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RESEARCH INFRASTRUCTURE FOR SCIENCE AND INNOVATION POLICY STUDIES

Research Seminar

R&D networks and their effects on heterogeneous modes of knowledge creation: Evidence from a spatial econometric perspective

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Background & objective

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Background

- Knowledge is heterogeneous and unequally dispersed across regions, which does not allow for easy access at every point in space
- Literature highlights the role of R&D networks as channel for cross-region knowledge flows, assuming important impacts of networks on knowledge creation
- Scarce empirical evidence so far – mainly at an aggregated level – neglecting different modes of knowledge creation and types of knowledge outputs (e.g. Sebestyén and Varga 2013, Wanzenböck and Piribauer 2018)

Objective

Estimating impacts of networks on different modes of regional knowledge creation

- from a spatial econometric perspective,
- focusing on knowledge exploration vs. knowledge exploitation, and on
- differences in terms of quantity vs. quality of the knowledge produced

A focus on knowledge exploitation vs. exploration

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- Knowledge creation is a non-linear and heterogeneous process
- Frameworks to categorise the dimensions of heterogeneity

  → different '*modes*' or '*regimes*' of knowledge creation to describe the specific characteristics of the knowledge creation processes
  (e.g. March 1991, Gibbons et al. 1994, Moodysson et al. 2008)

- Following March (1991) we use **exploitation** and **exploration** to grasp the heterogeneity in knowledge creation

Exploitation	Exploration
- application-oriented - industrial setting - product development - market knowledge	- science-oriented - academic setting - research projects & scientific publications - driven by technology and science

Data & scope

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- RISIS as new valuable instrument to jointly analyse data on different modes of knowledge creation in an integrated manner
- To proxy **exploitative** and **explorative** knowledge creation
  - Patent applications (PATSTAT)
  - Scientific publications (CWTS)
- To measure the **quantity** and **quality** of knowledge creation
  - Patent quality index (Squicciarini et al. (2013); PATSTAT)
  - Mean Normalised Citation Score (CWTS)
- **R&D networks** based on European Framework programs (FPs) (EUPRO)
- 270 European NUTS2 regions (EU 27 incl. Switzerland, Norway, UK)
- Econometric approach to estimate determinants:
  Spatial Durbin model (SDM)

Spatial econometric perspective

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- A subfield of econometrics for observing relationships in spatial data, dealing with the issue of spatial dependence (spatial autocorrelation)
- Spatial dependence violates the modelling assumption of independent observations in regression models featuring spatial observations (leading to biased estimates)
- Accounts for this methodological inconsistency by explicitly considering the dependence structure (neighbourhood structure) in the model expression
- By this, interdependencies between (neighbouring) regions can be observed and quantified; also referred to as **spatial spillovers** or **externalities**

A general spatial Durbin model for network effects

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$$y = \rho W y + X\beta + \gamma WX + \varepsilon$$

n–by–1 vector of knowledge output

spatial lag of y with W being the n–by–n spatial weights matrix

n-by-m matrix of knowledge input variables, incl. **regional network embeddedness** (m being the number of expl. variables)

Spatial lags of m explanatory variables (n-by-m)

n–by–1 error term, *with* $\varepsilon \sim N(0, \sigma^2 I_N)$

ρ … spatial autoregressive parameter
β, γ … m-by-1 vectors of estimates

for $i = 1, \ldots, n$ = regions

- Estimation by means of Maximum Likelihood (ML) procedures
- Interpretation of results by means of impact measures

Dependent variables

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- Represent different modes of knowledge creation and knowledge output

	Exploitation	Exploration
Quantity	Share of patents (share of total patents)	Share of scientific publications (share of total publications)
Quality	Patent quality index[a]	Mean Normalised Citation Score (MNCS)

[a] index composed of patents forward citations, patent family size, the number of claims, and the patent generality index (Squicciarini et al. 2013)

- Variables are averages over the period 2013-2015 to reduce the effect of yearly variations
- All dependent variables enter the model in their log-transformed form

Independent variables

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- **Network variables:** R&D networks based on European Framework programs (FPs) to measure regional network embeddedness measured by
  - Degree centrality: number of collaboration partners in EU FPs (measure of direct influence)
  - Authority: Intensity of a region‘s inter-linking with central nodes (measure of indirect influence; log-transformed in model)
- **Control variables:**
  - R&D intensity: R&D expenditures in % of GRP
  - Human resources: share of persons with tertiary education and/or employed in S&T
  - Population: number of inhabitants
  - Specialisation: Index of Specialisation
- All independent variables are averaged over the period of 2007-2009

Impact measures

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- The model coefficients cannot be interpreted directly
- A change in a certain region associated with any given explanatory variable affects the region itself (direct impact), and potentially
- affects all other regions indirectly through the spatial multiplier effect (indirect impact)
- Hence, direct, indirect and total impact measures need to be derived; following LeSage and Pace (2009) the average impact measures are defined as

$$\bar{M}(m)_{direct} = N^{-1}\mathrm{tr}(S_m(W))$$

$$\bar{M}(m)_{total} = N^{-1}\iota_m' \quad (S_m(W))\iota_m$$

$$\bar{M}(m)_{indirect} = \bar{M}(m)_{total} - \bar{M}(m)_{direct}$$

where $$S_m(W) = (I_N - \rho W)^{-1}(I_N\beta_m + W\gamma_m)$$

Direct SDM impact effects

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Quantity

	(1)	(2)	(3)	(4)
	Exploitation	*Exploration*	*Exploitation*	*Exploration*
Direct effects				
Degree	0.001	0.005***	-	-
Authority (log)	-	-	0.064*	0.344***
R&D intensity	0.221***	0.094**	0.210***	0.060*
Human resources	0.014**	0.030***	0.012**	0.021***
Population	0.003***	0.002***	0.002*	0.002***
Specialisation	0.358	0.169	0.346	0.148

Quality

	(1)	(2)	(3)	(4)
	Exploitation	*Exploration*	*Exploitation*	*Exploration*
Direct effects				
Degree	0.007***	0.005**	-	-
Authority (log)	-	-	0.359***	0.267**
R&D intensity	0.277***	0.178*	0.275***	0.163*
Human resources	0.024*	-0.034**	0.019	-0.040***
Population	0.004***	0.002**	0.003***	0.001*
Specialisation	2.767**	2.581**	2.862**	2.637**

Indirect SDM impact effects

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Quantity

	(1)	(2)	(3)	(4)
	Exploitation	*Exploration*	*Exploitation*	*Exploration*
Indirect effects				
Degree	0.001	0.001	-	-
Authority (log)	-	-	0.086	-0.013
R&D intensity	0.324*	-0.125*	0.300*	-0.099*
Human resources	0.022	-0.007	0.021	-0.002
Population	0.001	0.000	0.001	0.001
Specialisation	0.237	-0.801	0.375	-0.678

Quality

	(1)	(2)	(3)	(4)
	Exploitation	*Exploration*	*Exploitation*	*Exploration*
Indirect effects				
Degree	0.010	0.006	-	-
Authority (log)	-	-	0.467	0.288
R&D intensity	0.574	-0.502***	0.617	-0.494***
Human resources	0.083**	0.050**	0.081*	0.048**
Population	0.002	-0.001	0.002	-0.001
Specialisation	5.564	-3.586*	5.621	-3.462*

Impacts of EU funded networks

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- Significant positive impacts on both *exploitative* and *explorative* knowledge creation, **but** effect estimates differ across different modes:
  - For knowledge exploitation, we find generally higher networks effects on the quality of knowledge produced, rather than pure quantity
  - For knowledge exploration, network authority seems to be specifically important, in particular in terms of the quantity of knowledge produced
- In general, network authority (*being connected with other central partners*) has a significantly higher impact on all modes of knowledge creation than degree centrality (*pure number of partners*)
  - Importance of easily branching into different knowledge domains by means of other central inter-regional collaboration partners
  - Supporting effect of tapping into heterogenous knowledge networks
- Spatial spillovers insignificant for network effects, but significant for some control variables, in particular R&D intensity for knowledge exploitation

Individual regional effects - quality (authority)

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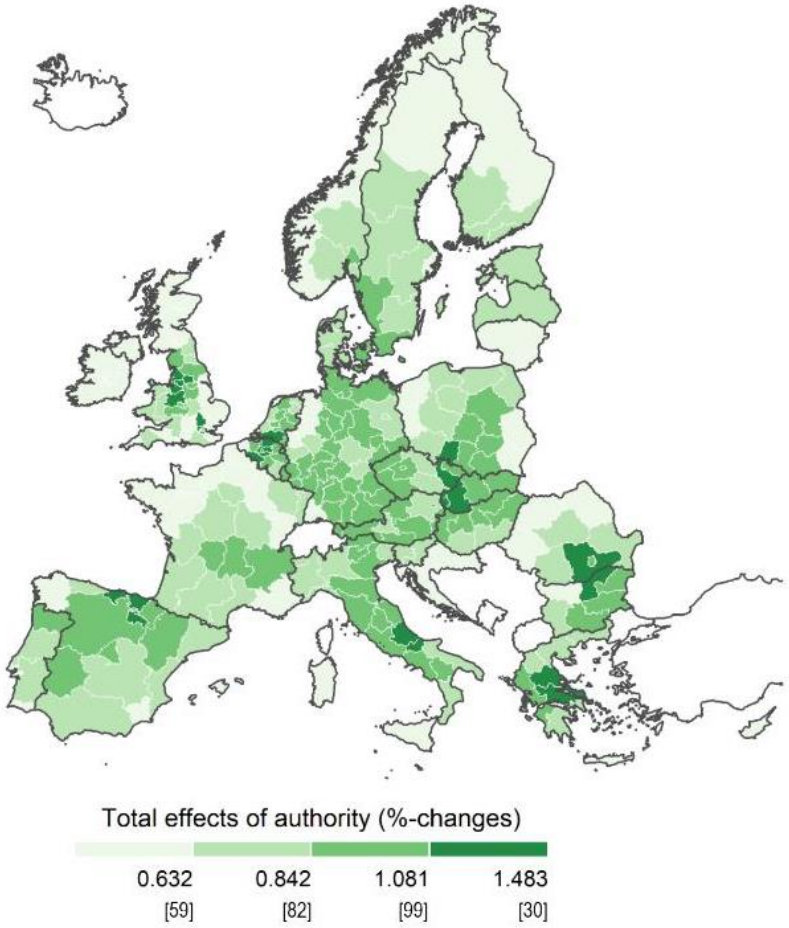
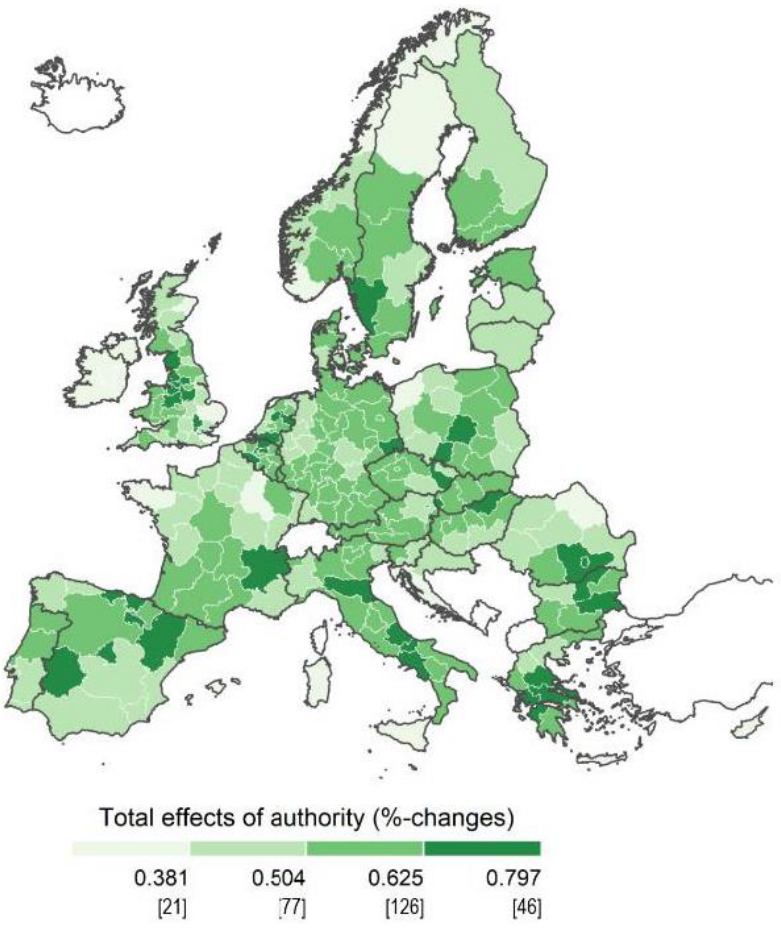
Exploitation



Exploration



Summary & policy conclusions

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- EU funded networks are in general a significant driver for both modes of knowledge creation
  - A higher positive impact of networks on explorative knowledge creation for the quantity of knowledge output, and
  - a higher positive impact of networks on exploitative knowledge creation for the quality of knowledge output

- Differing individual region-specific network effects; some regions particularly benefit (e.g. many UK regions)

  => restricting access to EU funded collaborative projects with possibly strong consequences

  => e.g. for the UK, which could be seen as exemplary for other potential 'exiteers'

- Simple co-location to strongly connected regions is not sufficient (no evidence for spatial spillovers of network effects)

  => policy measures should be targeted at developing region-internal network capability

Limitations

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- Results rest on the choice of the R&D network
  => interpretation of the impacts is limited to this kind of R&D networks
- Aspects of knowledge quality could be highlighed in much more detail
  => considering e.g. a comparison of different types of knowledge quality
- A dynamic perspective on the role of R&D networks might be particularly fruitful in enhancing the future scientific discussion on modes of knowledge creation
- Steadily advancing data bases in RISIS-KNOWMAK, e.g. in the direction of Sustainable Development Goals (SDGs) may open new possibilities for studying field- or technology-specific network effects

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THANK YOU !

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