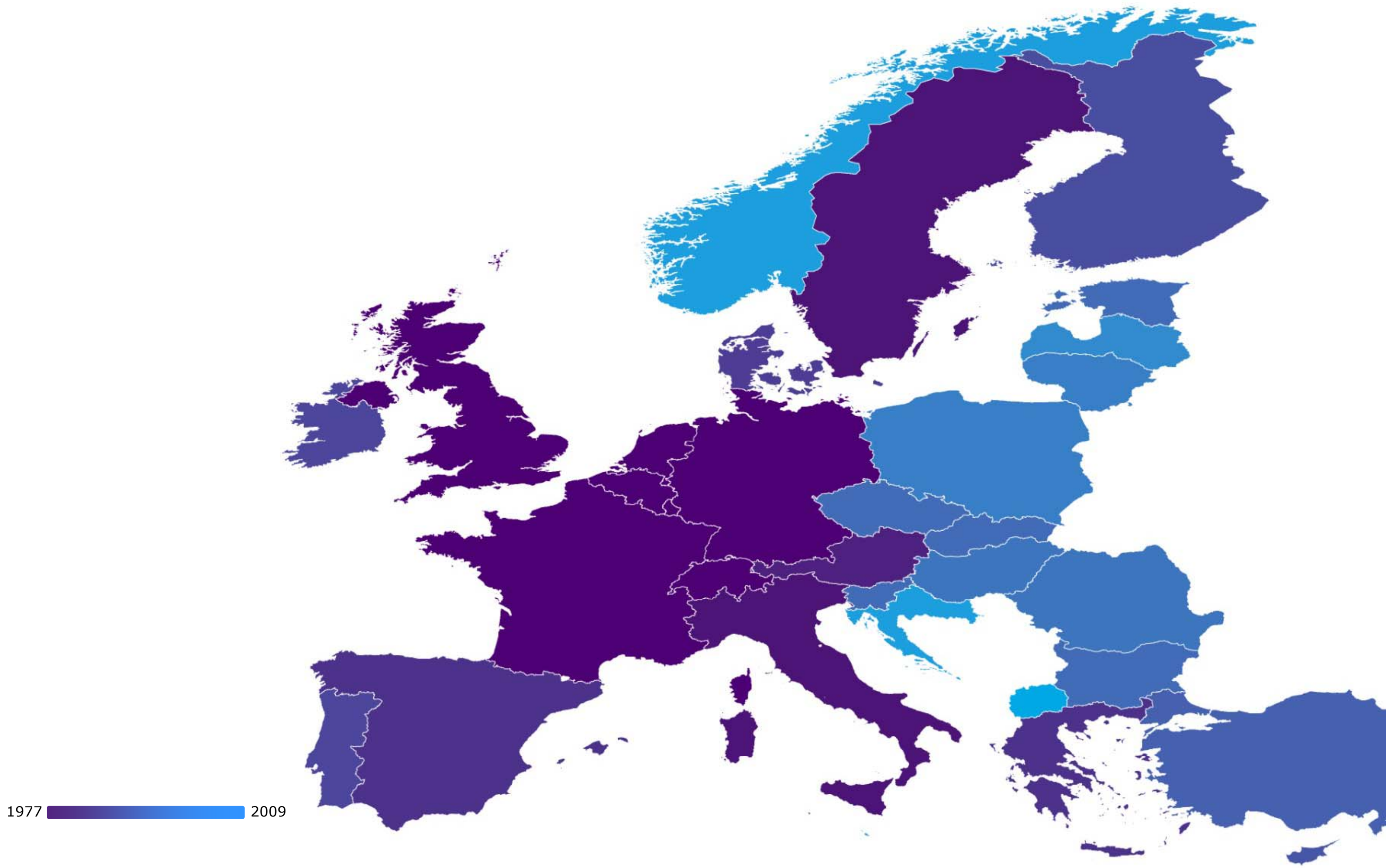
- Griliches (1979) assigns research and development the role of „a major source of economic growth and one of the few variables which public policy can affect in the future and has affected in the past".
- A useful proxy to knowledge spillovers was identified in patenting by Jaffe, Trajtenberg and Henderson (1993): „Despite the invisibility of knowledge spillovers, they do leave a paper trail in the form of citations. We find evidence that these trails, at least, are geographically localized".

Introduction

- Research on knowledge exchange networks in Europe has to be based on the patent records provided by the European Patent Organization.
- The EPO is an intergovernmental institution set up in 1977. Currently there are 37 member states.
- The EPO „applies a centralized procedure to examine patent applications for the members. Applicants can obtain patent protection in as many of the member and extension countries as they designate on the basis of their application".

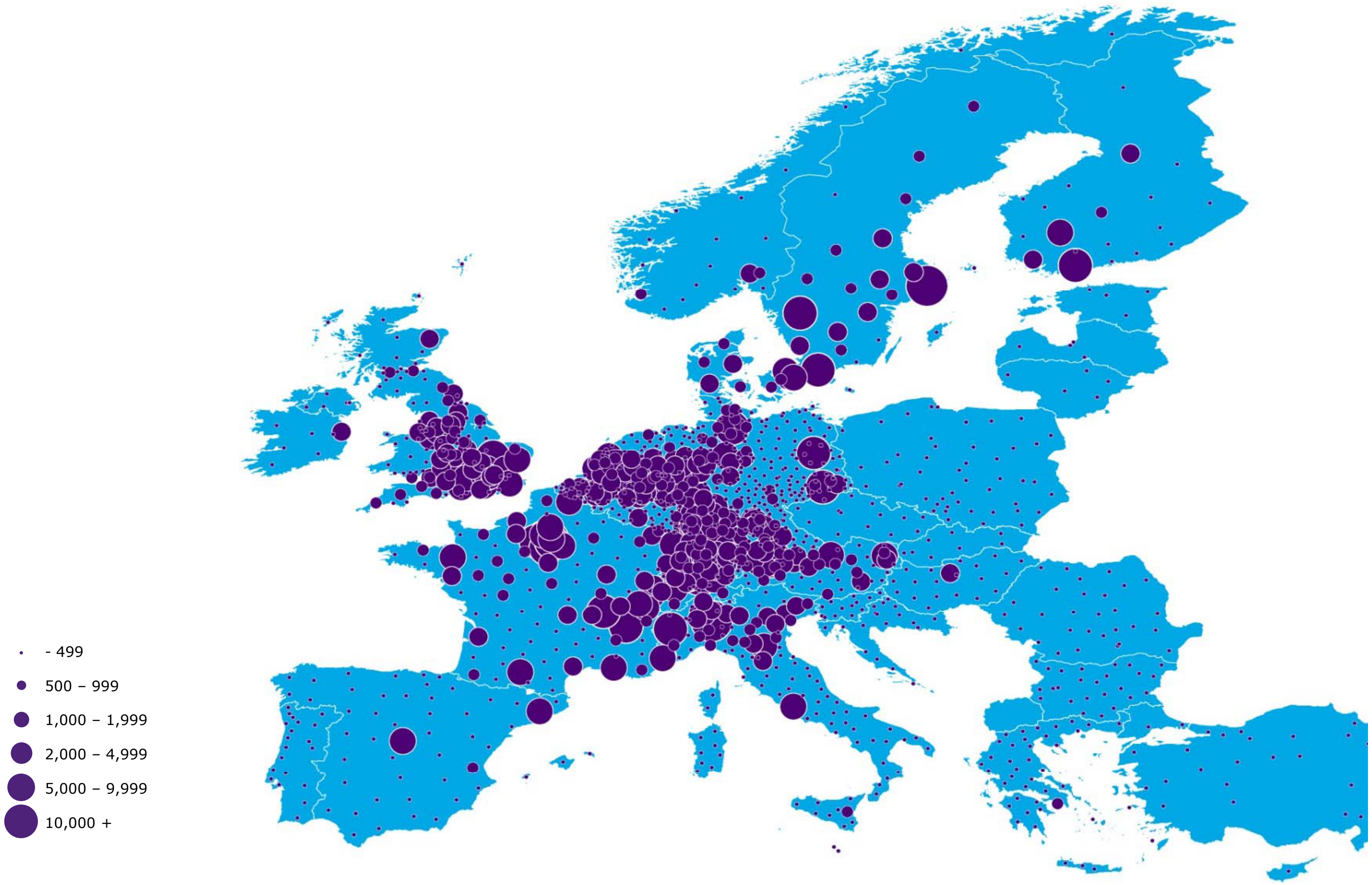
Source: http://www.epo.org/topics/news/2010/20100501.html

Member states of the EPO according to accession



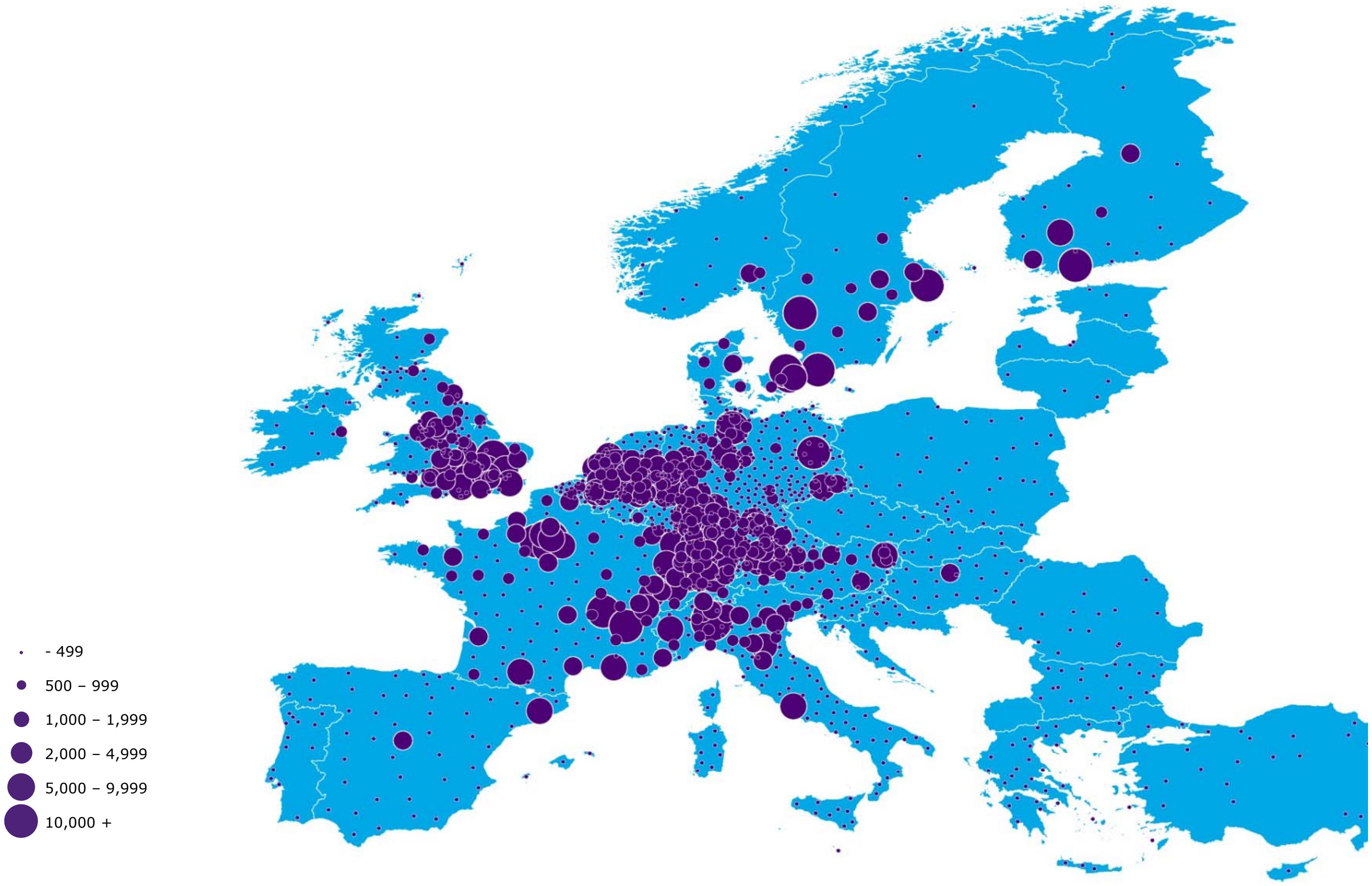
Source: http://www.epo.org/about-us/epo/member-states.html

Number of granted patents 1978-2006, European NUTS3



Source: OECD REGPAT Database, version 201001

Number of citations made 1979-2006, European NUTS3



Source: OECD REGPAT Database, version 201001

Number of citations received 1979-2006, European NUTS3

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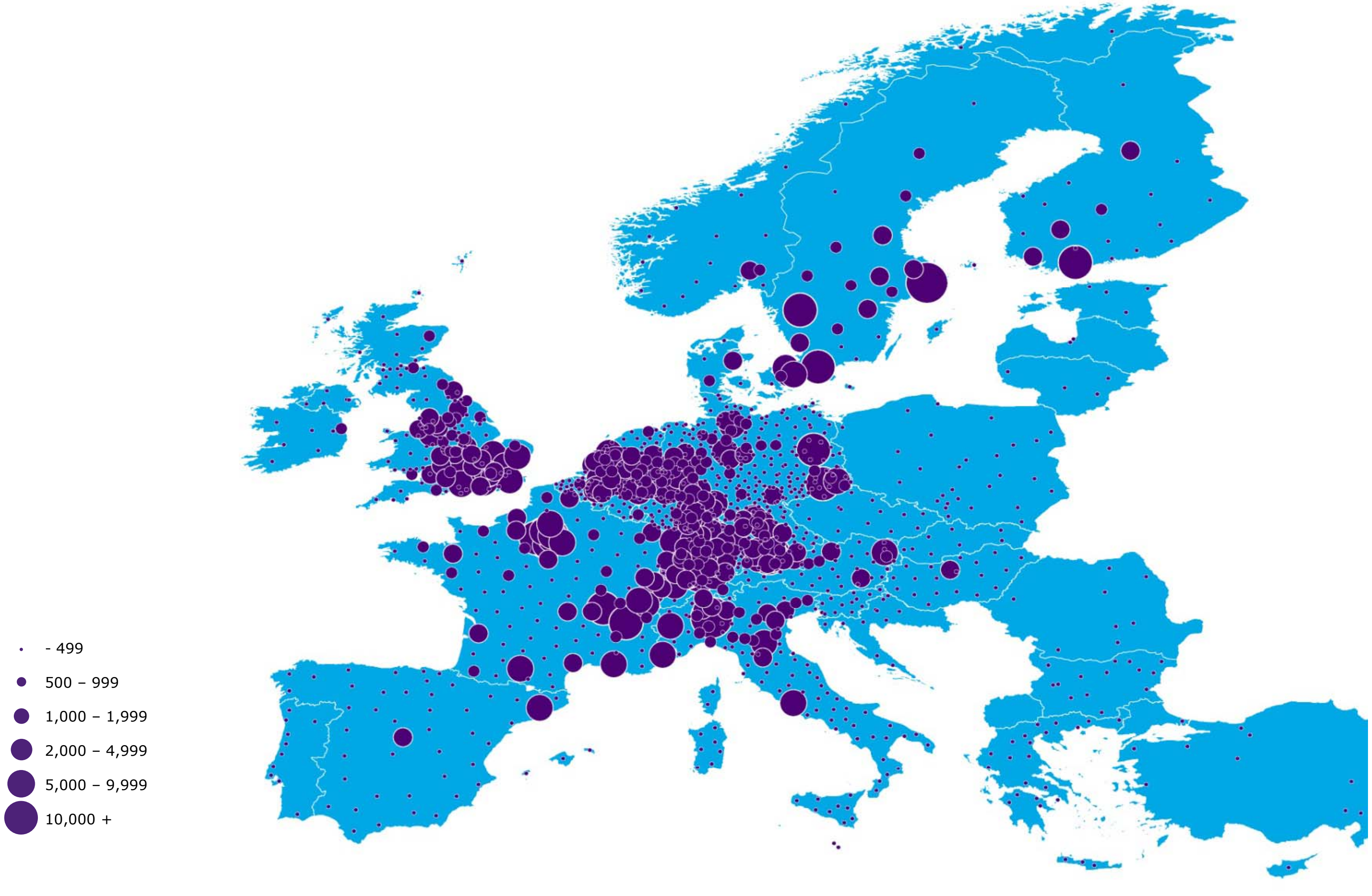
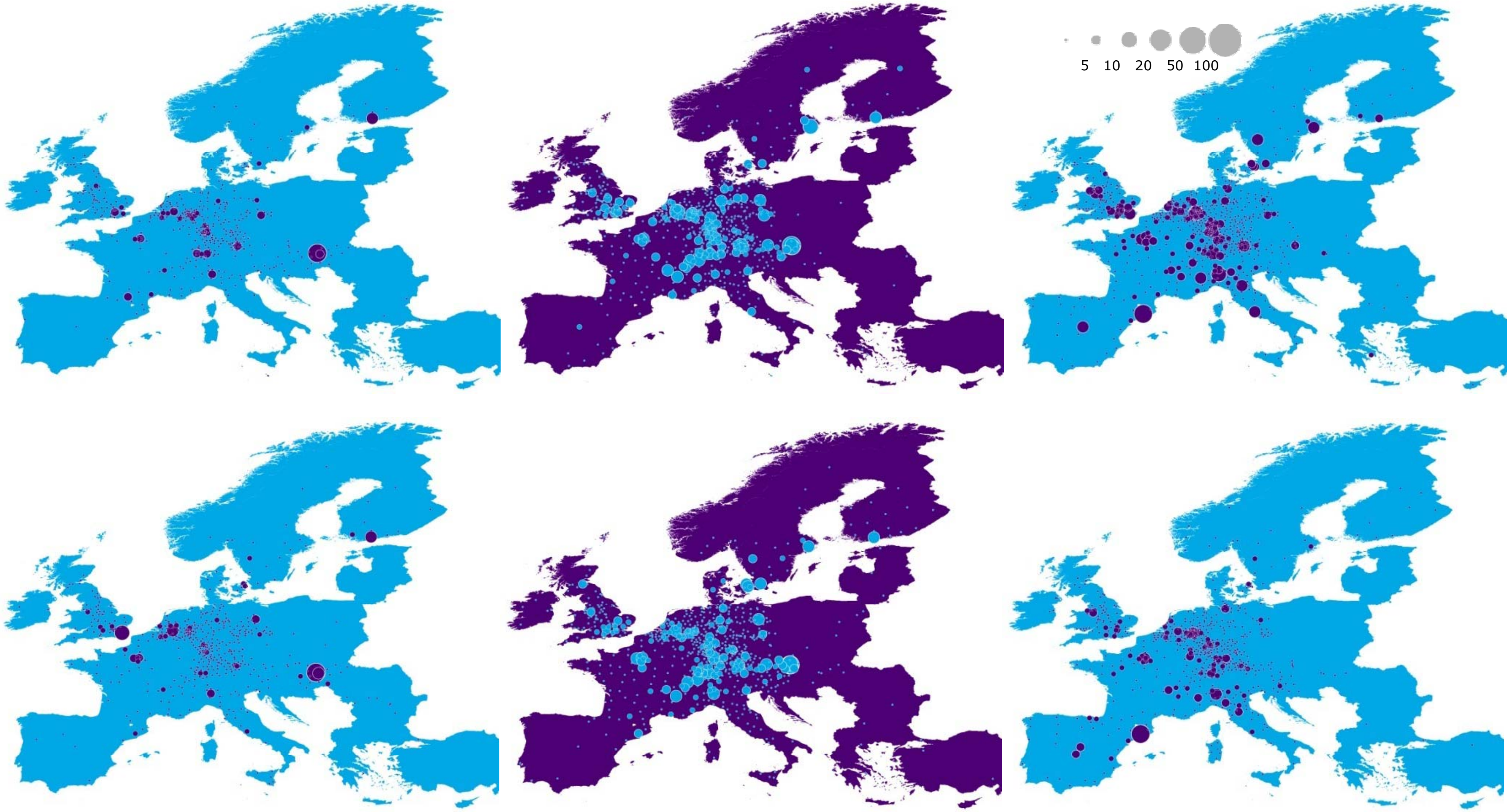


Source: OECD REGPAT Database, version 201001

Budapest, Vienna and Barcelona, patent citations

Citations made

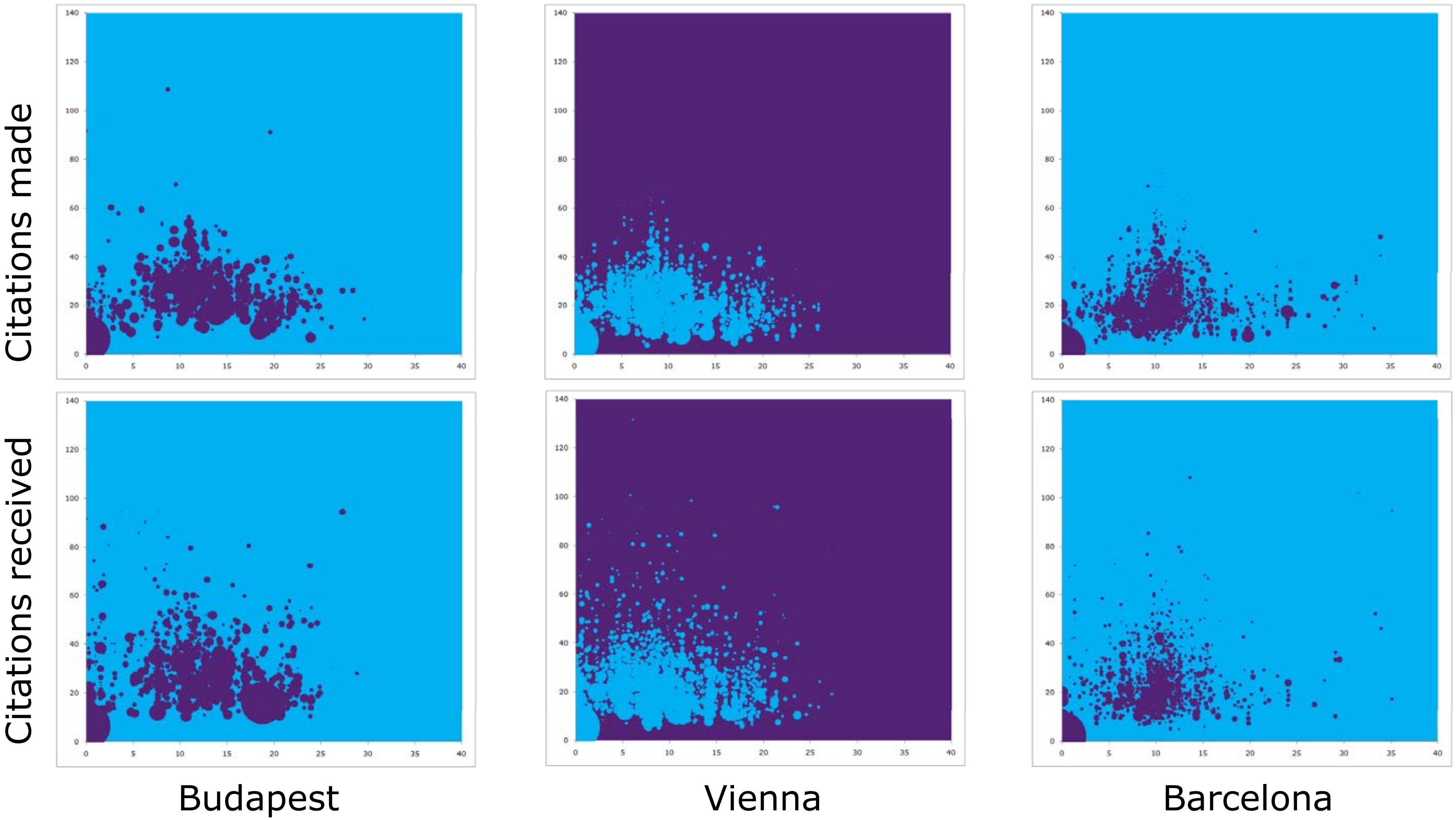
Citations received



Budapest   Vienna   Barcelona

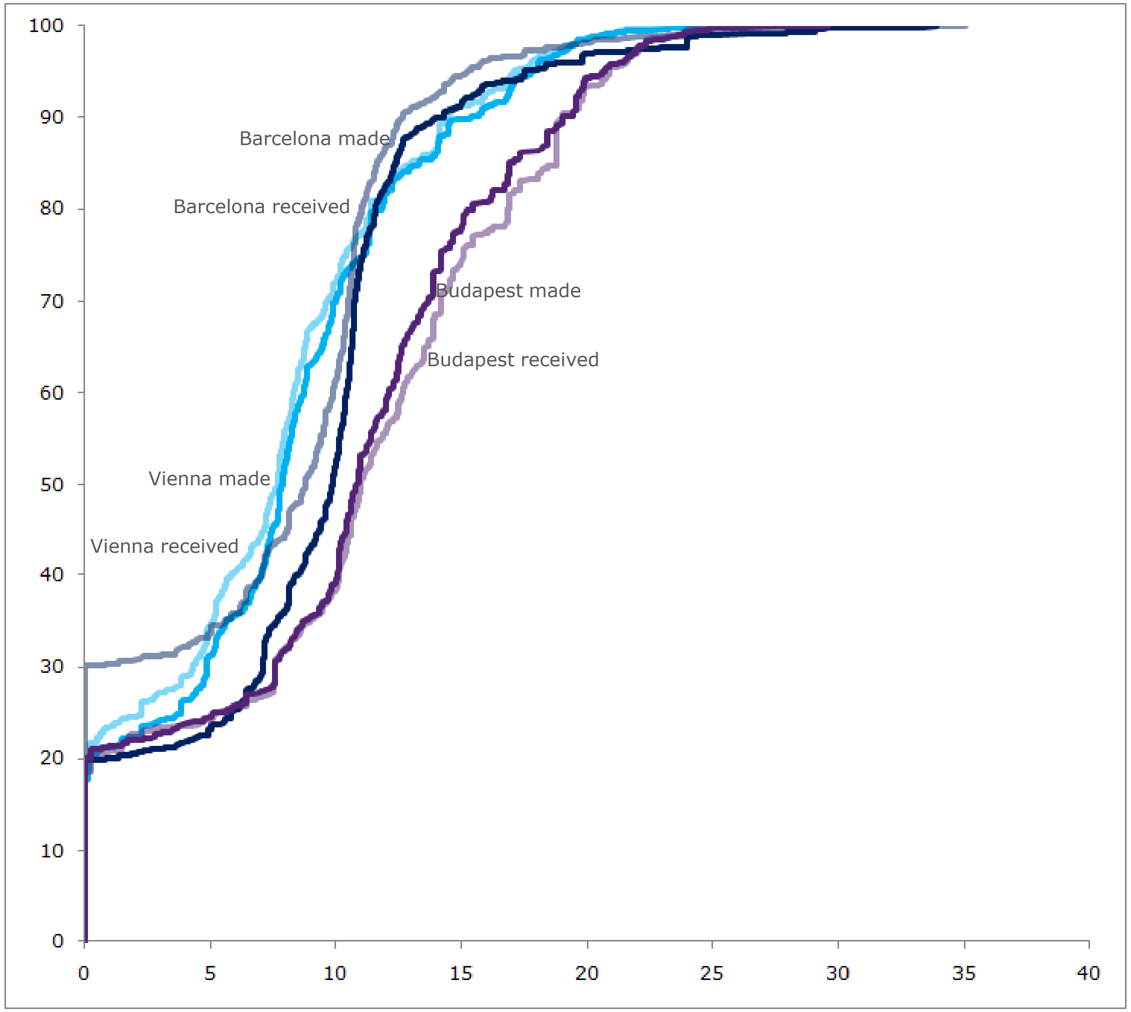
Source: OECD REGPAT Database, version 201001

Budapest, Vienna and Barcelona, *z:* citations according to *x:* d_{ij}, *y:* t_{ij}



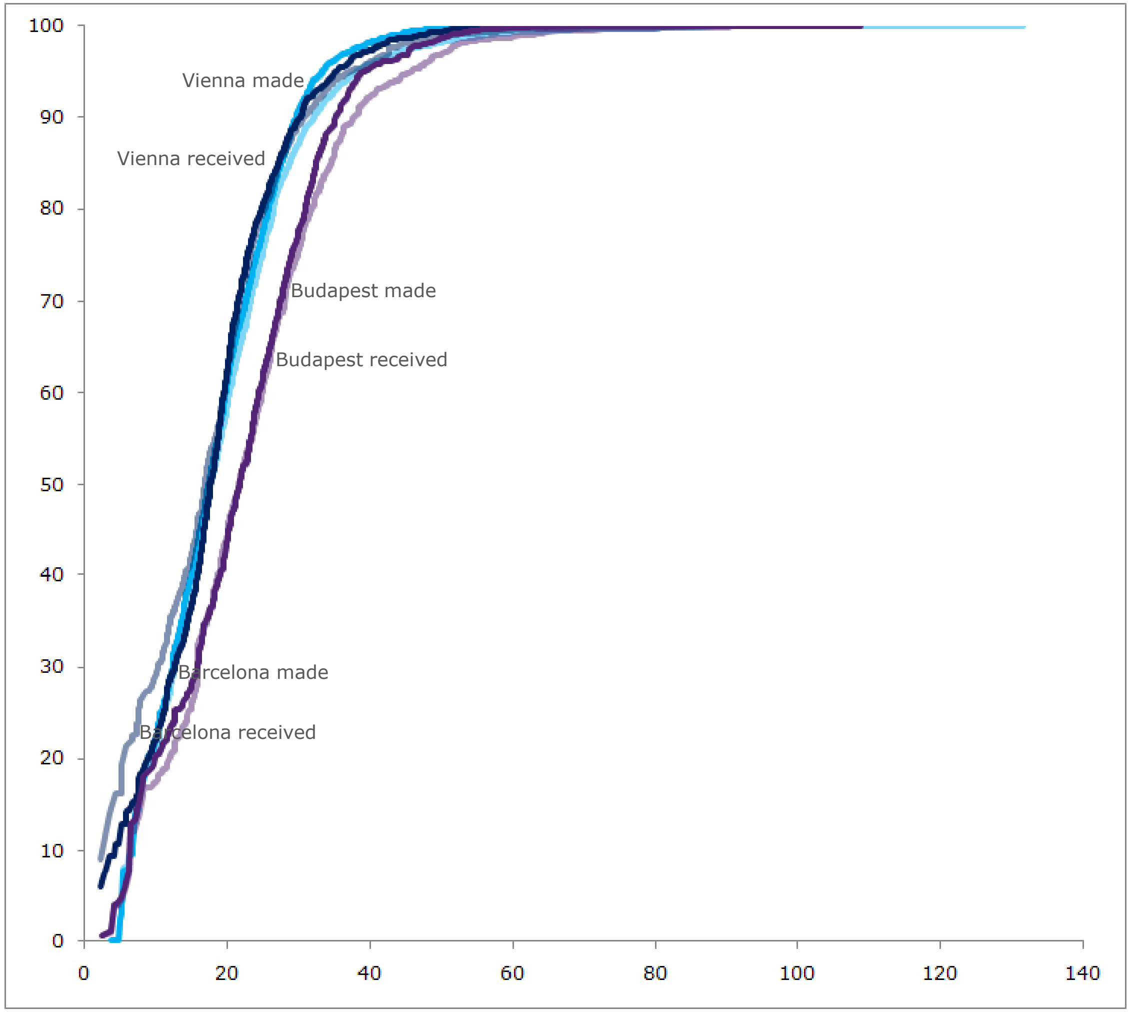
Source: OECD REGPAT Database, version 201001

Budapest, Vienna and Barcelona, *y:* citations share according to distance *x:* d_{ij}



Source: OECD REGPAT Database, version 201001

Budapest, Vienna and Barcelona, *y:* citations share according to distance *x:* t_{ij}



Source: OECD REGPAT Database, version 201001

Introduction

- The motivation is to explore spatiotemporal differentiation existing in the patent citations network using the OECD REGPAT database „which links patent records to regions according to the addresses of the applicants and inventors”.
- The question is whether spatial effects identified in knowledge exchange (Paci and Usai, 2009) will persist if we (1) test a panel model, (2) sample observations at the maximum spatial resolution currently available, and (3) control for spatial and temporal autocorrelation.

Source: http://www.oecd.org/LongAbstract/0,3425,en_2649_34451_40794373_1_1_1_1,00.html

Methods and data

Methods

- Following Fischer, Scherngell and Jansenberger (2006) we are constructing a spatial interaction model of interregional knowledge spillovers captured by the patent citation events between the European NUTS3 regions.
- The model incorporates the effects of origin region A_i, destination region B_j, and multivariate separation $F_{ij}(d_{ij})$ on expected citation flow μ_{ij}

$$\mu_{ij} = A_i \, B_j \, F_{ij}(d_{ij})$$
$$i = 1, \ldots, I, \; j = 1, \ldots, J$$

Methods

$$A_i = A(a_i, \alpha_1) = a_i^{\alpha_1}$$
$$B_j = B(b_j, \alpha_2) = b_j^{\alpha_2}$$
$$F_{ij} = F(d_{ij}, \beta) = exp\ (\beta_1 d_{ij}^{(1)} + \ldots + \beta_K d_{ij}^{(K)})$$

- It is recommended not to estimate the parameters α_1, α_2 and β_K from a log-additive transformation. The Poisson model should be used instead since (1) the estimates $log \mu_{ij} \neq \mu_{ij}$, and (2) citations are discrete in their nature with variance very likely to be proportional to the mean value (Fischer et al. 2006).

Data

- Dependent variable (CITATION) measures the annual citation flow between the patent segments aggregated in the regions where they were made and received.
- Our sampling strategy is (1) not to exclude the regional self-citing flows ($i=j$), and (2) focus the flows realized ($\mu_{ijT} \neq 0$) instead of all potential flows ($\mu_{ijT} \geq 0$). The opposite would require total 59,725,680 instead of 853,872 observations we will use. The sampling excludes 98.6% non-realized interactions in the network.

Data

- At least two independent variables have to define the fundamental conditions for citation phenomenon, source and destination size.
- The source region is characterized by the number of patents granted having their inventor(s) residing in the region i during the year $t=T$ (SOURCE).
- The destination region is characterized by the number of patents applied having their inventor(s) residing in the the region j during the period $t \leq T$ (DESTINATION).

Data

- First separation variable (DISTANCE) is geographical distance d_{ij} dividing two regions based on the coordinates of their polygon centroids using the Eurostat geodata

$$d_{ij} = (\Delta x^2 + \Delta y^2)^{1/2}$$

- Additional separation variables indicate whether citation flows end in the origin region (REGION), in direct neighborhood (CONTIGUITY), or any region within the national borders (NATION).

Data

- Other separation is defined by technological distance t_{ij} between the source and the destination region's patents (TECHNOLOGY).
- Patent section shares (International Patent Classification) are defined first for eight sections (ΔA, ΔB, ..., ΔH) between the pool of granted patents in the region i ($t=T$) and the pool of applied patents in the region j ($t \leq T$) open to potential interactions between them

$$t_{ij} = (\Delta A^2 + \Delta B^2 + \ldots + \Delta H^2)^{1/2}$$

Data

- Presence of autocorrelation effects is tested in three forms. Knowledge spillovers with high probability depend upon the past (*t=T-1*) exchange (T_LAG).
- Factors affecting interactions are with high probability similar to factors affecting links between the neighbors of origin and destination, as well as origin and the neighbors of destination. Spatial lag is constructed as the average of both (S_LAG).
- Past spatial lag is the third effect (ST_LAG).

Results

Results I

Random-effects negative binomial regression
Group variable: panlink
Random effects u_i ~ Beta

Number of obs = 853872
Number of groups = 317172
Obs per group: min = 1
avg = 2.7
max = 28

Wald chi2(3) = 103150.82
Prob > chi2 = 0.0000

Log likelihood = -975214.7

CITATION	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SOURCE	**.000602**	**2.51e-06**	**240.07**	**0.000**	**.000597**	**.0006069**
DESTINATION	**.0001034**	**5.53e-07**	**187.13**	**0.000**	**.0001023**	**.0001045**
DISTANCE	**-.000755**	**.0003336**	**-2.26**	**0.024**	**-.0014088**	**-.0001013**
CONSTANT	1.335569	.0064047	208.53	0.000	1.323016	1.348122
/ln_r	3.421105	.0069093			3.407563	3.434647
/ln_s	1.367531	.0057195			1.356321	1.378741
r	30.6032	.2114476			30.19157	31.02045
s	3.925645	.0224528			3.881884	3.9699

Likelihood-ratio test vs. pooled: chibar2(01) = 3.4e+05 Prob>=chibar2 = 0.000

Source: OECD REGPAT Database, version 201001

Results II

Random-effects negative binomial regression
Group variable: panlink
Random effects u_i ~ Beta

Log likelihood = -968486.31

Number of obs	=	853872
Number of groups	=	317172
Obs per group: min	=	1
avg	=	2.7
max	=	28
Wald chi2(6)	=	147456.31
Prob > chi2	=	0.0000

CITATION	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
SOURCE	.0005416	2.58e-06	210.05	0.000	.0005366	.0005467
DESTINATION	.0000948	5.50e-07	172.43	0.000	.0000938	.0000959
DISTANCE	-.0003368	.0003302	-1.02	0.308	-.0009841	.0003105
S_LAG	**.0130734**	**.000374**	**34.96**	**0.000**	**.0123405**	**.0138064**
T_LAG	**.0004041**	**.0000628**	**6.43**	**0.000**	**.0002809**	**.0005272**
ST_LAG	**.0146991**	**.0006746**	**21.79**	**0.000**	**.013377**	**.0160213**
CONSTANT	1.431499	.0068165	210.01	0.000	1.418139	1.444859
/ln_r	3.541382	.0072618			3.527149	3.555615
/ln_s	1.41415	.0058478			1.402689	1.425612
r	34.51458	.2506369			34.02682	35.00934
s	4.112991	.0240521			4.066119	4.160403

Likelihood-ratio test vs. pooled: chibar2(01) = 3.1e+05 Prob>=chibar2 = 0.000

Source: OECD REGPAT Database, version 201001

Results III

Random-effects negative binomial regression		Number of obs	= 853872
Group variable: panlink		Number of groups	= 317172
Random effects u_i ~ Beta		Obs per group: min	= 1
		avg	= 2.7
		max	= 28
		Wald chi2(7)	= 166526.50
Log likelihood	= -962049.41	Prob > chi2	= 0.0000

CITATION	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SOURCE	.0005209	2.52e-06	206.69	0.000	.000516	.0005258
DESTINATION	.0000935	5.34e-07	175.18	0.000	.0000924	.0000945
DISTANCE	-3.83e-06	.0003298	-0.01	0.991	-.0006503	.0006426
TECHNOLOGY	**-.0157228**	**.0001417**	**-110.98**	**0.000**	**-.0160005**	**-.0154452**
S_LAG	.0130045	.000358	36.33	0.000	.0123029	.0137061
T_LAG	.000533	.0000552	9.65	0.000	.0004247	.0006413
ST_LAG	.0134128	.0006428	20.87	0.000	.0121529	.0146727
CONSTANT	1.955082	.0087458	223.55	0.000	1.937941	1.972223
/ln_r	3.722082	.0079217			3.706556	3.737609
/ln_s	1.503756	.006057			1.491885	1.515628
r	41.3504	.3275675			40.71334	41.99743
s	4.498556	.0272479			4.445467	4.552279

Likelihood-ratio test vs. pooled: chibar2(01) = 2.9e+05 Prob>=chibar2 = 0.000

Source: OECD REGPAT Database, version 201001

Results IV

Random-effects negative binomial regression — Number of obs = 853872
Group variable: panlink — Number of groups = 317172
Random effects u_i ~ Beta — Obs per group: min = 1
avg = 2.7
max = 28

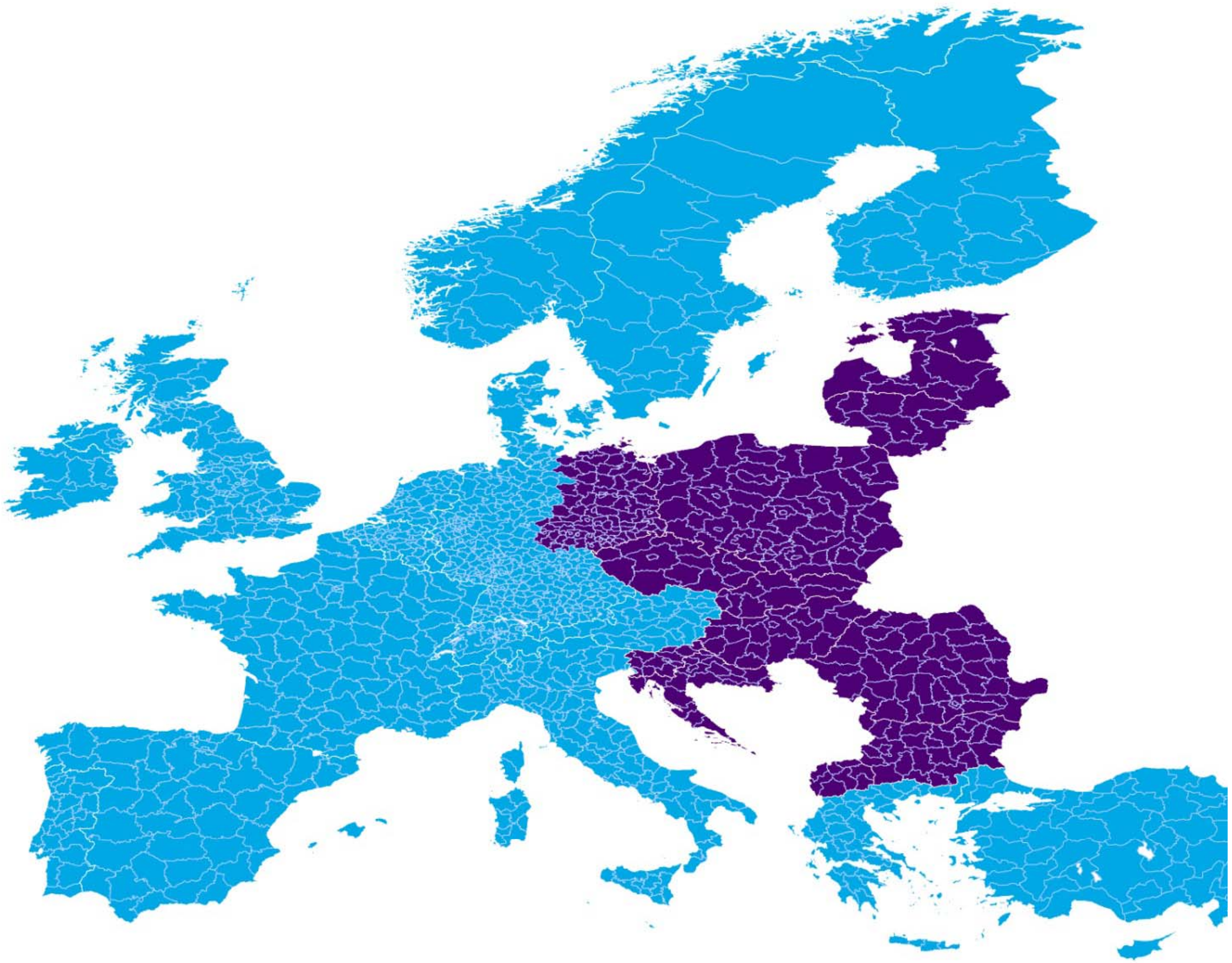
Wald chi2(10) = 176946.42
Log likelihood = -960295.24 — Prob > chi2 = 0.0000

CITATION	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
ORIGIN	.0005267	2.47e-06	213.34	0.000	.0005218	.0005315
DESTINATION	.0000954	5.22e-07	182.70	0.000	.0000943	.0000964
DISTANCE	.0033273	.0003939	8.45	0.000	.0025554	.0040993
TECHNOLOGY	-.0157056	.0001403	-111.91	0.000	-.0159806	-.0154305
S_LAG	.0128318	.0003407	37.66	0.000	.012164	.0134996
T_LAG	.0005333	.0000505	10.57	0.000	.0004344	.0006322
ST_LAG	.0123787	.0006091	20.32	0.000	.0111849	.0135724
1.REGION	**.3950595**	**.0135662**	**29.12**	**0.000**	**.3684703**	**.4216487**
1.CONTIGUITY	**.5768744**	**.0103355**	**55.81**	**0.000**	**.5566172**	**.5971317**
1.NATION	**-.0280407**	**.0044349**	**-6.32**	**0.000**	**-.0367329**	**-.0193484**
CONSTANT	1.942463	.0095459	203.49	0.000	1.923753	1.961173
/ln_r	3.873356	.0092954			3.855137	3.891574
/ln_s	1.627683	.0071212			1.613726	1.64164
r	48.10353	.4471433			47.23508	48.98795
s	5.092062	.0362617			5.021484	5.163632

Likelihood-ratio test vs. pooled: chibar2(01) = 1.7e+05 Prob>=chibar2 = 0.000

Source: OECD REGPAT Database, version 201001

Potential historical heterogeneity in Europe



Results V

Random-effects negative binomial regression
Group variable: panlink
Random effects u_i ~ Beta

Number of obs = 853872
Number of groups = 317172
Obs per group: min = 1
avg = 2.7
max = 28

Wald chi2(12) = 178126.93
Prob > chi2 = 0.0000

Log likelihood = -959727

CITATION	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
ORIGIN	.0005265	2.47e-06	213.25	0.000	.0005217	.0005313
DESTINATION	.0000956	5.22e-07	183.02	0.000	.0000946	.0000966
DISTANCE	.0045682	.0003937	11.60	0.000	.0037966	.0053399
TECHNOLOGY	-.0155172	.0001406	-110.34	0.000	-.0157929	-.0152416
S_LAG	.0128072	.0003398	37.69	0.000	.0121412	.0134732
T_LAG	.0005282	.0000503	10.51	0.000	.0004296	.0006267
ST_LAG	.0123781	.0006072	20.38	0.000	.0111879	.0135682
1.REGION	.3966071	.0136395	29.08	0.000	.369874	.4233401
1.CONTIGUITY	.5712277	.0103457	55.21	0.000	.5509504	.5915049
1.NATION	-.005049	.0044801	-1.13	0.260	-.0138298	.0037318
1.EAST_O	**-.1660905**	**.0077564**	**-21.41**	**0.000**	**-.1812928**	**-.1508883**
1.EAST_D	**-.187015**	**.0077124**	**-24.25**	**0.000**	**-.2021311**	**-.171899**
CONSTANT	1.94203 .	0095698	202.93	0.000	1.923274	1.960787
/ln_r	3.883124	.0093494			3.8648	3.901449
/ln_s	1.635212	.0071388			1.62122	1.649204
r	48.57573	.454155			47.69371	49.47407
s	5.130546	.0366258			5.05926	5.202835

Likelihood-ratio test vs. pooled: chibar2(01) = 1.7e+05 Prob>=chibar2 = 0.000

Conclusions

Conclusions

- The size of source and destination patent pools have stable significant positive effects. Unlike full spatial interaction sample including non-realized flows (μ_{ij}) both α coefficients are small.
- Addition of a source patent increases citation flow by 0.05-0.06%. The effect on destination side is 0.01%. The size of source is 6-times more important than the size of destination.
- Knowledge exchange once happening depends very little on production of knowledge itself.

Conclusions

- Geographical distance seems to affect little of knowledge exchange between regions.
- A significant negative effect is found only in the model I. Additional unit of d_{ij} is responsible for citation flow decreased by 0.08%.
- In presence of other separation variables in the models IV-V the effect of distance on exchange is positive, 0.33% and 0.46%.
- Decrease of knowledge exchange from technological distance is identified stable at the level 1.56% per unit of t_{ij}.

Conclusions

- In all models the autocorrelation factors are significant and positive if included.
- Estimated effects from temporal lag of citation are small at the level 0.04-0.05% for additional citation.
- The estimated effects from spatial lag of citation are practically at the same level. Additional citation in spatially lagged set of citations increases exchange by 1.29-1.32%. The effect from spatial and temporal lag combined is 1.25-1.48%.

Conclusions

- Origin and destination in the same region increase citation by 48.45-48.68%.
- Spillovers are increased by 77.04-78.05% between neighbors. In presence of this variable distance becomes positive.
- National area is significant only in non-presence of two East-block indicators. The effect is at the level -2.77%.
- Origin within the East-block is responsible for exchange lower by 15.30%. Location of destination on the same side decreases flow by additional 17.06%.

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