Metropolisation, peripheries and funding of nano sciences & technologies production in Europe

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Background and objectives

First works in nano S&T field demonstrated some interesting findings:

- a **very fast rate** of growth (14% yearly) fitting with Bonaccorsi s approach (Bonaccorsi, 2008).
- secondly, it highlighted a **strong agglomeration** effects where over 80% of world knowledge production is located in few places (Robinson, D. K. et al., 2007, Delemarle et al., 2009).

Does the European funding play a role ?

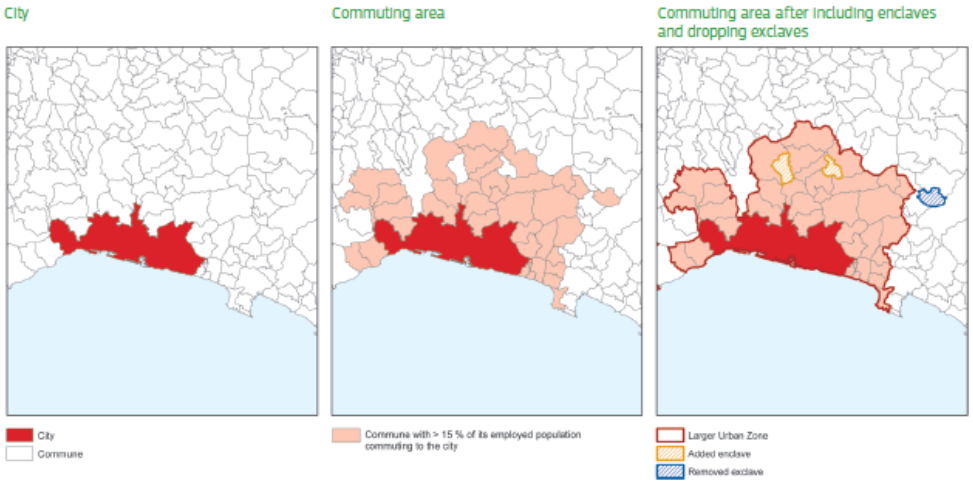
Does it drive collaborations across urban areas in Europe ?

Unit of analysis as a proxy to link analytical dimensions: Functional Urban Areas

Traditional approaches are usually based on **administrative boundaries** (NUTS, municipalities) and make difficult to reflect the **geographical continuity** of socio-economic phenomena of S&T productions.

Functional Urban Areas (Brezzi, OECD, 2012):

- At a municipality scale
- With a core (density of population) and an hinterland (based mainly on a commuting data)



688 FUA in Europe (EU-28 and associated countries) and some other countries (Japan, USA, Canada…).

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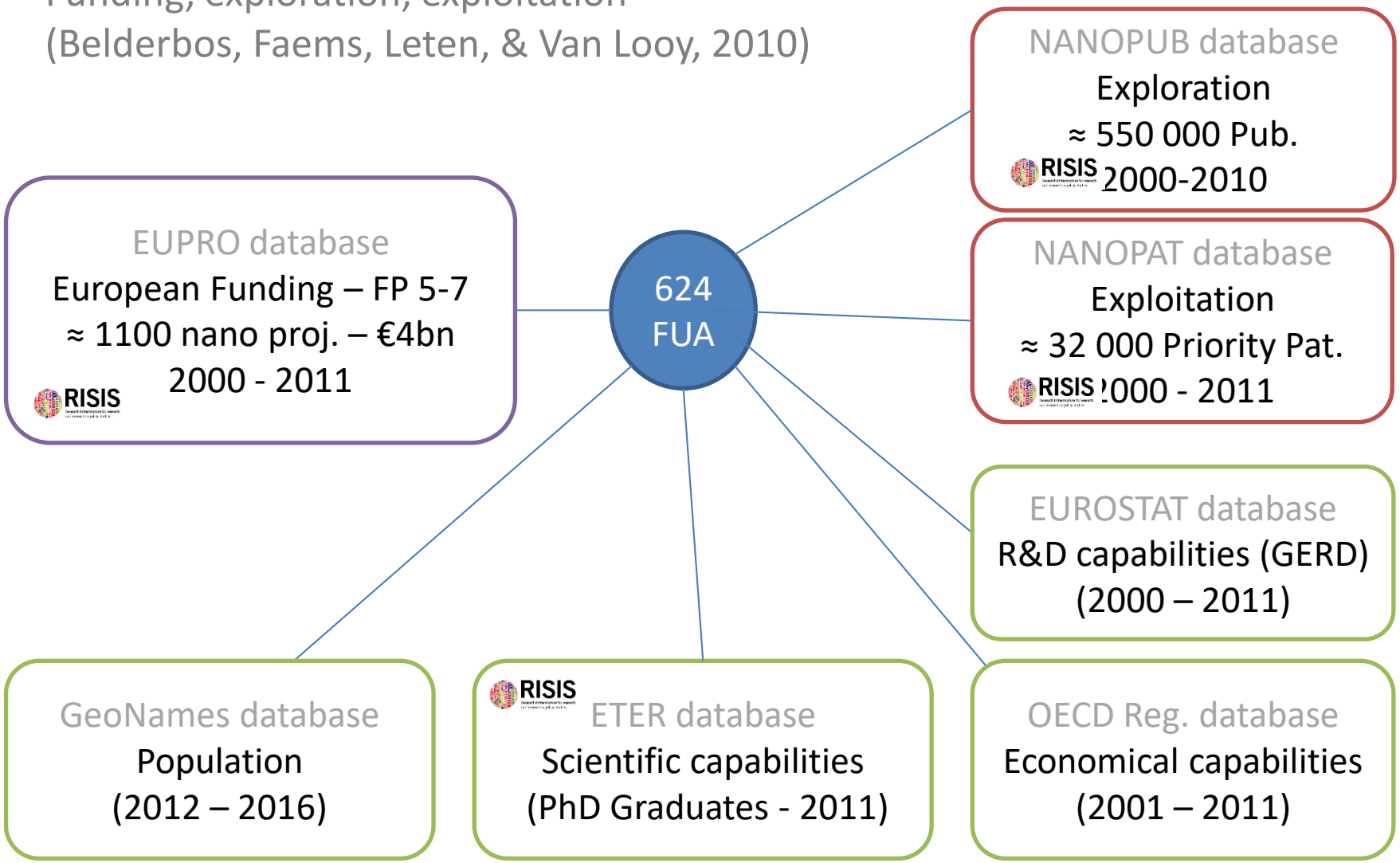
Nanotechnology sciences & technologies

Funding, exploration, exploitation
(Belderbos, Faems, Leten, & Van Looy, 2010)



Estimation results I

	Exploration (publications)						**Exploitation** (patents)					
	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.
EU funding	**1.334**	***	**1.311**	***	**1.231**	***	**1.174**	***	**1.179**	***	**1.166**	***
Population	2.265	***	2.459	***	1.903	***	2.593	***	2.658	***	2.435	***
GDP per capita	1.080		1.167		0.964		2.902	***	1.597		-0.606	
R&D expenditures	-		1.029		1.188		-		1.843	***	1.874	***
PhD students	-		-		1.124	***	-		-		0.932	
Constant	-5.316	**	-4.723	***	-3.897	***	-13.781	***	-12.423	***	-11.374	***
Overdispersion	2.915	***	1.515	***	1.011	***	1.630	***	1.585	***	1.415	***
LR (NegBin)	420.56	***	508.97	***	387.26	***	492.50	***	390.69	***	498.25	***

Based on Negative Binomial Regression; Mean marginal effects indicate elasticities (percent changes) of the dependent variable to changes in the independent variables, holding all other variables at their mean; *** significant at the 0.01 level, ** significant at the 0.05 level, * significant at the 0.1 level;

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Findings from the 1st model

- **Positive and statistically significant EU funding effects** on both knowledge **exploration** and **exploitation**
- Effects are slightly, but statistically significant **higher for exploration in all model versions**.
- The full model (controlling for R&D expenditures and Phd students) predicts for a 1% increase of EU funding a 1.23% increase in publications, while a 1.16% increase in patenting
- Results stay robust when **controlling for R&D expenditures**; these turn out to be not significant for exploration, but significant and highly influential for exploitation (for exploitation, GDP per capita becomes insignificant when adding R&D expenditures, pointing to a high correlation between the two variables)
- **PhD students** are a significant and important driver for exploration, but insignificant for exploitation

Estimation results II

	Exploration (Top 10% publications)						Exploitation (Top 10% patents)					
	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.	mean marg.effect	sign.
EU funding	**1.401**	***	**1.370**	***	**1.301**	***	**1.167**	***	**1.093**	*	**1.125**	***
Population	2.097	***	2.320	***	1.789	***	2.381	***	2.715	***	2.846	***
GDP per capita	2.755	***	1.678		1.699		3.761	***	0.772		0.443	
R&D expenditures	-		1.417		1.408	***	-		2.188	***	3.046	***
PhD students	-		-		1.134	***	-		-		1.035	
Constant	-9.963	**	-11.452	***	-8.432	***	-15.835	***	-16.488	***	-17.181	***
Overdispersion	1.971	***	1.910	***	1.181	***	3.542	***	4.958	***	3.891	***
LR (NegBin)	529.87	***	435.49	***	373.71	***	208.35	***	125.24	***	115.92	***

Based on Negative Binomial Regression; Mean marginal effects indicate elasticities (percent changes) of the dependent variable to changes in the independent variables, holding all other variables at their mean; *** significant at the 0.01 level, ** significant at the 0.05 level, * significant at the 0.1 level;

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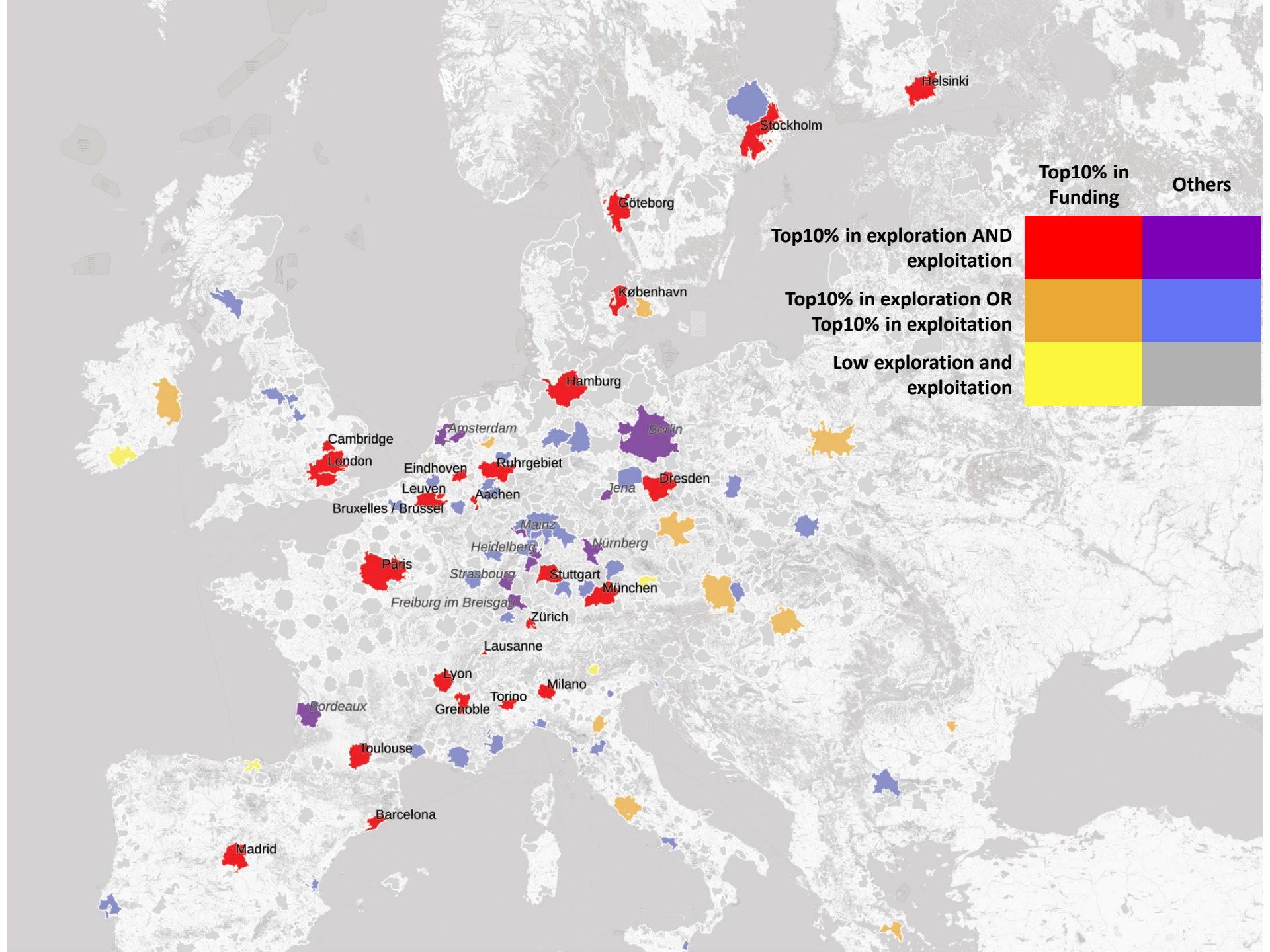
Main findings in terms of quality

- **EU funding effects** increase when looking at quality for knowledge exploration, but slightly decrease for exploitation
- **R&D expenditures** become a highly significant determinant for knowledge exploration when looking at quality, and also increases its importance markedly for exploitation
- **Phd students** are still important at the same level for exploration in terms of quality
- The remaining patterns of estimates stay the same between the ‘quantity’ and the ‘quality’ models


Helsinki
Stockholm
Göteborg
København
Hamburg
Amsterdam
Berlin
Cambridge
London
Eindhoven
Ruhrgebiet
Leuven
Aachen
Dresden
Jena
Bruxelles / Brussel
Mainz
Heidelberg
Nürnberg
Paris
Strasbourg
Stuttgart
München
Freiburg im Breisgau
Zürich
Lausanne
Lyon
Milano
Torino
Grenoble
Bordeaux
Toulouse
Barcelona
Madrid
Top10% in Funding
Others
Top10% in exploration AND exploitation
Top10% in exploration OR Top10% in exploitation
Low exploration and exploitation

Cores and peripheries analysis

Three different networks :

- EU Funding (link: same European project)
- Knowledge Exploration (link: same scientific publication)
- Knowledge Exploitation (link: same priority patent)

Traditional approaches : **coreness as a continuous phenomenon** trough space (Borgatti and Everett 1999, and after).

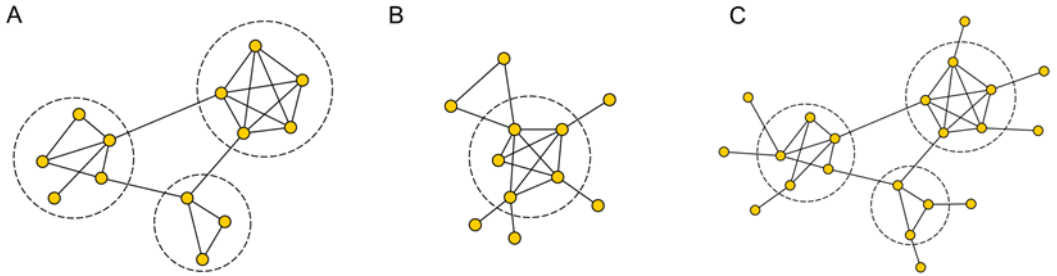


Fig. 1. Examples of meso-scale network structures: (A) community; (B) core-periphery; (C) multicore-periphery.

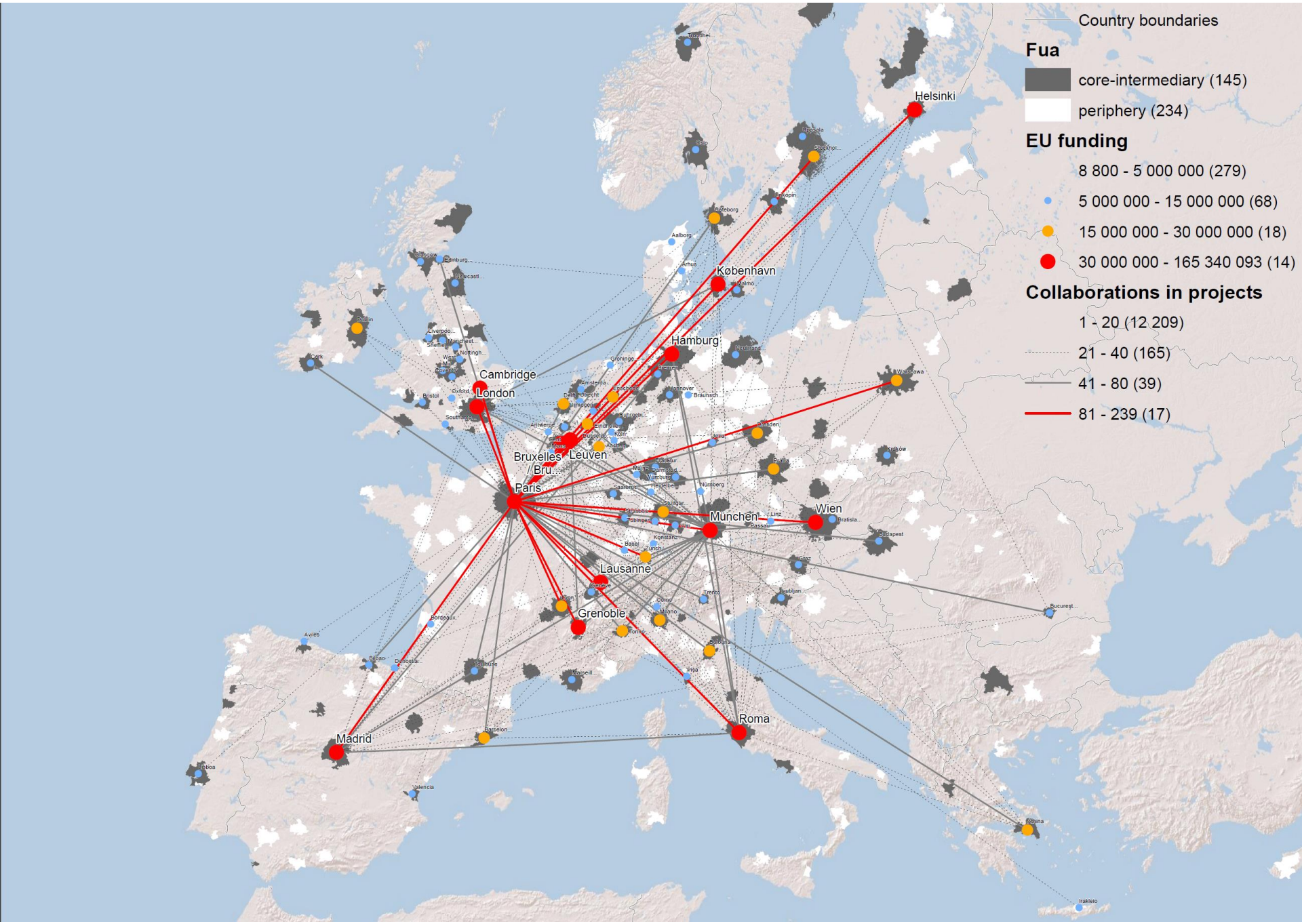
Challenge: real-world networks, may have multiple cores (Yan and Luo 2015).

Cores and peripheries analysis

Two steps to identify core and peripheral FUAs:

1. Community detection (Louvain algorithm Blondel et al. 2008)

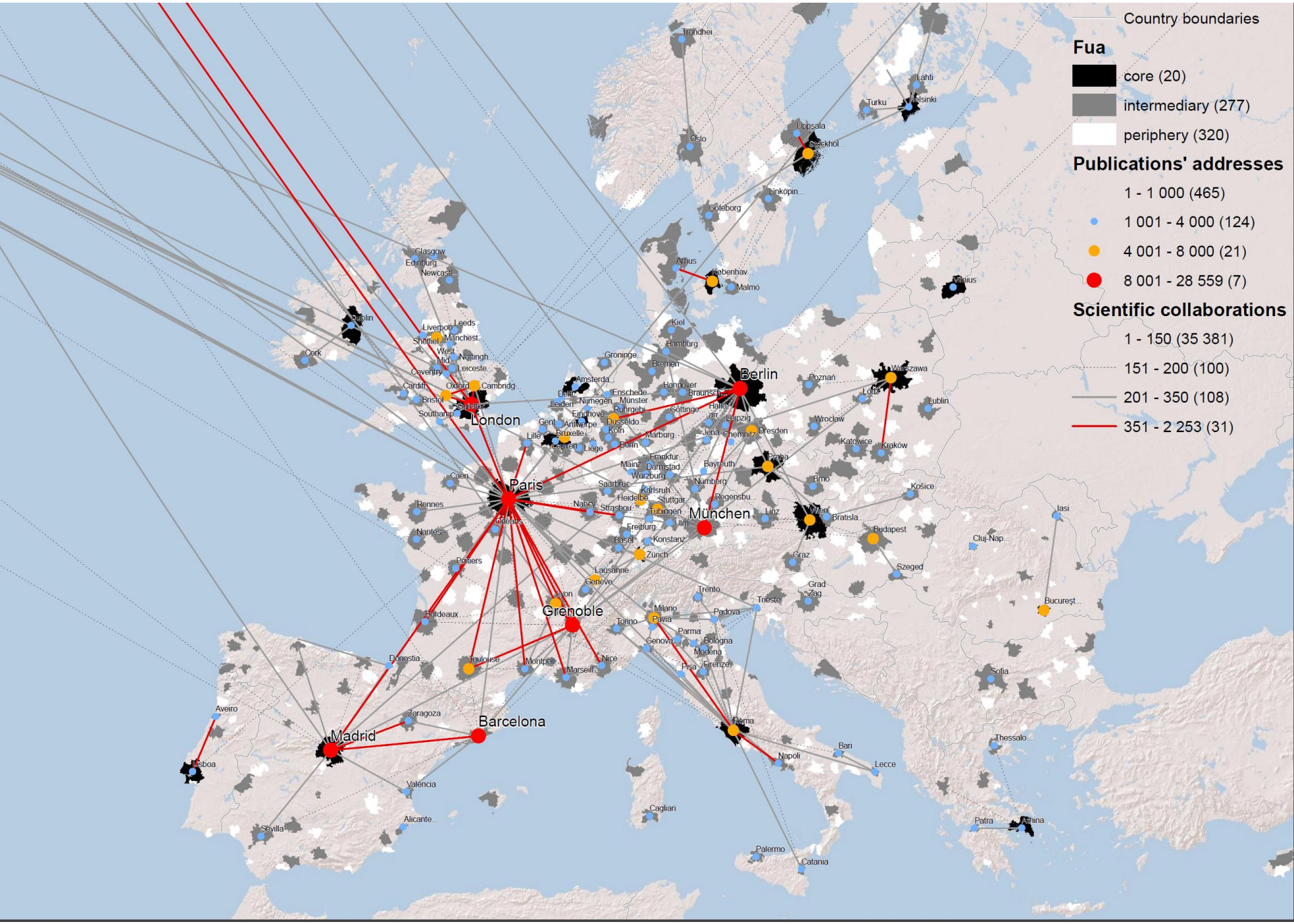
2. Inside each community, with a *Nodal flow* approach (Beauguitte, Giraud, & Guerois, 2016; Nystuen & Dacey, 1961) we identified :
   - Peripheral FUAs – nodes dominated in all their relations
   - Intermediary FUAs - nodes dominating peripheral nodes but dominated by other cores.
   - Core FUAs – nodes dominating all the nodes of their community


Country boundaries
Fua
core-intermediary (145)
periphery (234)
EU funding
8 800 - 5 000 000 (279)
5 000 000 - 15 000 000 (68)
15 000 000 - 30 000 000 (18)
30 000 000 - 165 340 093 (14)
Collaborations in projects
1 - 20 (12 209)
21 - 40 (165)
41 - 80 (39)
81 - 239 (17)
Helsinki
København
Hamburg
Cambridge
London
Bruxelles / Bru...
Leuven
Paris
München
Wien
Lausanne
Grenoble
Roma
Madrid

Main findings from the network of participations

- Collaborations through time do not build community.

- Strong interdependency of main hubs: FUA linked at the European level (Paris, Munich, Roma, and London) which are also driving strong participations with other FUA.
- Paris is dominating these hubs in term of participations (and funding).
- Dense second league of FUA in term of funding in the central part of Europe.

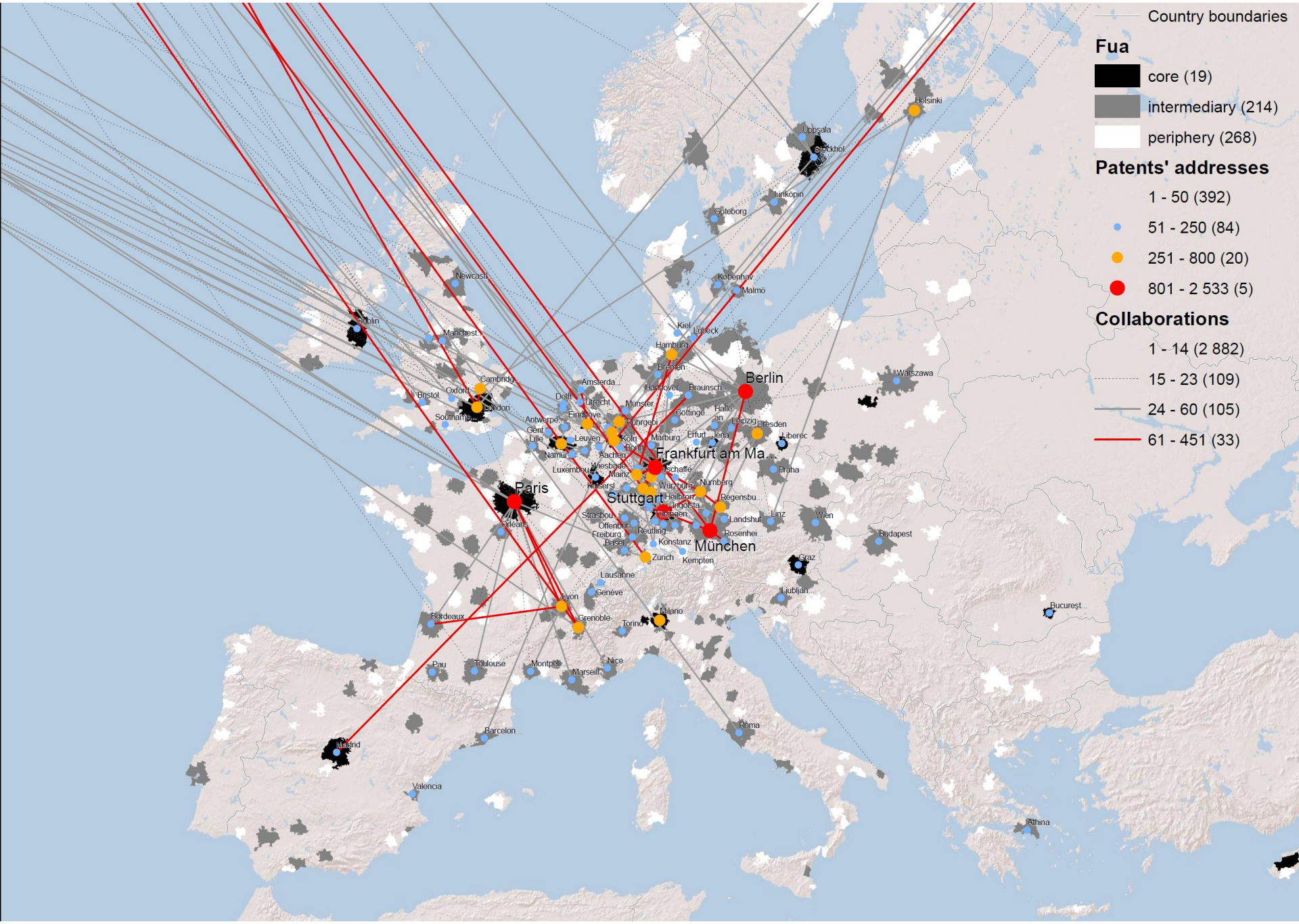

Country boundaries
Fua
core (20)
intermediary (277)
periphery (320)
Publications' addresses
1 - 1 000 (465)
1 001 - 4 000 (124)
4 001 - 8 000 (21)
8 001 - 28 559 (7)
Scientific collaborations
1 - 150 (35 381)
151 - 200 (100)
201 - 350 (108)
351 - 2 253 (31)
Paris
London
Berlin
München
Grenoble
Barcelona
Madrid
Roma
Trondhei...
Oslo
Göteborg
Århus
København
Malmö
Helsinki
Turku
Lahti
Uppsala
Linköpin...
Vilnius
Glasgow
Edinburg...
Newcastl...
Dublin
Cork
Liverpool
Leeds
Manchest...
Sheffiel...
West Mid...
Nottingh...
Leiceste...
Coventry
Cardiff
Oxford
Cambridg...
Bristol
Southamp...
Kiel
Hamburg
Bremen
Groninge...
Amsterda...
Hannover
Braunsch...
Enschede
Delft
Leiden
Nimegen
Münster
Ruhrgebi...
Göttinge...
Halle an...
Leipzig
Dresden
Chemnitz
Jena
Eindhove...
Antwerpe...
Gent
Brüxelle...
Lille
Leuven
Liege
Dusseldo...
Köln
Bonn
Marburg
Frankfur...
Mainz
Darmstad...
Würzburg
Saarbruc...
Karlsruh...
Heidelbe...
Stuttgar...
Nürnberg
Bayreuth
Regensbu...
Tübingen
Ulm
Freiburg
Basel
Konstanz
Zürich
Lausanne
Genève
Trento
Trieste
Milano
Padova
Pavia
Torino
Parma
Genova
Bologna
Modena
Pisa
Firenze
Nice
Montpell...
Marseill...
Toulouse
Bordeaux
Caen
Rennes
Nantes
Poitiers
Orléans
Donostia...
Aveiro
Lisboa
Zaragoza
Valencia
Alicante...
Sevilla
Cagliari
Palermo
Catania
Napoli
Bari
Lecce
Thessalo...
Patra
Athina
Sofia
Bucureşt...
Iasi
Cluj-Nap...
Szeged
Budapest
Graz
Grad Zag...
Wien
Bratisla...
Linz
Brno
Košice
Praha
Katowice
Kraków
Wrocław
Poznań
Łódź
Warszawa
Lublin

Main findings from the collaboration network of authors (exploration)

- More geographically distributed.

- A strong community pattern, with 16 subnetworks (and 21 cores):
  - Nationally structured with the capital city as a core (FR, DE, IT, BE)
  - Language structure for English (UK with AU, CAN, US) and Spanish (ES with Mex, Chile, Colombia)
  - Some others more transnational in Europe (Austria with Finland, Hungary … Poland with Czech, Republic…)

- A set of **cores interlinked FUA** (Paris, Berlin, Munich, Roma …), mainly capital city. They are also driving strong international extra-European relations. There are irrigating intra-national sub-networks intermediary (Grenoble) and with peripheral FUA.
- **Intra-national networks** in the Southern (Madrid and Roma), Eastern (Greece, Warszawa and Vienna) and the Northern (Stockholm and Helsinki) parts of Europe: articulated around FUA (mainly core) with the capital city linked with regional intermediary and peripheral FUA.


Country boundaries
Fua
core (19)
intermediary (214)
periphery (268)
Patents' addresses
1 - 50 (392)
51 - 250 (84)
251 - 800 (20)
801 - 2 533 (5)
Collaborations
1 - 14 (2 882)
15 - 23 (109)
24 - 60 (105)
61 - 451 (33)
Paris
Berlin
Frankfurt am Ma...
Stuttgart
München
Helsinki
Uppsala
Stockhol...
Linköpin...
Göteborg
København
Malmö
Kiel
Lübeck
Hamburg
Bremen
Hannover
Braunsch...
Warszawa
Newcastl...
Dublin
Manchest...
Cambridg...
Oxford
Bristol
London
Southamp...
Amsterda...
Delft
Utrecht
Eindhove...
Antwerpe...
Gent
Lille
Leuven
Namur
Luxembou...
Münster
Bielefeld
Gottinge...
Hallen...
Leipzig
Dresden
Liberec
Erfurt
Jena
Marburg
Köln
Bonn
Aachen
Wiesbade...
Mainz
Kaisersl...
Karlsruhe
Würzburg
Nürnberg
Praha
Heilbronn
Regensbu...
Ingolsta...
Augsburg
Landshut
Linz
Wien
Budapest
Strasbou...
Offenburg
Freiburg ...
Basel
Reutling...
Konstanz
Rosenhei...
Zürich
Kempten
Graz
Lausanne
Genève
Lyon
Ljubljan...
Grenoble
Milano
Torino
Bucureşt...
Bordeaux
Pau
Toulouse
Montpell...
Marseill...
Nice
Barcelon...
Madrid
Valencia
Roma
Athina

Main findings from the collaboration network of inventors (exploitation)

- Also 16 communities (and 22 cores):
  - Two strong nationally structured (France, with two in Germany, but Berlin is not a core);
  - But other communities are much more trans-European (i.e. three communities take place in Italia, where two of them are densely link with others countries).

- A strong “belt” in the central part of Europe, with some core FUA (and sub-national networks), and strong international extra-European collaborations.

- Nearly empty spaces, with peripheral and intermediary FUA, in the southern and Eastern parts of Europe.

- Some European subnetworks are driven and linked by core FUA in US (San-Francisco, Chicago).

Conclusion

- EU Funding plays a role in exploration and exploitation
- EU Funding effect is higher on exploration, specifically on high quality exploration
- Funding, exploration and exploitation networks are different (communities, concentration)
- Other determinants to explain the FUA's performances in exploration / exploitation

Further developments

- Estimation of spatial spillovers between FUAs by means of a spatial econometric extension
- Using yearly data to specify a dynamic model accounting for time effects on the role of EU funding
- Using yearly data to analyse the evolution of the networks over time

Thank you

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