

European Disparities in Regional Health R&I Performance

Raquel Ortega-Argilés (University of Birmingham, City-REDI)

Monica Plechero (Ca' Foscari University of Venice)

Claudio Cozza (Area Science Park)

Introduction

- Health represents:
 - One of the goals of the European economic growth umbrella strategy Horizon 2020
 - One of the thematic priorities for Smart Specialisation.
- However, until now it has been **difficult to properly measure research and innovation (R&I) in Health sector** and this has represented a barrier to address specific policies in favour of less performing regions.

Introduction

- Why?
 - Lack of data availability particularly at the regional level
 - A difficulty in defining the boundaries of the health sector

Motivation & Aim

- Motivation:
 - A novel dataset on Health as FP7 thematic priority
 - Recent data on ongoing clinical trials and health infrastructures
 - Regional level
- Aim:
 - Provide an analysis of **potential determinants of EU regional health R&I inequalities**, disentangling factors related to two different innovation outputs: **publications propensity and those related to patents propensity.**

Literature review – Innovation in Regions

- **Substantial literature in innovation studies** investigating the R&I capacity of firms and industries in relation to a wide range of determinants
- Recent literature investigating European NUTS2 regions has shown that **knowledge outcomes** are explained by **different elements underpinning their innovation systems** (national, regional and local levels)
- Regions may have **local governance settings** prone to promote specific innovation initiatives, organizations and agents with different attitudes towards acquiring knowledge and innovate

Health industry literature

Innovation scholars have analysed many peculiar aspects of the R&I processes in Health industry and its sub-sectors (pharmaceuticals, biotech, medical devices, etc.)

- **Private sector** takes advantage, via R&D and patents, of the public knowledge generated by **public scientific publications** (Gambardella, 1992)
- **Cumulativeness** of innovation reinforces the concentration of the health sector (Malerba and Orsenigo, 2002)
- Medical equipment industry turns out to be the one where **patents** are considered the most effective mechanisms for appropriating returns from **product innovation** (Cohen et al., 2000; Pammolli et al., 2005)

Health industry literature

- **Collaboration** plays a role. Laboratory **science and clinical research** represent fundamentally different research paradigms. Teams composed by different types of knowledge are more successful in **patenting** (Marting and Moddysson, 2013; Ali and Gittelman, 2016)
- In a more aggregated way, high-tech sector performance (where health can be included) are influenced by **location determinants**, among them: finance capacity, human resources, institutions and infrastructures (Baesu et al., 2015)

H1: Important factors influencing Health R&I performance in Europe are regional high investment in R&D, a good attitude to international collaboration, but also a regional system with a qualitative pool of human resources and good organizational and institutional potential.

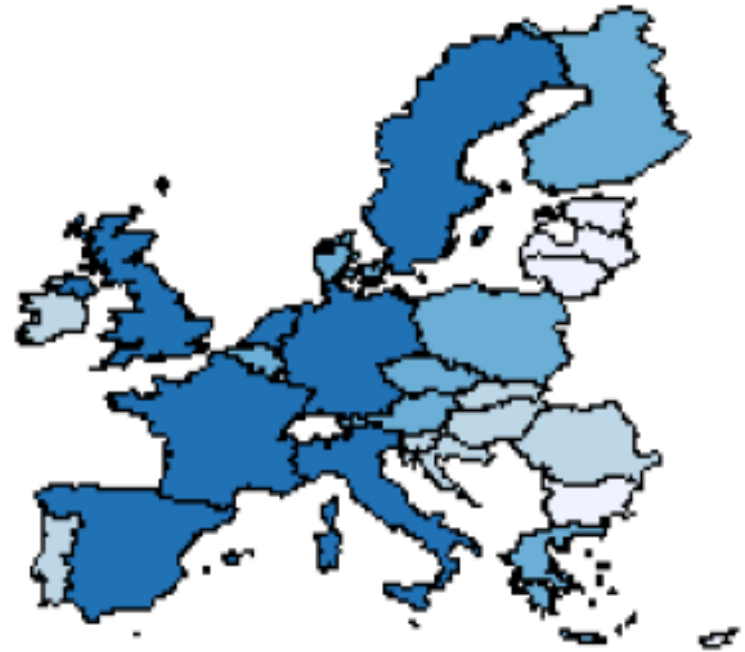
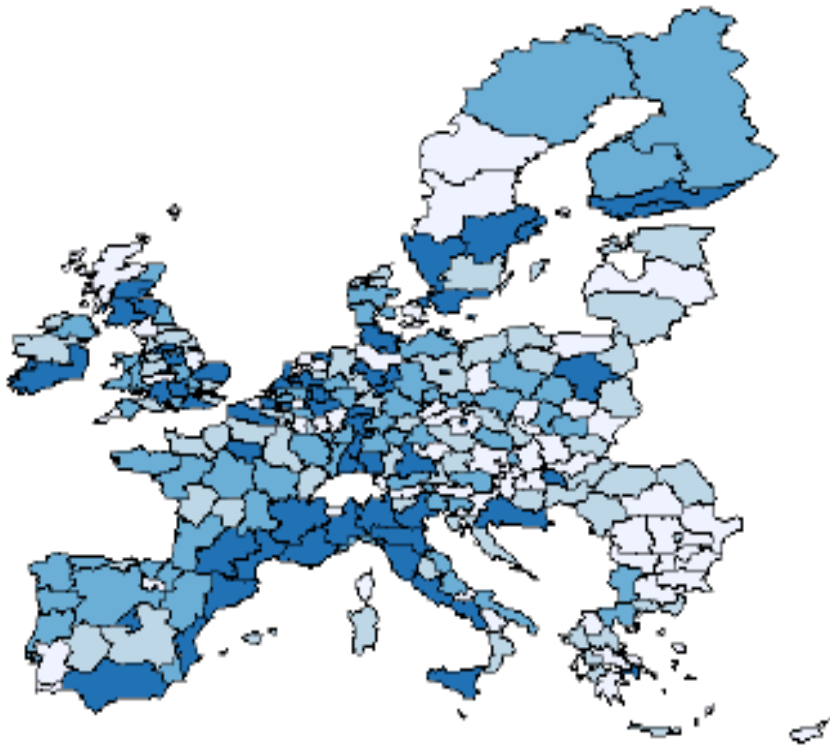
Science vs. technological performances literature

- Regional performance disparities looking alternatively at patents and/or publications.
- Science and technological outputs have **different incentives and aim** to answer different goals (Dasgupta and David, 1987; 1994).
- Negative correlation between highly cited academic publications and patents (Gittelman and Kogut, 2003; Rothermel and Hess, 2007; Subramanian and Lim, 2013)

R&I output propensity in the Health sector - scientific publications

Publications at Regional level

Publications at National level

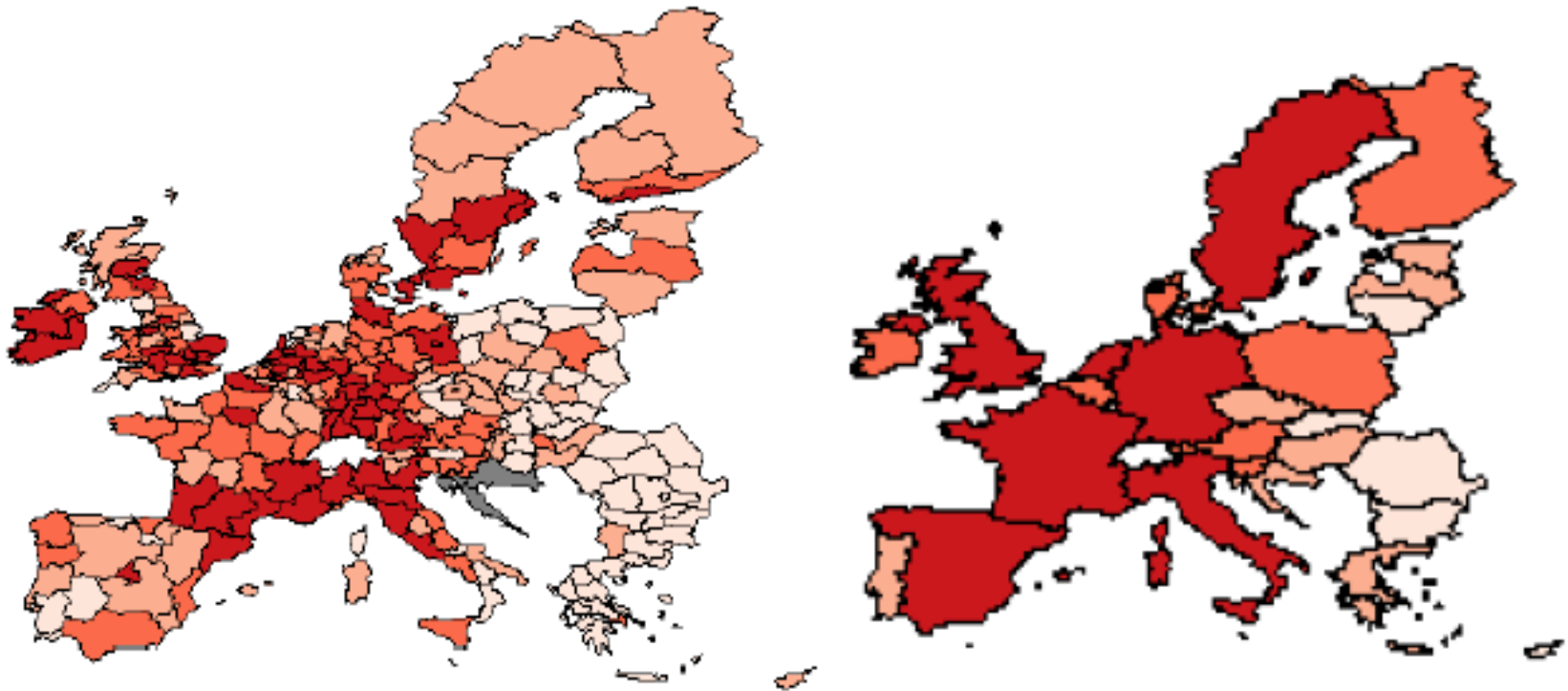


Publications have been classified by FP7 thematic priority – only Health thematic priority is considered here. Publications are in fractional counts. Data are expressed in quartiles and refers to a mean calculated for the years 2008-2010. Lighter colours indicates the first quartile 0.25 (less performing regions).

R&I output propensity in the Health sector – patents

Patents at Regional level

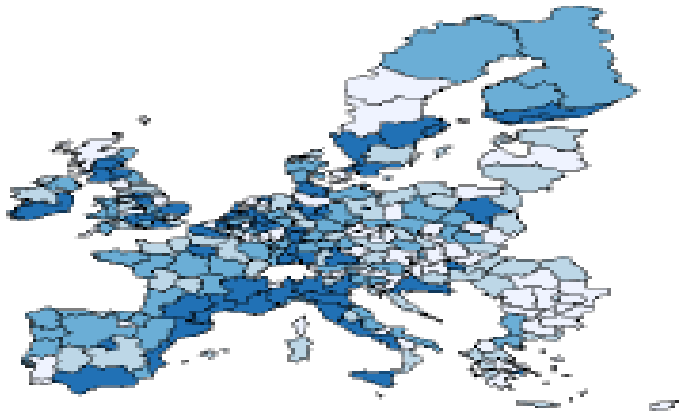
Patents at National level



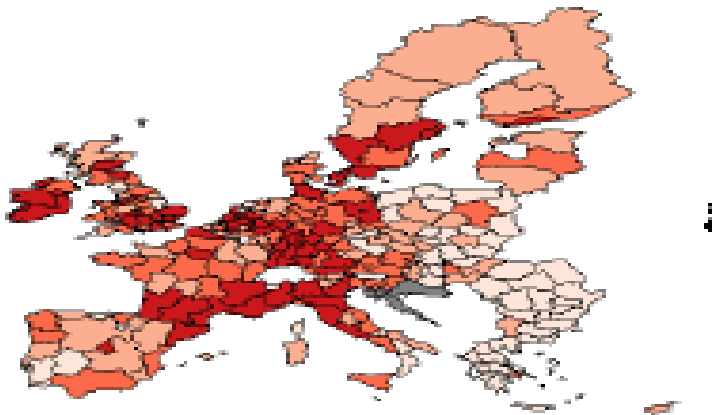
Patents have been classified by FP7 thematic priority – only Health thematic priority is considered here. Patents are EPO patents applications by country of inventor. Data are expressed in quartiles and refers to a mean calculated for the years 2008-2010. Lighter colours indicates the first quartile 0.25 (less performing regions).

R&I output propensity in the Health sector – publications vs. patents

Publications at Regional level



Patents at Regional level



The national homogeneity in health publication and patent disappears looking at the regional level.

Regions outperforming in patenting may underperform in publications and viceversa

Therefore using only one output measure may give a partial image

Science vs. technological performances

- **Scientific performance:**

- Patient-oriented research, population-based research, long-term aim of improving the health of the public (McGartl and Rubio et al., 2010)
- Driven by **research infrastructures** such as medical schools or translational research centres.
- Better represented by **scientific publications and citations**

Give only sense of the **quantity** but not the **quality** of the R&I output in Health (Rigter, 1986 – time consuming heterogeneity

vs.

- **Technological outcomes:**

- Better represented by **patenting activities**
- Follow **market logic strategies** (mainly)
- They do not measure the economic value of the technology (Hall et al., 2001) however they **measure the knowledge production** for example in high-tech innovative milieu/clusters and agglomerations (Baesu et al., 2015; Buesa et al., 2010)

H2: Factors determining patents and publications propensity in Health may be of different nature.

Data

- Place-based analysis suitable data with an industrial focus.
- Novel dataset of Health patents and scientific publications classified on the basis of the Health thematic priority targeted by European Union in two previous FP7 projects.
- Defining Health as the thematic priority used by the European Commission allows contributing better through the analysis to rethink policies in line with targets and economic growth prospects included in their RIS3.
- Additional novel secondary data at regional and sectoral levels for the Health case.

Variables

Typology	Variable name	Variable description	Source
Dependent variables	Health patents	Number of EPO patents application by region of inventor classified on the basis of the Health thematic priority (year 2010)	EC DG-RTD (Framework contract)
	Health publications	Number of publications (frac) classified on the basis of the Health thematic priority (year 2010)	EC DG-RTD (Framework contract)
Independent variables	R&D expenditure on GDP	Intramural RD Expenditure % of GDP 2009	
	Medical schools	N of medical schools in the region with active graduation until year 2009	Own elaboration FAIMER (IMED) database
	Experience in Health publications	Number of publications (frac) classified on the basis of the Health thematic priority (mean: years 2005 - 2009)	EC DG-RTD (Framework contract)
	Experience in Health patents	Number of EPO patents application by region of inventor classified on the basis of the Health thematic priority (mean: years 2005 to 2009)	EC DG-RTD (Framework contract)
	Ongoing clinical trials	Number of recruiting ongoing clinical trials * (year 2015)	Own elaboration CenterWatch database
	FP7 projects participation	Number of FP7 project participation in the region (excluding duplication)	EC DG-RTD (Framework contract)
	EFPIA participation in FP7 projects	Percentage of EFPIA in the region participating in the FP7 projects on total participants	EC DG-RTD (Framework contract)
	Firms participation in FP7 projects	Percentage of firms (including SME) in the region participating in the FP7 projects on total participants	EC DG-RTD (Framework contract)
	Biopharmaceutical top cluster	Cluster specialization (flag for Europe's top clusters in Biopharmaceuticals). Dummy equal to 1 if in the region there is the presence of top clusters, 0 otherwise.	European Cluster Observatory: European Cluster Panorama 2014
	Medical Devices top cluster	Cluster specialization (flag for Europe's top clusters in Medical Devices) Dummy equal to 1 if in the region there is the presence of top clusters, 0 otherwise.	European Cluster Observatory: European Cluster Panorama 2014

Variables (cont.)

	Knowledge workers	Percentage of knowledge workers on total employment (year 2011)	Eurostat, LFS
	Health International tech collaboration	Number of international co-patents involving the given inventors NUTS2 region and third countries inventors for EPO patent applications classified on the bases of Health thematic priority (mean: years 2005-2009) *	EC DG-RTD (Framework contract)
	Government effectiveness	Govern effectiveness: standardized index of quality and fairness of local public school and healthcare system (year 2009) High numbers means higher perception of government effectiveness	EC DG Regio project on QoG
	Low technologically advanced region	1 Low technologically advanced region; 0 otherwise (year 2007)	Eurostat, Politecnico di Milano
	Advanced services region	1 Advanced services region; 0 otherwise (year 2007)	Eurostat, Politecnico di Milano
	Advanced manufacturing region	1 Advanced manufacturing region; 0 otherwise (year 2007)	Eurostat, Politecnico di Milano
	Technologically advanced region	1 Technologically advanced region; 0 otherwise (year 2007)	Eurostat, Politecnico di Milano
Control variables	Widening effect	dummy value equal to 1 if Widening country; 0 otherwise	EC
	Population	Population expressed in habitants (year 2010)	Eurostat
	Health Specialization Index	Specialization in Health with respect to other sectors.(year 2010) Index above 1 means that the country is specialised more in Health with respect to other sectors that the relative specialization of the world, while an index below 1 means the opposite	EC DG-RTD (Framework contract)

Descriptive statistics

Typology	Variable name, unit	Obs.	Mean	Std Dev.	Min	Max
Dependent variables	Health patents, ln	206	1.905	1.528	-2.996	5.241
	Health publications, ln	206	6.114	1.146	3.060	9.051
Independent variables	R&D expenditure on GDP, %	206	1.807	1.257	0.200	7.900
	Medical schools, num.	206	1.481	2.050	0	18
	Experience in Health publications, ln.	206	6.054	1.174	2.771	9.068
	Experience in Health patents, ln.	205	2.140	1.593	-4.605	5.525
	Ongoing clinical trials, ln	206	5.031	1.074	0	7.327
	FP7 projects participation, num.	206	43.087	63.329	1	433
	EFPIA participation in FP7 projects, %	206	1.802	8.216	0	76.471
	Firms participation in FP7 projects, %	206	24.188	22.935	0	100
	Biopharmaceutical top cluster, 0/1	206	0.131	0.338	0	1
	Medical Devices top cluster, 0/1	206	0.097	0.297	0	1
	Knowledge workers, %	206	39.453	7.114	23.300	58.600
	Health International tech collaboration, log	206	0.072	0.334	0	3.620

Descriptive statistics (cont.)

	Government effectiveness, standardized index	206	0.343	0.857	-2.640	1.870
	Low technologically advanced region, 0/1	206	0.199	0.400	0	1
	Advanced services region, 0/1	206	0.350	0.478	0	1
	Advanced manufacturing region, 0/1	206	0.189	0.393	0	1
	Technologically advanced region, 0/1	206	0.262	0.441	0	1
Control variables	Widening effect, 0/1	206	0.175	0.380	0	1
	Population, 100000 of habitants	206	21.214	16.092	3.199	117.862
	Health Specialization Index, standardized index	206	1.098	0.318	0.300	2.360
	Potential market size, standardized index	206	236.169	247.990	2.100	1280

Results

Regional as well as sectoral determinants influence both types of outputs.

Among the common determinants appear:

- Population (+)
- Health Specialisation Index (+)
- R&D expenditure over GDP (+)

	Health patents propensity		Health Publications propensity	
	All regional effects Model A (I)	Widening effect Model A (II)	All regional effects Model B (I)	Widening effect Model B (II)
Widening effect		-0.492** [0.224]		-0.101 [0.148]
Population	0.030*** [0.006]	0.029*** [0.006]	0.015*** [0.004]	0.015*** [0.004]
Potential market size	0.000 [0.000]	0.000 [0.000]	-0.000* [0.000]	-0.000* [0.000]
Health Specialization Index	0.491** [0.224]	0.375* [0.215]	0.780*** [0.161]	0.755*** [0.154]
R&D expenditure on GDP	0.242*** [0.063]	0.218*** [0.061]	0.131*** [0.041]	0.128*** [0.040]
Medical schools	-0.061 [0.039]	-0.058 [0.037]	0.026 [0.033]	0.026 [0.033]
Experience in Health publications	0.234* [0.125]	0.188 [0.124]		
Experience in Health patents			0.198*** [0.054]	0.187*** [0.057]
Ongoing clinical trials	-0.032 [0.085]	0.011 [0.089]	0.277*** [0.057]	0.285*** [0.059]
FP7 project participation	0.002 [0.001]	0.002* [0.001]	0.003*** [0.001]	0.003*** [0.001]
EFPIA participation in FP7 projects	-0.001 [0.006]	-0.001 [0.006]	-0.007** [0.003]	-0.007** [0.003]
Firms participation in FP7 projects	0.009*** [0.003]	0.008** [0.003]	-0.012*** [0.002]	-0.012*** [0.002]
Biopharmaceutical top cluster	0.379*** [0.144]	0.375*** [0.140]	-0.052 [0.100]	-0.048 [0.100]
Medical Devices top cluster	0.677*** [0.181]	0.652*** [0.181]	-0.070 [0.095]	-0.070 [0.095]
Knowledge workers	0.014 [0.016]	0.028* [0.017]	0.012 [0.010]	0.015 [0.011]
Health International tech collaboration	0.438*** [0.071]	0.415*** [0.068]	-0.018 [0.042]	-0.018 [0.042]
Government effectiveness	0.281*** [0.091]	0.207** [0.100]	-0.090 [0.054]	-0.102* [0.054]
Advanced service region	0.241 [0.246]	0.160 [0.256]	-0.119 [0.158]	-0.133 [0.161]
Advanced manufacturing region	0.404 [0.281]	0.422 [0.270]	-0.404*** [0.154]	-0.394*** [0.150]
Technologically advanced region	0.509** [0.251]	0.421 [0.262]	-0.148 [0.167]	-0.162 [0.170]
Constant	-2.356*** [0.623]	-2.397*** [0.638]	2.849*** [0.418]	2.797*** [0.447]
N	206	206	205	205
Adjusted R-squared	0.6746	0.6818	0.7916	0.7911
P	0	0	0	0

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, denote 10%, 5% and 1% significance

level respectively. Robust standard errors in parenthesis

Health Patents Propensity

• The main determinants are:

– **Critical mass:**

- R&D intensity
- Population
- Health specialisation
- Technological advanced region
- Promoting cluster creation
- Knowledge workers

– **Collaboration:**

- Local/Regional contribution to FP7 programmes – firm participation (+)
- Health international collaboration (+)
- Top cluster activity (+)

• Patenting activities seem to be more linked to **private sector** activities and technological assets

	Health patents propensity	
	All regional effects Model A (I)	Widening effect Model A (II)
Widening effect		-0.492** [0.224]
Population	0.030*** [0.006]	0.029*** [0.006]
Potential market size	0.000 [0.000]	0.000 [0.000]
Health Specialization Index		0.375* [0.215]
R&D expenditure on GDP	0.242*** [0.063]	0.218*** [0.061]
Medical schools	-0.061 [0.039]	-0.058 [0.037]
Experience in Health publications	0.234* [0.125]	0.188 [0.124]
Experience in Health patents		
Ongoing clinical trials	-0.032 [0.085]	0.011 [0.089]
FP7 project participation	0.002 [0.001]	0.002* [0.001]
EFPIA participation in FP7 projects	-0.001 [0.006]	-0.001 [0.006]
Firms participation in FP7 projects	0.009*** [0.003]	0.008** [0.003]
Biopharmaceutical top cluster	0.379*** [0.144]	0.375*** [0.140]
Medical Devices top cluster	0.677*** [0.181]	0.652*** [0.181]
Knowledge workers	0.014 [0.016]	0.028* [0.017]
Health International tech collaboration	0.438*** [0.071]	0.415*** [0.068]
Government effectiveness	0.281*** [0.091]	0.207** [0.100]
Advanced service region	0.241 [0.246]	0.160 [0.256]
Advanced manufacturing region	0.404 [0.281]	0.422 [0.270]
Technologically advanced region	0.509** [0.251]	0.421 [0.262]
Constant	-2.356*** [0.623]	-2.397*** [0.638]
N	206	206
Adjusted R-squared	0.6746	0.6818
P	0	0

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, denote 10%, 5% and 1% significance level respectively. F

errors in parenthesis

Health Publications Propensity

- The main determinants:
 - **Critical mass** including knowledge workers
 - **Health history of the region**
 - Regional path dependency: experience in Health patenting and ongoing clinical trials.
- Publication activities seem to be more linked to **public sector** activities, in particular, hospitals and education.
- **Private activity seems to lower publication propensity** (advanced manufacturing region, firms participation in FP7 projects)
- Publications processes are more linked to **previous stages in the patenting and commercialisation processes**, such as basic science (“bench”) to tangible medical innovation (“the bedside”) captured by R&D and clinical trials.

	Health Publications propensity	
	All regional effects Model B (I)	Widening effect Model B (II)
Widening effect		-0.101 [0.148]
Population	0.015*** [0.004]	0.015*** [0.004]
Potential market size	-0.000* [0.000]	-0.000* [0.000]
Health Specialization Index	0.780*** [0.161]	0.755*** [0.154]
R&D expenditure on GDP	0.131*** [0.041]	0.128*** [0.040]
Medical schools	0.026 [0.033]	0.026 [0.033]
Experience in Health publications		
Experience in Health patents	0.198*** [0.054]	0.187*** [0.057]
Ongoing clinical trials	0.277*** [0.057]	0.285*** [0.059]
FP7 project participation	0.003*** [0.001]	0.003*** [0.001]
EFPIA participation in FP7 projects	-0.007*** [0.003]	-0.007*** [0.003]
Firms participation in FP7 projects	-0.012*** [0.002]	-0.012*** [0.002]
Biopharmaceutical top cluster	-0.052 [0.100]	-0.048 [0.100]
Medical Devices top cluster	-0.070 [0.095]	-0.070 [0.095]
Knowledge workers	0.012 [0.010]	0.015 [0.011]
Health International tech collaboration	-0.018 [0.042]	-0.018 [0.042]
Government effectiveness	-0.090 [0.054]	-0.102* [0.054]
Advanced service region	-0.119 [0.158]	-0.133 [0.161]
Advanced manufacturing region	-0.404*** [0.154]	-0.394*** [0.150]
Technologically advanced region	-0.148 [0.167]	-0.162 [0.170]
Constant	2.849*** [0.418]	2.797*** [0.447]
N	205	205
Adjusted R-squared	0.7916	0.7911
P	0	0

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, denote 10%, 5% and 1% significance

level respectively. Robust standard errors in parenthesis

Private-Public R&D investment dichotomy

Tab. 2 - Correlation coefficient between different typology of expenditure in R&D and patents and publications propensity

R&D expenditure	Health Patents	Health Publications
BERD R&D (n 83)	0.7555	0.6140
GOVERD R&D (n. 113)	0.5640	0.6956
HERD 0509 (n. 116)	0.6006	0.8666

Source: own elaboration EU DG data and EUROSTAT data. BERD (business expenditure in R&D), GOVERD (government expenditure in R&D) and HERD (higher educational R&D expenditure) are calculated on the average of previous 5 years to the referred year 2010 for patents and publications. All variables are in log terms. Correlations are significant at 1% level.

Conclusions

- Our paper aimed at contributing to a better understanding of the **Health sector in European regions**.
- Through the use of novel data at regional and sectoral levels the paper has analysed for the health sector targeted as a priority for EU S3 the **propensity to produce research and innovation outcomes measured as publications and patent counts**.

Conclusions

- Our findings are clearly in line with previous empirical evidence supporting the benefits of **agglomeration, specialisation and internationalisation in promoting innovation at the regional level**.
- **Scientific publications and patents** promotion require differentiate inputs and regional conditions.
- The **nature** of these two innovation outputs differs. **Patenting** is linked with industrial **private sector** and commercialisation purposes, **publications** are mainly related to **public basic research** (“bench”) and **experimentation** in the form of clinical trials (“bedside”).
- Higher propensity to **patent** in **non-widening countries**, although regional factors play also a role in widening countries. Good performances in **publications** can also be found in **regions belonging to widening countries** – concluding that codified knowledge is usually less linked to the territorial aspects (Polanyi, 1983) if not directly related to support the experimentation of new knowledge.

Policy implications

- Importance of analysing the **characteristics of favourable innovation and entrepreneurship ecosystems for the development of emerging industries** and cluster initiatives in the area of health care and related industries.
- Nurturing **emerging healthcare niches** at the same time, relying on local and international collaboration platforms and favouring the cross-disciplinary skills needed in the industry.
- Given the importance of specialisation and path dependence, investments for smart specialisation should be done in regions that show a **real potential to exploit the benefits.**