KIT
Knowledge, Innovation, Territory

Applied Research 2013/1/13

Final Report | Version 13/11/2012

EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

This report presents the interim results of an Applied Research Project conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

Information on the ESPON Programme and projects can be found on www.espon.eu

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This basic report exists only in an electronic version.

List of authors

BEST – Politecnico di Milano, LP

Prof. Roberta Capello (Project scientific coordinator)
Prof. Roberto Camagni
Dr. Camilla Lenzi (Project manager)
Dr. Andrea Caragliu

CRENOS – University of Cagliari, P2

Prof. Raffaele Paci
Prof. Emanuela Marrocu
Prof. Stefano Usai
Dr. Alessandra Colombelli
Dr. Marta Foddi

AQR – University of Barcelona, P3

Prof. Rosina Moreno
Prof. Jordi Suriñach
Prof. Raúl Ramos
Dr. Ernest Miguélez

London School of Economics, P4

Dr. Riccardo Crescenzi
Prof. Andrés Rodríguez-Pose
Prof. Michael Storper

University of Economics in Bratislava, P5

Prof. Milan Buček
Dr. Miroslav Šipikal
Dr. Rudolf Pástor

Cardiff University, P6

Prof. Phil Cooke
Dr. Selyf Morgan
Julie Porter

Table of contents

Figures

Maps

Tables

Acronyms and glossary

CIS – Community Innovation Survey
DEA - Data Envelopment Analysis
EFTA - European Free Trade Association
ELASTICITY - Elasticity is the measurement of how changing one independent variable affects the dependent variable; in detail, it is the ratio of the percentage change in one independent variable to the percentage change in the dependent variable, being thus independent of units.
EPO – European Patent Office
ERA – European Research Area
EU – European Union
EU15 – Austria, Belgium, Denmark, Germany, Finland, France, Greece, Spain, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden, United Kingdom
EU12 - Bulgaria, Cyprus, Czech Republic, Hungary, Estonia, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia
FDI – Foreign Direct Investment
GDP – Gross Domestic Product
GMR – Gross Migration Rate
GPT – General Purpose Technology
KIS – Knowledge-Intensive services
KIT – Knowledge, Innovation and Territory
KPF – Knowledge Production Function
IMR – Inward Migration Rate
IPC – International Patent Classification
MHHT – Medium-high tech manufacturing
MNC – Multinational Corporation
MSA – Metropolitan Statistical Areas
NMR – Net Migration Rate
NMS – New Member States
NUTS – "Nomenclature d'unites territoriales statistiques"
OECD – Organisation for Economic Cooperation and Development
OMR – Outward Migration Rate
OST - Observatoire des Sciences et des Techniques
PF – Production function
R&D – Research and Development
SAR - Spatial Autoregressive Model
SEM - Spatial Error Model
SME – Small-Medium Enterprises
SNA – Social Network Analysis
TAR – Technologically Advanced Regions
TFP – Total Factor Productivity
UK – United Kingdom
US – United States

Introduction: aim of the project

The KIT project has the general aim to help – on the basis of sound scientific research – the setting up of strategies on innovation that are consistent with the overall reforms of EU Cohesion Policy. For this aim, the KIT project provides suggestions for implementing the smart specialization policies in the field of innovation - called for by the EU in its official document *Regional Policy Contributing to Smart Growth in Europe* (EU, 2010) - and to launch a territorial strategy to achieve a "smart Europe" in the years to come.

The KIT project enters the debate on "smart specialization" strategies in the field of innovation by overcoming the simplistic dichotomy – made by the first promoters of such a policy (Foray et al., 2009) – between centre and periphery, between an European research area (the core) and a co-application of scientific general purpose technologies area (the periphery). As the whole KIT project demonstrates, the geography of innovation is much more complex than a simple core-periphery model; the capacity to turn knowledge and innovation into regional growth is different among regions, and the identification of regional specificities in innovation patterns is essential to build targeted normative strategies efficient for a cohesion policy goal.

A specific conceptual approach lies behind the KIT project. All the analysis tries to escape the idea that knowledge and innovation are coinciding processes, giving for granted that if knowledge is created locally, this inevitably leads to innovation, or if innovation takes place, this is due to local knowledge availability. A similar conceptual distance is assumed also with regard to the straightforward linkage between knowledge/innovation and performance, which expects a productivity increase in all cases in which a creative effort, a learning process, an interactive and cooperative atmosphere characterize the local economy.

Instead, factors that enhance the implementation of new knowledge, an invention, can be quite different from the factors which stimulate innovation. Invention, innovation and diffusion are not necessarily intertwined, especially at the local level. Firms and individuals which are leading an invention are not necessarily also leaders in innovation or in the widespread diffusion of new technologies. The history of technology and innovation is full of examples of this kind; the fax machine, first developed in Germany, was turned into a worldwide successful product by Japanese companies. Similarly, the anti-lock brake systems (ABS) was invented by US car makers but became prominent primarily due to German automotive suppliers (Licht, 2009).

Moreover, it is by no means always the case that technological catching-up shows a positive correlation with economic convergence; the strong economic growth performance of Eastern countries up to 2008 is certainly not related to knowledge economy growth, as these countries (and their regions) have witnessed no technological catching-up in those years. Regional economic growth is weakly related to different scientific indicators, both of input (R&D) and of output (patenting activity). To support this further, a simple correlation run on a sample of 286 NUTS2 regions in Europe between regional growth in the years 2006-2008 and R&D on GDP in 2007 shows a negative (and significant) value (-0.33); the value of the correlation index remains negative and significant (-0.23) when the correlation is measured between regional growth in the years 2006-2008 and patents per capita in a period of 2005-2006.

All this suggests that innovation can be the result of different modes of performing each phase of the innovation process; that the increase in knowledge and innovation does not always lead to greater regional performance; and that regional productivity gains can be the result of innovation gains in regions with limited knowledge creation capabilities.

The variety of innovation modes explains the failure of a "one-size-fits-all" policy to innovation, like the thematically/regionally neutral and generic R&D incentives, with the expectation to develop a knowledge economy everywhere. On the contrary, innovation modes specific of each area have to be identified, based on local specificities and capabilities to cumulate knowledge, and to turn it into innovation and growth. It is on these specificities that ad-hoc, targeted innovation policies can be drawn, in order for cohesion policies in the field of innovation to be efficient and effective.

In order to identify local specificities and capabilities of regions to cumulate knowledge, and to turn it into innovation and growth, a careful analysis is required on: i) knowledge and innovation diffusion; iii) territorial specificities behind innovation modes; and iii) knowledge and innovation impact on regional growth.

The final report of the KIT project presents a large quantity of empirical material, dealing with:

i) the spatial trends of the knowledge economy (sec. 1);

ii) the identification of the pathways towards innovation and modernization, which turn to be highly differentiated among regions according to local specificities (sec. 2);

iii) the measurement of the impact of knowledge and innovation on regional economic performance for differentiated territorial modes of innovation (sec. 3 to 5);

iv) the suggestion of ad-hoc innovation policy actions that go beyond the thematically and regionally neutral and generic orientation of R&D funding investments (sec. 6).

A specific definition of "knowledge economy" is behind the empirical analysis, since we are convinced that the knowledge economy has a multidimensional definition, based on the three main conceptual paradigms; a sector-based paradigm, a function-based paradigm, and a networking paradigm. The geographical picture of the knowledge economy shows a remarkably impressive and unexpected lag in its spatial diffusion. What is also impressive from the geographical descriptive analysis is the wide spatial variance of all kinds of innovation (product, process, managerial, social innovation) that crashes with the high concentration of knowledge activities in core areas in Europe (sec. 1).

The discrepancy between knowledge and innovation at the spatial level can only be understood by identifying the different pathways towards innovation and modernization that each region in Europe follows, based on local preconditions that can guarantee the creation of knowledge and the capacity to exploit knowledge for innovating (sec. 2). With this exercise, a map of we call the "**territorial patterns of innovation**" in Europe is obtained, in which regions are grouped according to the different modes of performing the different phases of the innovation process (sec. 2).

This typology of regions overcomes similar attempts made to cluster European regions according to their knowledge performance (OECD, 2010, 2011); it moves in fact away from the traditional science-based typology, and classifies the modes of performing all phases of the innovation process, from knowledge creation (and knowledge acquisition), to innovation, to growth. This linear model of innovation is sometimes a process that takes place all in the same region, but can also be the result of an innovation process that builds mostly on (formal and informal) external knowledge, or can even take place mostly outside the region, which innovates thanks to an imitative process of external innovation (sec. 2).

It is on the concept of patterns of innovation that the KIT project analyses the impact of knowledge and innovation on regional performance (sec. 3 and 4). The richness of the results obtained by this empirical analysis helps in understanding the difficulties in using innovation tools to generate growth. For example, R&D generates positive effects only when a critical mass of R&D is present, but also has a lower elasticity with respect to human capital for generating knowledge and growth; or, total factor productivity is high in areas with a very limited R&D activity, telling us once again that R&D is not the only tool to achieve high productivity levels (sec. 4). Much more information is obtained by the twelve case studies (sec. 5).

All results are fundamental to respond to the question how a smart specialization sectoral concept, like the innovation policy concept, can be targeted to a spatial regional setting; the results of the project lead to the formulation of smart innovation policies oriented to reinforce each territorial innovation mode and to support evolutionary processes from one territorial innovation pattern to another (sec. 6). **The normative suggestions that come out can fulfil the gap nowadays existing in implementing the "smart specialization policies" in the field of innovation** – as required by the EU in its official document *Regional Policy Contributing to Smart Growth in Europe* (EU, 2010).

1. Spatial patterns of knowledge and innovation in Europe

1.1. Definition of the knowledge economy

The knowledge economy has a multidimensional definition, something reflected also in the literature that probably explains the suggestion of OECD to use about sixty indicators - among which R&D and high technology activities play a dominant role - to measure a knowledge economy (OECD, 2004). We adopted a historical approach to identify a definition to the concept, finding interesting ideas in the three main conceptual paradigms with which knowledge economy was interpreted; a sector-based paradigm, a function-based paradigm, and a networking paradigm. All these were successively proposed and held for long times. Based on these paradigms, the definition of a knowledge economy used in this project is that a local economy can be labelled a knowledge economy when it is able to produce new knowledge from technologically advanced sectors and/or functions present in the area and/or where knowledge is obtained being linked (formally or informally) with other economies.

We therefore analysed the EU territory according to the presence of "science-based" or high-technology sectors; regions hosting these sectors are considered as regions helping the transformation of the economy, and labelled **"technologically advanced regions".** However, this approach is far too simplistic, since it does not explain many knowledge-based advances that were (and are) possible and are actually introduced by "traditional" sectors – such as textiles and car production - in their path towards rejuvenation in the eighties. A second typology of regions is therefore identified, based on a function-based approach, which stressed the importance of pervasive and horizontal functions like R&D and high education. "**Scientific regions"**, hosting large and well-known scientific institutions, are for this reason identified in the EU territory. This approach, equating knowledge and scientific research, is very important since it was the one launched again by the European Commission Strategy defined in the Lisbon Agenda, and, more recently, in the EU2020. It is difficult to escape the impression that both the sector-based and the function-based paradigms to the knowledge-based economy, both driven by the need to measure and quantify, result in a simplified picture of the complex nature of knowledge creation and its relation to inventive and innovative capability. The presence of advanced sectors and advanced functions like R&D and higher education are special features of only some of the possible innovation paths and, though relevant, cannot be considered as necessary or sufficient preconditions for innovation. The third stage of reflection, typical of the present in which a relation-based paradigm emerges, concentrates on the identification of a "cognitive capability" (Foray, 2000): the ability to manage information in order to identify and solve problems, or, more precisely in the economic sphere, the ability to transform information and inventions into innovation and productivity increases, through co-operative or market interaction. Based on these paradigms, technologically advanced regions and scientific regions have to be complemented by "**knowledge networking regions**".[1]

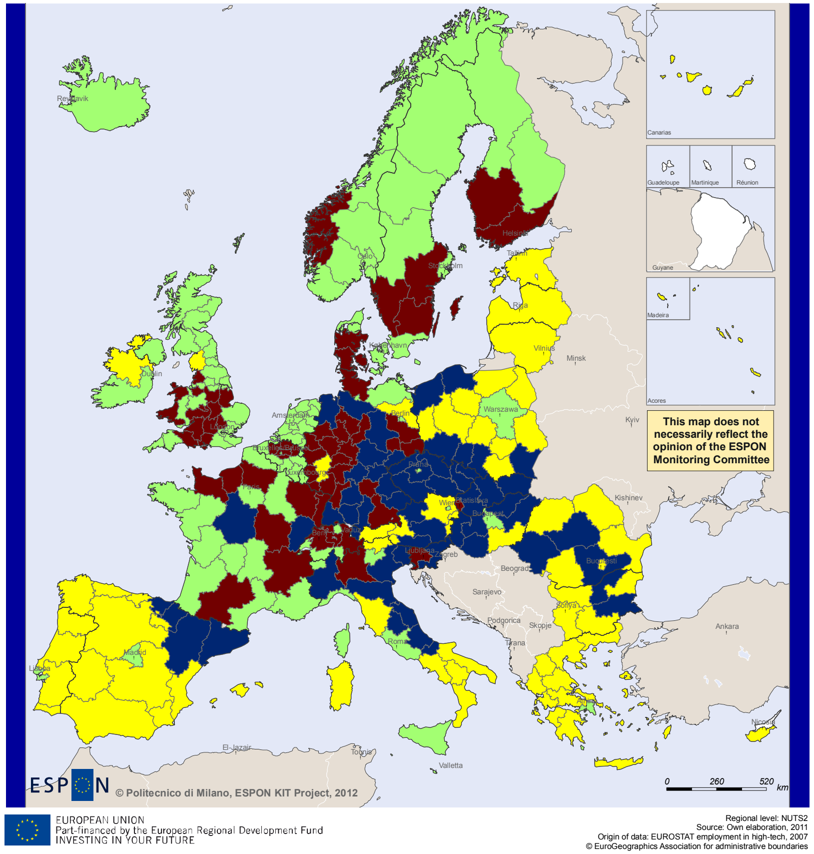
The knowledge economy can manifest itself in these three different forms on the territory, forms that sometimes complement each-other and sometimes substitute each-other. This multidimensional definition (sector-, function-, networking-based) is a first step **to go away from the simplified idea that: i) R&D equates knowledge, that ii) a knowledge economy is a synonymous of a scientific (R&D-based) economy and iii) that R&D investments are the right and unique innovation policy measures to support a knowledge economy**.

1.2. Spatial patterns of the knowledge economy in Europe

Following the logic outlined above, this project maps the knowledge economy in Europe by measuring the presence in each region of technologically advanced sectors, of scientific functions and of knowledge networking activities.

Map 1.1.1. presents the *Technologically-Advanced Regions* (henceforth, TAR), defined as those regions which present simultaneous specialization in both medium-high tech manufacturing (MHHT) and knowledge-intensive services (KIS). The definition of high tech industries is also

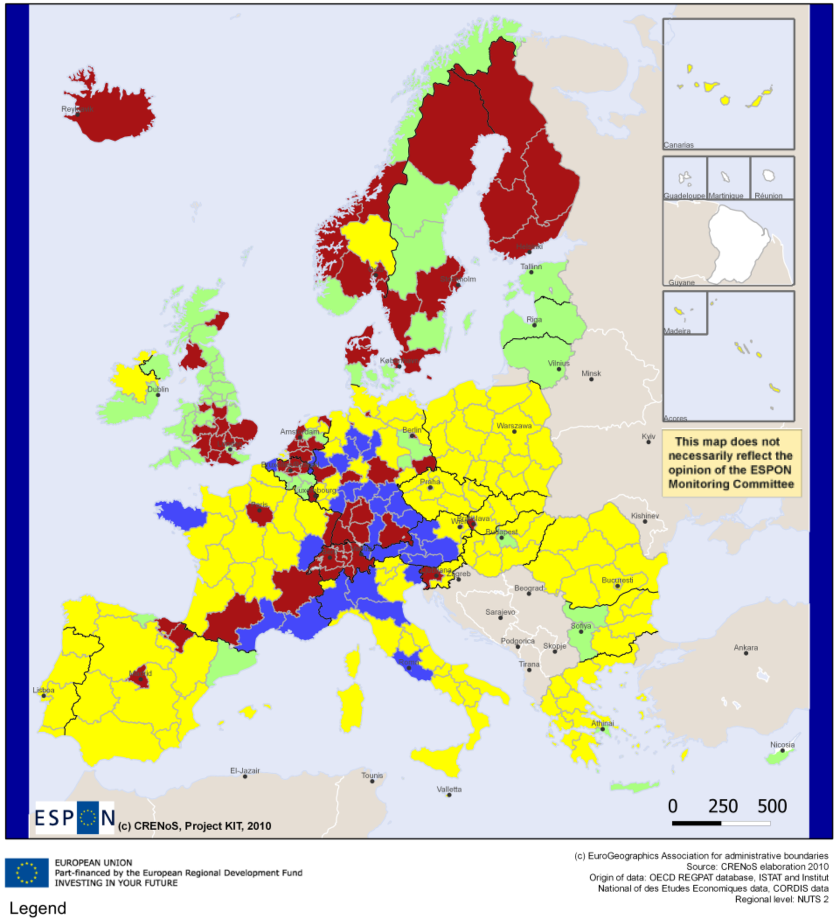
[1] For technical details on the construction of the three typologies of knowledge-economy regions, see the KIT Interim report.



Legend

- No data
- Low-tech regions
- Advanced manufacturing regions
- Advanced services regions
- Technologically-advanced regions

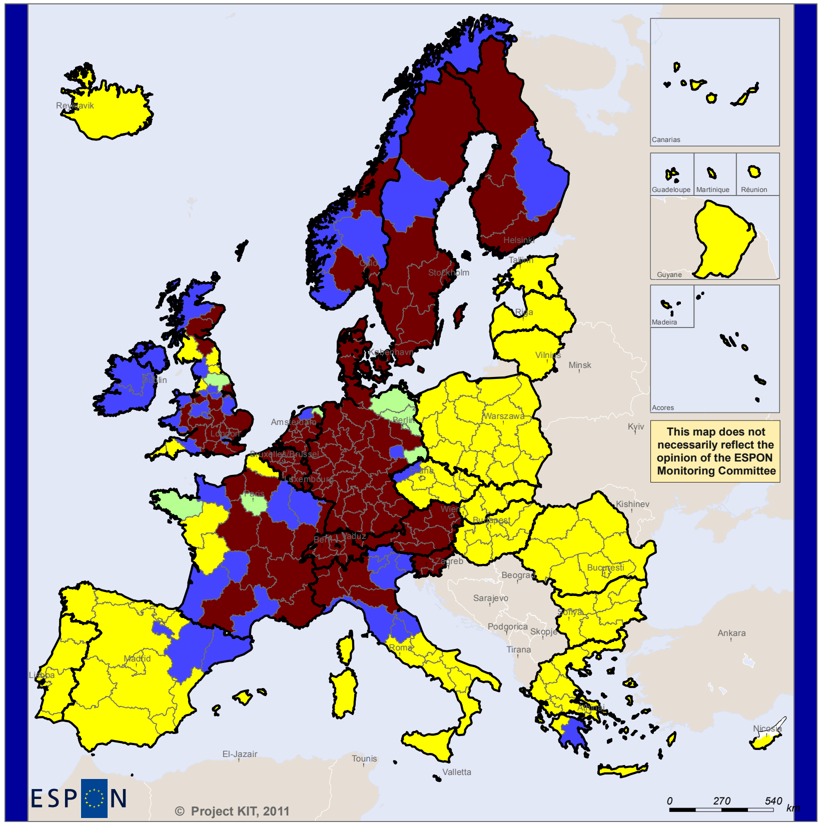
Map 1.1.1. Technologically-advanced regions in Europe (2007)



Legend

- no data
- Scientific regions
- Research intensive regions
- Regions with no specialization in knowledge activities
- Human capital intensive regions

Map 1.1.2. Scientific regions in Europe



EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

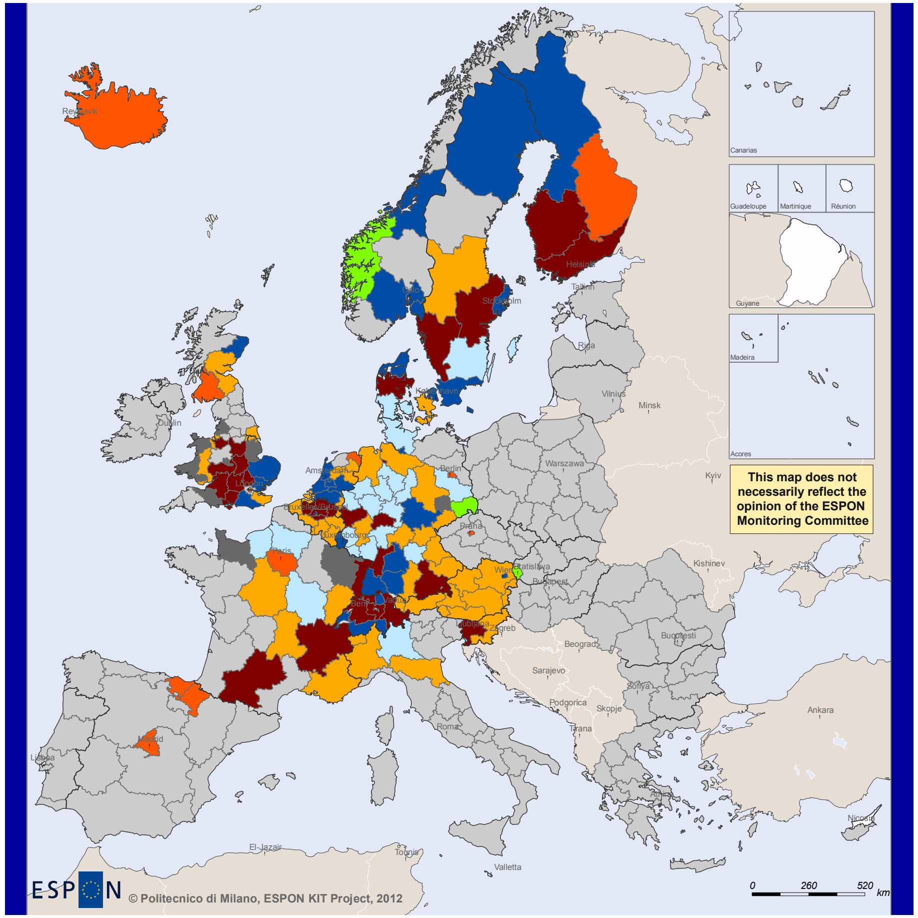
Regional level: NUTS 2
Source: AQR elaboration, 2011
Origin of data: OECD REGPAT Database, Cordis, EUROSTAT, ISTAT and Institute National de la Statistique et des Études Économiques data

Category	Meaning	Specialization in informal linkages	Specialization in formal linkages
1	Non-interactive regions	No	No
2	Clustering regions	Yes	No
3	Globalizing regions	No	Yes
4	Networking regions	Yes	Yes

Knowledge networking regions

- Non-interactive regions
- Clustering regions
- Globalizing regions
- Networking regions
- No data

Map 1.1.3. Knowledge networking regions in Europe



EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

Regional level: NUTS2
Source: Own elaboration, 2011
Origin of data: EUROSTAT and REGPAT, 2007

Legend

- No data
- None (137 regions)
- TAR only (8 regions)
- Scientific regions only (11 regions)
- Networking regions only (43 regions)
- TAR and scientific regions (3 regions)
- TAR and networking regions (20 regions)
- Scientific and networking regions (29 regions)
- TAR, scientific and networking regions (31 regions)

Map 1.1.4. The Knowledge Economy in Europe

subjective; therefore, we decided to choose a broad one, encompassing industries with medium-high and high-tech content so to capture a wide range of industries characterized by consistent high-tech creation and deployment. High-tech industries are classified according to the OECD methodology (OECD, 2005). Such industries include manufacturing of aircraft and spacecraft, pharmaceuticals, office, accounting and computing machinery, radio, TV and communications equipment, and medical, precision and optical instruments.[2] High-tech services follow the OECD classification too, labeled "Knowledge-Intensive Service Activities ". Specialization is here defined with a location quotient calculated with respect to the EU27 average value; regional data include industry-specific employment in MHHT manufacturing and KIS.[3] Specialization is calculated for two years (2002 and 2007), in order to identify time trends, along with its spatial distribution. Twenty-one regions identified as TAR with our methodology are German, thirteen British, eight French, five Belgian, four Swiss, three Swedish, two Finnish and Danish, and one each for Italy, Norway, Slovenia, and Slovakia. The geography of technology in Europe is indeed highly concentrated, although peripheral regions and regions with capital cities in NMS do play a major role. Over time (although the time span considered may be too short to draw safe conclusions), no region acquired or lost the status of Technologically-Advanced Regions. The productive fabric of Europe shows therefore a remarkable concentration of technology,[4] either related to the advanced manufacturing or services activities.

Scientific regions are defined as those regions showing at the same time a higher than average research activity and a higher than average high-quality human capital. The level of research activities is captured by 4 indicators: the R&D expenditures per capita; the percentage of employees in R&D; the number of patent per capita for all economic sectors; the number of patent per capita for the subsample of high-tech sectors. A composite indicator is next calculated as the unweighted average of the re-scaled scores for all indicators within the respective dimension. The human capital stock in a region is measured by means of the following indicators: the percentage of population employed in the education sector (i.e. percentage of population employed in the NACE education sector); the share of population that has attained at least a university degree (i.e. percentage of population aged 15 and over by highest level of education attained); funding per capita in the activities of the 5th Framework Programmes (i.e. funding over population divided by 1000). A composite indicator is next calculated as the unweighted average of the re-scaled scores for all indicators within the respective dimension.[5]
We classify as "Scientific regions" those regions showing for both indicators values greater than zero. Regions showing values greater than zero for human capital indicator but less than zero for research activity are labelled Human capital intensive regions. On the contrary, regions characterized by values greater than zero for research activity and less than zero for the human capital indicator are indicated as Research intensive regions. Finally, regions showing values less than zero for both indicators are defined as Regions with no specialisations in knowledge activities.

This classification is shown in Map 1.1.2. We can observe 74 Scientific regions, 30 Research Intensive regions and 52 Human capital Intensive regions. But most of regions, 126, are concentrated on the third quadrant where we identify regions with no specialisation in

---

[2] Medium-high and high-tech manufacturing industries correspond to employment in chemicals (NACE24), machinery (NACE29), office equipment (NACE30), electrical equipment (NACE31), telecommunications and related equipment (NACE32), precision instruments (NACE33), automobiles (NACE34) and aerospace and other transport (NACE35); KIS include water transport (NACE 61), air transport (NACE 62), post and telecommunications (NACE64), financial intermediation (NACE 65), insurance and pension funding (NACE 66), activities auxiliary to financial intermediation (NACE 67), real estate activities (NACE 70), renting of machinery and equipment (NACE 71), computer and related activities (NACE72), research and development (NACE73) and other business activities (NACE 74).
[3] Source of the data is EUROSTAT.
[4] Moran's I index, measuring the degree of spatial autocorrelation among regions and calculated on the basis of a rook contiguity matrix of second order, is equal to 0.18, and significant at all conventional levels, for the categorical variable "Technologically-Advanced Region" depicted in Map 1.1.1.
[5] For both composite indicators, all simple indicators are firstly standardized around the European average imposed equal to zero. Next, following the methodology used in the Community innovation scoreboard, re-scaled values are calculated by first subtracting the minimum sample value and then dividing by the difference between the maximum and minimum value. The maximum re-scaled value is thus equal to 1 and the minimum re-scaled score is equal to -1. More details are available in the KIT Interim Scientific report – Part A.

knowledge activities. Among the 74 Scientific regions there are 59 regions belonging to EU 15 countries, 3 belonging to NMS and 12 belonging to Efta countries. Moreover, 58 are competitive regions, 3 are convergence regions and only one is a transition region. Regions with no specialization in knowledge activities are mainly located on the peripheral territories of Europe and Research Intensive regions are concentrated on territories characterized by a manufacturing productive specialization (i.e. Northern Italy, German regions). Finally, as expected Human capital intensive regions are mainly on the north.

When defining **knowledge networking regions** we follow the idea that knowledge is created within some crucial nodes (i.e. firms and universities) which tend to co-locate in specific places. Knowledge is then diffused and exchanged through two different diffusive patterns that do not exclude on another: (1) informal interactions and nonintentional relations arising from serendipitous encounters between actors who lie in close spatial proximity; (2) formal, intentional relations based on coordinated and well-defined linkages between actors who might, or might not, be in close spatial proximity. Translating these ideas to the regional level, **knowledge networking regions** can be understood as regions that rely on external sources of knowledge and on facilitating interactive learning and interaction in innovation; in other words, regions in a better strategic position to use extra-regional ideas in the production of innovation. This knowledge flows can take place through informal, nonintentional and serendipitous patterns of knowledge interactions that take place between regions located in spatial proximity (henceforth "informal linkages") and/or through formal, intentional and conscious relations based on networks or non-spatially mediated mechanisms ("formal linkages").

The level of "formal linkages" is measured by means of 3 indicators: external R&D (i.e. Average value of the millions of Euro spent in RD activities over Population divided by 1000 in the first-order neighbouring regions), external patent applications (i.e. average number of patents released over population divided by 1000 in the first-order neighbouring regions) and external Framework Program budgets (i.e. Average funding received by the 5th Framework Programme projects in per capita terms in the first order neighbours). A composite indicator is next calculated as the unweighted average of the re-scaled scores for all indicators within the respective dimension.[6]

The level of "informal linkages" is measured by means of 3 indicators: co-patents (i.e. Number of patent co-authored with inventors from outside the region over population divided by 1 million), inflows of inventors (i.e. number of inflows of inventors coming from other regions over population divided by 1 million) and citations made to patents from other regions, regardless their geographical contiguity (i.e. number of citations made to patents from other regions over population divided by 1 million). A composite indicator is next calculated as the unweighted average of the re-scaled scores for all indicators within the respective dimension.[7]

Knowledge networking regions are those European regions showing for both synthetic indicators, on spatial and a-spatial linkages, values greater than the European average. Regions showing values greater than the average for spatial linkages indicator but lower than the average for a-spatial linkages are labelled *Clustering regions*. On the contrary, regions characterized by values lower than the average for spatial linkages but higher for a-spatial linkages are indicated as *Globalizing regions*. Finally, regions showing values lower than the average for both indicators are *Non-interactive regions*..

Map 1.1.3 shows that *Networking regions* are concentrated in the centre of Europe as well as in the Scandinavian countries, whereas the *Non-interactive regions* are mainly those belonging to the NMS and some specific regions in the South European countries (the whole of Portugal and Greece, most Spain except the North-East area, and the South of Italy). This provides

[6] Data are firstly transformed using a square root transformation. Secondly, based on the square root values, re-scaled values are obtained by subtracting the Minimum value and then dividing by the difference between the Maximum and Minimum value. More details are available in the KIT Interim Scientific report – Part B.

[7] Data are firstly transformed using a square root transformation. Secondly, based on the square root values, re-scaled values are obtained by subtracting the Minimum value and then dividing by the difference between the Maximum and Minimum value. More details are available in the KIT Interim Scientific report – Part B.

evidence of a clear core-periphery pattern in the geographical distribution of the regions that in one way or another rely in external sources of knowledge for the development of innovation.

Map 1.1.4 presents an integrated picture of the different typologies of knowledge economy regions. The picture looks very fragmented, with quite a reasonable number of regions being only networking, and mainly in the central part of Europe. Only three technologically-advanced regions host scientific functions (Dresden, Vestlandet and Bratislava), while most of the technologically-advanced islands that host knowledge are also networking regions. In general, scientific regions are also networking regions, witnessing that knowledge accumulation inside a region also requires networking activity, which allows for the acquisition of knowledge from outside. What is really impressive is that a very high number of European regions, mainly in Eastern countries and in the Southern peripheral countries is below the EU average, witnessing that **in most of European regions the knowledge economy is still in its infancy**.

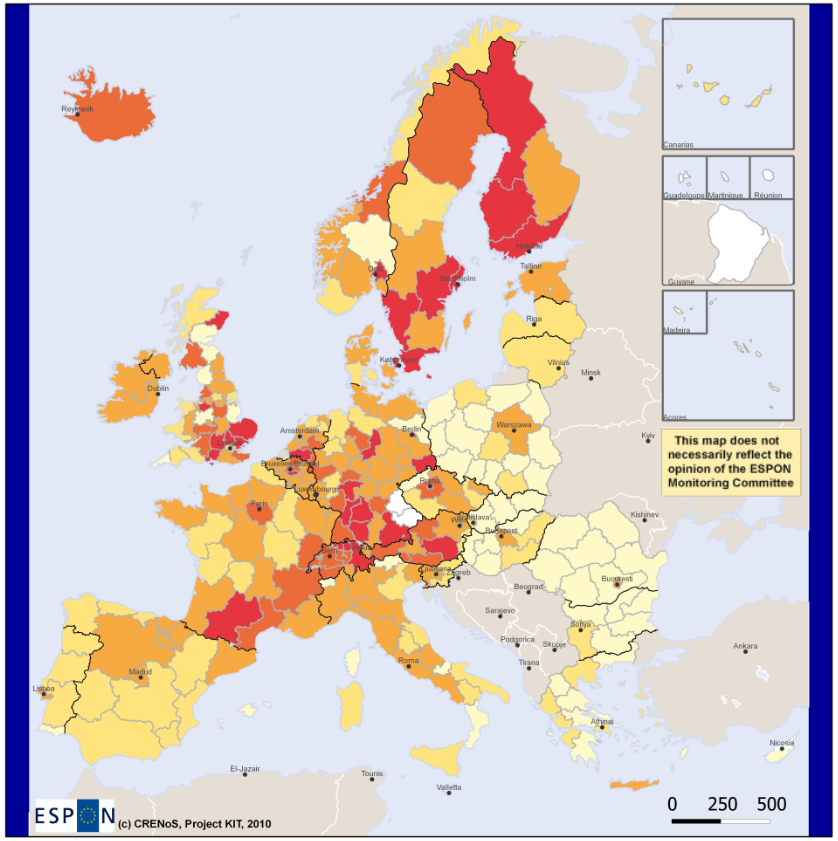
1.3. Spatial patterns of knowledge: a comparison between Europe, US, China and India

In Map 1.3.1 the spatial distribution of R&D expenditures on GDP is presented. This indicator is rather important since it has been used as a benchmark for the knowledge-economy development policies in official Ministerial documents like the Lisbon Agenda and Europe2020.

By observing the map, the first impression is that **the number of regions that reach the Lisbon objective is very limited (33 regions all over Europe, representing 11% of NUTS2 European regions)**, with a strong geographical concentration: dark red colored regions are concentrated on the Scandinavian regions, southern UK regions and territories located on the centre of Europe, with the exception of the French region of Toulouse. Nine European countries host the 32 virtuous regions (Austria, Belgium, Germany, Switzerland, Denmark, Finland, France, the Netherlands, Sweden and the UK), and within these countries, the spatial concentration is evident from the Map. Furthermore, **a very high number of regions belongs to the lowest class**, the one that registers a R&D on GDP lower than 0.5%.

There is a large difference between minimum and maximum value, ranging from less than 0.5% to more than 6%, and, last but not least, there is a clear Eastern-Western dichotomy, where Eastern regions show a very limited capacity of R&D spending with respect to Western countries. The same impressive result is obtained when we look at the spatial distribution of patent activities. Map 1.3.2. shows that patent activities are concentrated in the centre of Europe; although regions belonging to the lowest classes are mainly localized on the eastern part of the continent, there are some light yellow territory also on the north, for example UK regions (6 out of 37), 3 Dutch regions (out of 12) and 3 German regions (out of 39).

A comparison with US and with emerging countries, India and China, show that the concentration of research activities is something that Europe has in common with these countries. In particular, both India (around Delhi and the South) and China (coastal regions) have highly concentrated territorial patterns of scientific efforts, even more concentrated than a 'mature' innovation system like the US one, witnessing that the achievement of a critical mass is fundamental in scientific activities, especially in relatively less rich countries, with limited funds to be devoted to R&D (Map 1.3.3).



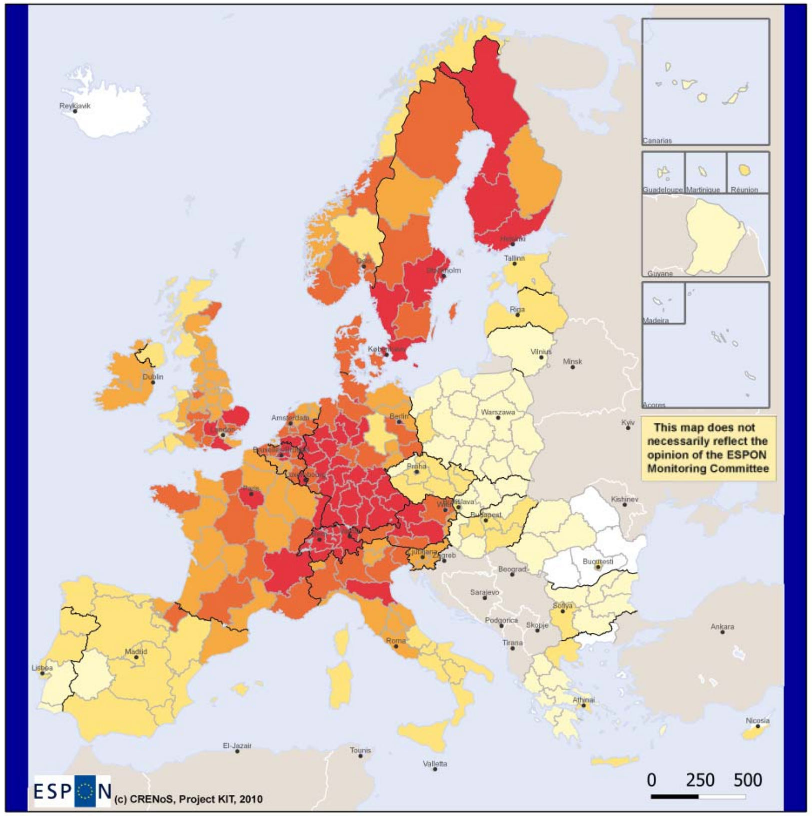
EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: CRENoS elaboration 2010
Origin of data: OECD REGPAT database, ISTAT and Institut National of des Etudes Economiques data, CORDIS data
Regional level: NUTS 2

Legend

- no data
- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 6.77

Map 1.3.1. Share of R&D Expenditures on GDP, average 2006-2007



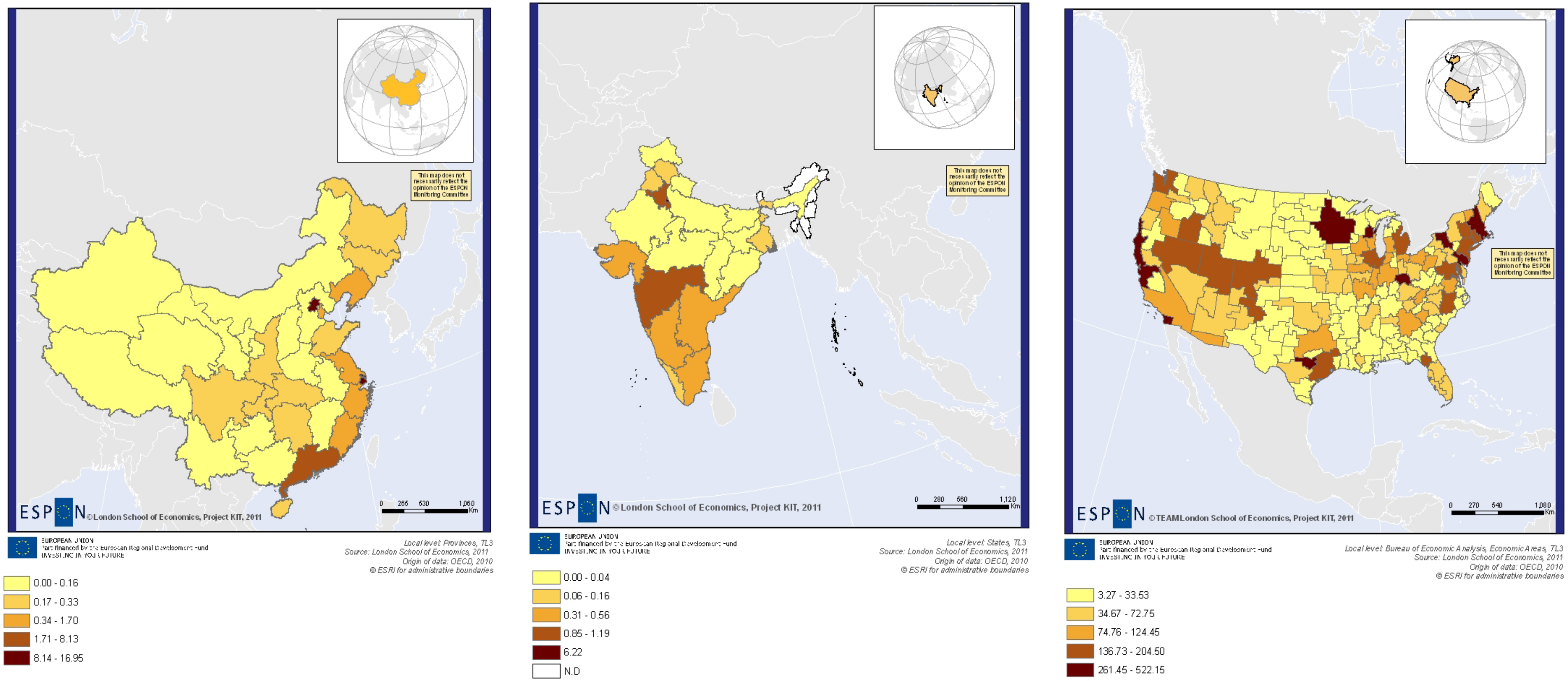
EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: CRENoS elaboration 2010
Origin of data: OECD REGPAT database, ISTAT and Institut National of des Etudes Economiques data, CORDIS data
Regional level: NUTS 2

Legend

- no data
- 0.000 - 0.005
- 0.005 - 0.042
- 0.042 - 0089
- 0.089 - 0.160
- 0.160 - 0.728

Map 1.3.2. Number of patents per 1000 inhabitants, average 2005-2006



Map 1.3.3. China, India, USA: population-weighted patent counts by region, 1994-2007

Source: OECD Regional Database. Notes: (1) population-weighted patent counts by applicant from OECD REGPAT Database, Patents filed under the Patent Co-operation Treaty (PCT), (2) Spatial units are provinces (China), states (India) and BEA Economic Areas (USA)

1.4. Spatial patterns of innovation

A value added of the KIT project is its estimation of regional innovation data, starting from CIS national data.[8] Data at regional level are made available by the KIT project about the share of firms having developed product innovation only; process innovation only; both product and process innovation; product and/or process innovation; marketing and organizational innovation.[9] We estimate regional data (i.e. NUTS2 level) starting from the national data (i.e. NUTS0 level) available from EUROSTAT in order to ensure comparability across countries. To do so we used weights to redistribute the NUTS0 data at NUTS2 level. We concentrated our efforts on CIS4 wave only. The use of previous waves was not feasible as they are based on a different sectoral stratification which impedes possible comparison with next waves. The use of later waves was not feasible either. In order to evaluate the impact of innovation on economic performance (e.g. GDP growth) in the pre-crisis period (i.e. until 2007) and considering the possible lags that innovation may experience to impact on economic performance, we chose to focus on CIS4 rather than on CIS2006 (which covers the 2004-2006 period).

Firstly, we estimated the regional respondents sample by redistributing the NUTS0 value according to the regional employment share.

Next, we estimated the regional sample of only product innovators, only process innovators, product and process innovators, and marketing and/or organizational innovators. To this end, we used different weights according to the different types of innovations. All weights are computed as regional share of national values of the selected variables. The weights aim at capturing both a functional as well as a sectoral dimension. The former is captured by looking at the share of professions, the latter by looking at the sectoral specialization. In absence of any a priori assumption on different relevance of the functional vs the sectoral dimension, we attributed equal importance to the selected weights. Table 1.4.1. shows the selected weights.

Table 1.4.1: Selected weights

TYPE of INNOVATION	Weights
Only PRODUCT	% scientists, % employment in high-tech (DL)
Only PROCESS	% employment in manufacturing, % technicians, % managers
PRODUCT & PROCESS	% scientists, % employment in high-tech (DL), % employment in manufacturing, % technicians, % managers
Marketing &/or organisational	% managers, % employment in services

The choice of the weights is based on rational expectations.

Product innovation is expected to take place at a greater extent in regions characterised by a larger endowment of advanced high-tech sectors, such as electrical and electronic equipment manufacturing (share of employment in the sector DL according to Nace Rev.1.1 classification), and advanced functions such as R&D (i.e. share of scientists). The definition used of high-tech sectors is restricted to advanced manufacturing sectors, since these are the sectors that are expected to generate product innovation. Sectors that can deploy product innovation are left aside.

Process innovation is expected to take place at a greater extent in regions characterised by a larger endowment of manufacturing sectors in which new production technologies or methods for producing goods can be introduced (share of employment in manufacturing) and a larger share of functions deeply involved into the production process implementation and monitoring (i.e. share of technicians and managers).

Product and process innovation is expected to take place at a greater extent in regions characterised by both a larger endowment of advanced high-tech sectors, such as electrical and electronic equipment manufacturing (share of employment in the sector DL according to Nace Rev.1.1 classification), and advanced functions such as R&D (i.e. share of scientists) as well as a larger endowment of manufacturing sectors in which new production technologies or

[8] For further details on the methodology applied, see Chapter 1 in Volume 1 of the Scientific report.

[9] For the whole sets of maps on innovation, see Chapter 1 in Volume 1 of the Scientific report. The latter also contains maps such as social and environment innovations.

methods for producing goods can be introduced (share of employment in manufacturing) and a larger share of functions deeply involved into the production process implementation and monitoring (i.e. share of technicians and managers).
Marketing and/or managerial innovation is expected to take place at a greater extent in regions characterised by a larger endowment of the service sector (share of employment in services), and a larger share of managerial functions (i.e. share of managers).

Spatial concentration characterizes product innovation, as is depicted in Map 1.4.1. This variable displays consistent concentration in strong countries, the core of product innovative activity in Europe being carried out in German, Scandinavian, Swiss and British regions, with a few notable exceptions outside these areas. EU15 regions tend on average to innovate more, and significantly so, than Eastern ones; the same applies to denser regions, while rural regions display a relatively lower product innovation rate. In general, in countries where product innovation is high, concentration seems pronounced. Spatial concentration of product innovation, on the contrary, strongly characterizes countries with low product innovation rates. This is the case of Portugal, where Lisbon is the only area with some product innovation activity; Spain, with Madrid, Barcelona and a few Pyrenean regions; Greece; and some NMS. Italy represents an exception to this pattern, since several regions in the Northern and central part of the Country display similar product innovation rates.

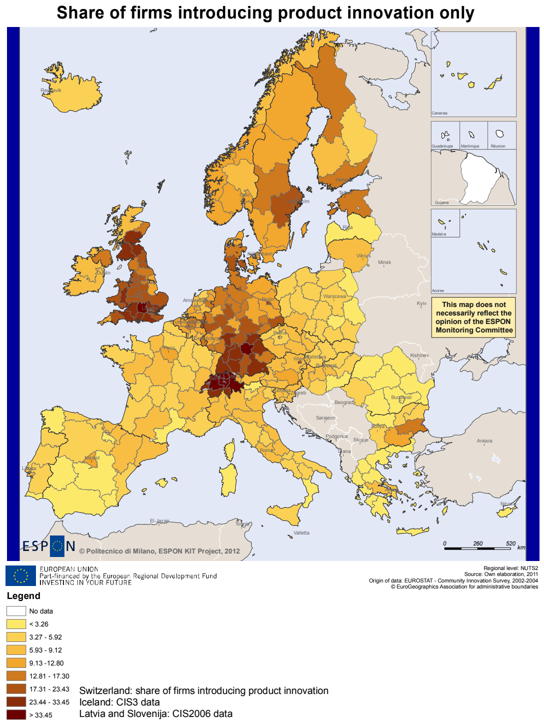
In general, process innovation shows a more dispersed pattern than product innovation (Map 1.4.2). Countries such as Portugal, Spain, France, Germany, and the UK do not display a remarkable concentration of process innovation within their boundaries. The variance associated with this variable is much lower than the same measure associated with product innovation.

This finding further strengthens the case for a more evenly distributed practice. In fact, this is also reflected in the case of NMS, that are unexpectedly characterized by homogeneous spatial trends. Process innovation takes place more frequently in densely populated regions and in metropolitan areas.

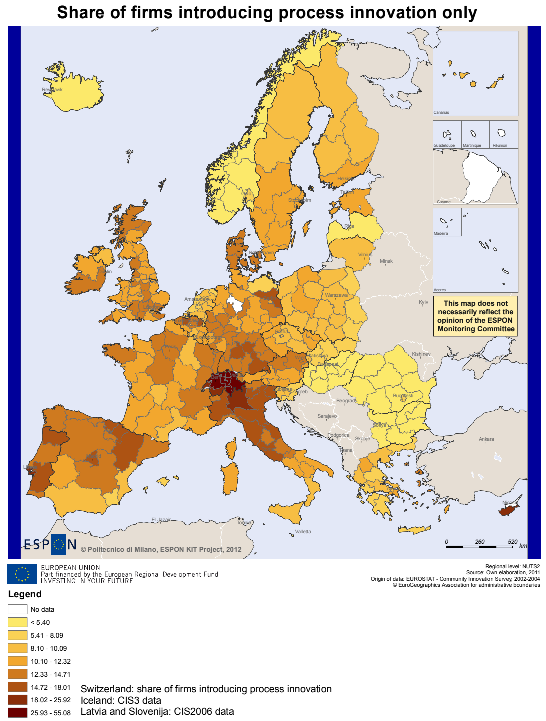
A relevant dichotomy shows up between Western and Eastern countries, the former averaging process innovation rates higher by about 5% than regions in NMS.

A quite different perspective on innovation is provided by the marketing and organizational innovation map (Map 1.4.3). In this case, non-technological innovation progress are surveyed – for instance, quality improvements, reductions of environmental damages stemming from firms' production, reductions of energy consumption, creation of new markets, reduced labour costs, reductions of amount of materials required for production, and conformance to regulations. The map highlights a significant concentration of marketing and organizational innovation in regions in the EU15 countries, with particularly high values in German and Austrian regions. However, the spatial distribution of this soft form of innovation seems much more even across the European space. The relatively even distribution is in particular remarkable when observed within countries, witnessing a similar innovative capability among regions.

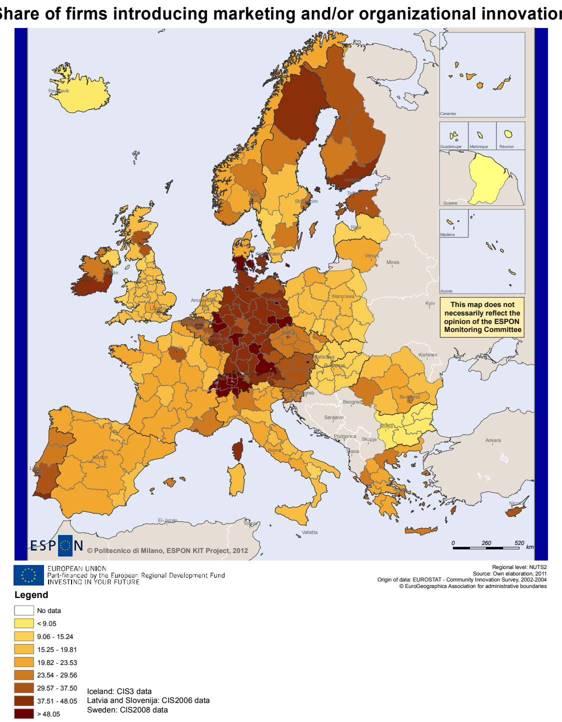
To account for 'softer forms' of innovation, we also considered the indicator of households propensity to adopt innovation (measured as households broadband penetration rate) which best captures the diffusion of a modern ICT in everyday life and offers an interesting perspective on the social diffusion of a new technology. The spatial distribution of this variable displays evident signs of country effects, naturally introduced in the data by the country-wide infrastructure ICT projects that both public as well as private companies launch and manage. Also, broadband connections penetrated more – and most unlike other innovation indicators – in regions belonging to Nordic countries and in Netherlands, more than on continental Europe. Besides, everywhere capital regions show over-performance in this measure of innovation diffusion with respect to other regions belonging to the same Country. Peripheral regions (Italian, Romanian, Bulgarian and Spanish) present some consistent lag when confronted with frontier ones (the map is available in the Scientific report, due to space constraints).



Map 1.4.1. Product innovation only



Map 1.4.2. Process innovation only



Map 1.4.3. Marketing and/or organizational innovation

Lastly, we considered an indicator of environmental innovation measured as the number of patent applications to the European Patent Office standardized by 1000 inhabitants in the following technologies: air pollution control/abatement; water pollution control (water and wastewater management); solid waste management; renewable energy (Wind, solar, geothermal, ocean, hydro power, biomass). A core of innovative activity in green technologies stands out in continental Europe, Scandinavian countries and the UK; of lesser, through relevant, importance regions in France, Greece and Italy also present some positive contribution to the activity of patenting in above mentioned fields. Also, a higher rate of innovation in green technologies is concentrated in denser and agglomerated regions, in EU15 countries regions, and finally in regions belonging to countries within the ESPON space, but outside the EU (the map is available in the Scientific report, due to space constraints).

1.5. The relationship between knowledge and innovation

Table 1.5.1. presents the level of innovation in the different types of knowledge economy regions. As expected, the highest difference lies between knowledge economy regions and others. The former definitely show a higher innovation performance, whatever definition is adopted.

Table 1.5.1. Share of innovation by type of knowledge-economy regions.

	Product innovation	Process innovation	Product and/or process innovation	Marketing and/or organizational innovation	Household propensity to adopt innovation	Environmental innovation
TAR	17,42	13,76	43,66	32,75	57	0,007
Scientific	18,16	13,48	43,71	29,51	62	0,007
Networking	16,19	13,2	44,24	31,95	57	0,007
Other	6,34	9,88	27,4	20,58	41	0,003

What is striking in the results presented in Table 1.5.1 is that one would have expected the regions with the highest R&D an scientific activities in general to be the ones that innovate the most. Our empirical results show instead that scientific regions, although registering a high innovation rate, are not significantly more innovative than TAR or networking. Only a few regions show a pattern of innovation that goes from R&D to innovation. Legitimate questions are raised in front of these results: how do regions innovate without R&D? Which are the innovation modes when R&D, and formal knowledge in general, are not present locally? The next section replies to these questions.

2. Territorial patterns of innovation

2.1. A new interpretative framework

Our empirical analysis suggests that knowledge, innovation and diffusion are not necessarily intertwined, especially at the local level. This can be explained by the fact that factors that enhance the implementation of new knowledge can be quite different from the factors which stimulate innovation. Firms and individuals which are leading an invention are not necessarily also leaders in innovation or in the widespread diffusion of new technologies.

The history of technology and innovation is full of examples of this kind; the fax machine, first developed in Germany, was turned into a worldwide successful product by Japanese companies. Similarly, the anti-lock brake systems (ABS) was invented by US car makers but became prominent primarily due to German automotive suppliers (Licht, 2009).

These reflections suggest that innovation can be the result of different patterns, different modes of performing each phase of the innovation process. The variety of innovation patterns explains the failure of a "one size fits all" policy to innovation, like the thematically/regionally neutral and generic R&D incentives, with the expectation to develop a knowledge economy everywhere. On the contrary, innovation patterns specific of each area have to be identified, on which ad-hoc and targeted innovation policies can be drawn.

The paradigmatic jump in interpreting regional innovation processes lies nowadays in the capacity to build on the single approaches developed for the interpretation of knowledge and innovation a conceptual framework interpreting not a single phase of the innovation process, but the different modes of performing the different phases of the innovation process, highlighting the context conditions (internal and external to the region) that accompany each innovation pattern. In this way, we are able to take into consideration alternative situations where innovation builds on internal knowledge, or where local creativity allows, even in front of the lack of local knowledge, an innovative application thanks to knowledge developed elsewhere and acquired via scientific linkages, or where innovation is made possible by an imitative process of innovations developed outside the region.

To this end, the concept of territorial patterns of innovation can be useful interpretative tool. A territorial pattern of innovation is a combination of ***context conditions*** and of ***specific modes of performing the different phases*** of the innovation process.

Among all possible combinations, the most interesting ones are the following, reflecting different knowledge and innovation aspects:

a) an endogenous innovation pattern in a scientific network, where the local conditions are all present to support the creation of knowledge, its local diffusion and transformation into innovation and its widespread local adoption so that higher growth rates can be achieved. Given the complex nature of knowledge nowadays, this pattern is expected to show a tight interplay in the creation of knowledge with other regions, and therefore being in an international scientific network. This pattern can be easily built from the conceptual point of view on all the literature dealing with knowledge and innovation creation and knowledge diffusion (Figure 2.1.1);

b) a creative application pattern, characterized by the presence of creative actors interested and curious enough to look for knowledge, lacking inside the region, in the external world, and creative enough to apply external knowledge to local innovation needs. This approach is conceptually built on the literature on regional innovation creation (Figure 2.1.2);

Figure 2.1.1. Endogenous innovative pattern in a scientific network

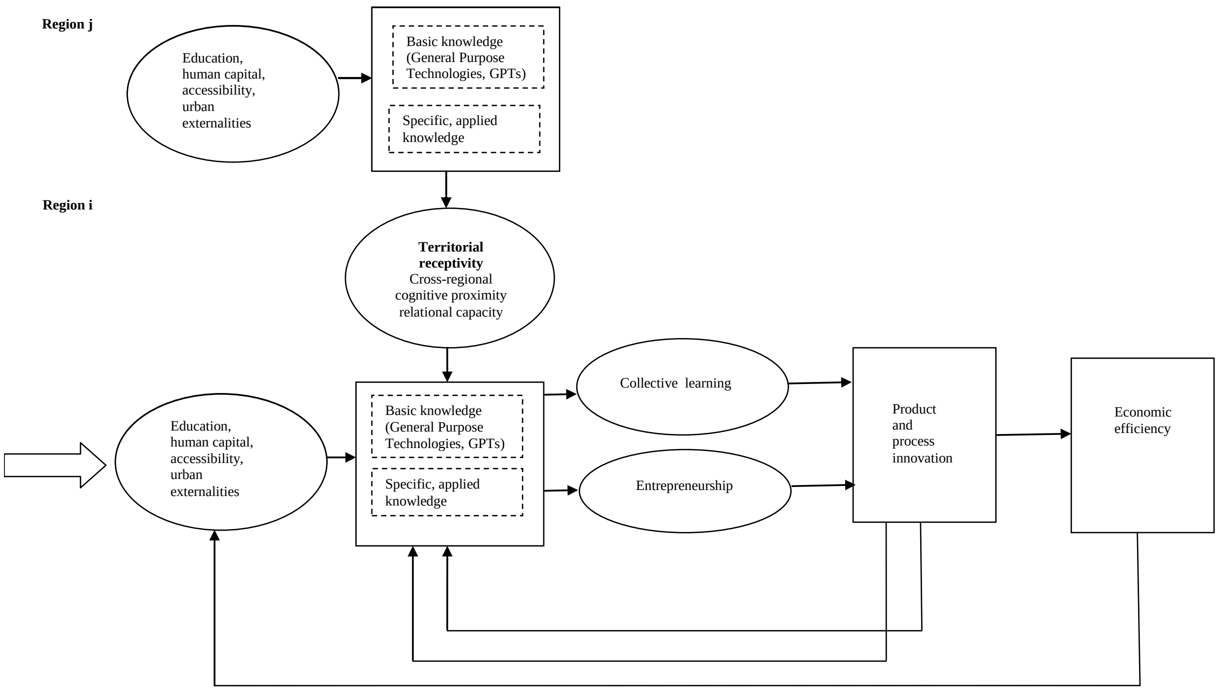


Figure 2.1.2. A creative application pattern

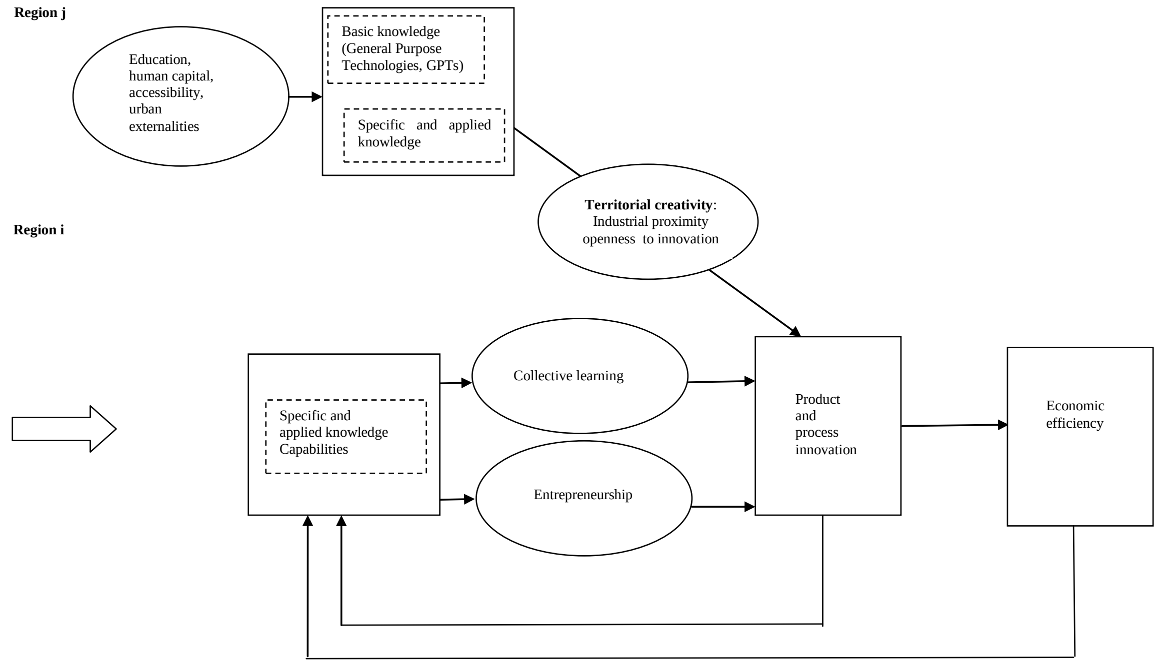
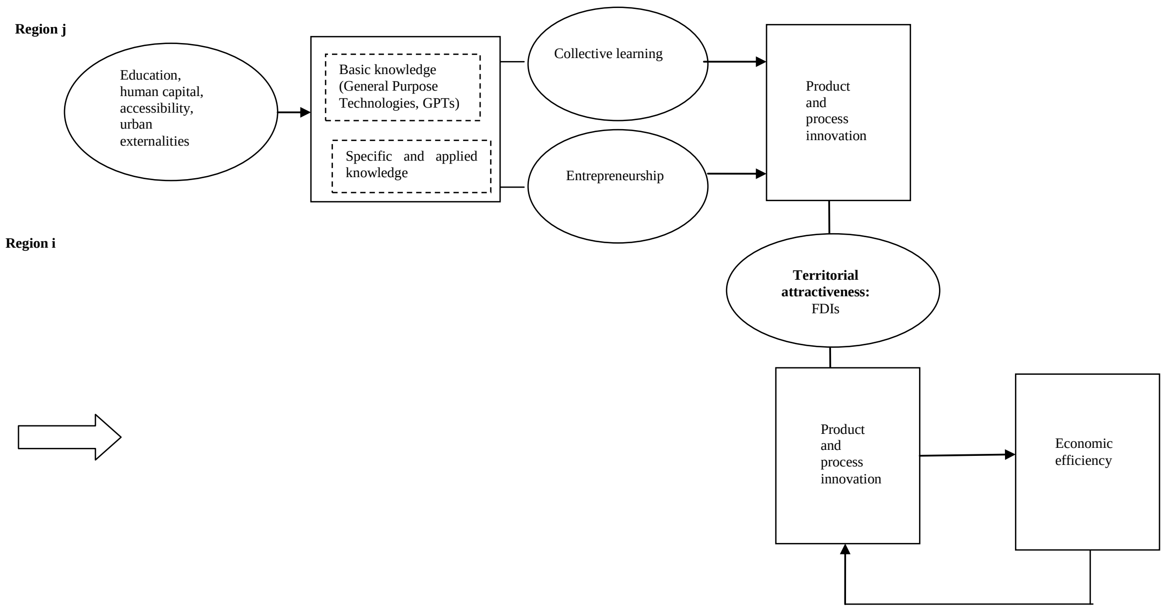


Figure 2.1.3. An imitative innovation pattern



c) an imitative innovation pattern, where the actors base their innovation capacity on imitative processes, that can take place with different degrees of creativity in the adaptation of an already existing innovation. This pattern is based on the literature dealing with innovation diffusion (Figure 2.1.3).

Conceptually speaking, these three patterns represent the different ways in which knowledge and innovation can take place in a regional economy. Each of them represents a different way of innovating, and calls for different policy styles to support innovation. An

R&D incentive policy can be extremely useful for the first kind of innovation pattern; incentives to co-inventing application (the typical Schumpeterian profits), enhancing the ability of regions to change rapidly in response to external stimuli (such as the emergence of a new technology) and to promote "shifting" from old to new uses, is a good policy aim for the second pattern. The maximum return to imitation is the right policy aim of the third innovation pattern, and this aim is achieved through a creative adaptation of already existing innovation, i.e. through adoption processes driven by creative ideas on the way already existing innovation can be adopted to reply to local needs.

2.2. Territorial patterns of innovation in Europe

An empirical analysis has been applied to identify whether the "territorial patterns of innovation" actually exist. Based on a list of indicators able to cover all aspects of the complex knowledge-innovation chain, a cluster analysis has been run in order to identify the existence of innovative behaviours that could be associated to the territorial patterns of innovation previously described.[10]

The empirical results show that a larger variety of possible innovation patterns than the ones conceptually envisaged; we identify two clusters that can be associated to our conceptual Pattern 1, albeit with some relevant distinctions between the two, two clusters that can be associated to Pattern 2, again with some differences between them, and one cluster that can be associated to Pattern 3. Interestingly, the five groups show sizeable differences in the variables considered in the clustering exercise, namely (Map. 2.2.1):

A European science-based area (pattern 1a), characterised by strong knowledge and innovation producing regions, specialized in general purpose technology, with a high generality and originality of science-based local knowledge, and a high R&D endowment. In terms of regional preconditions to create local knowledge and to acquire knowledge from other regions, this group of regions shows a high level of scientific human capital (i.e. share of inventors on population), highly educated human capital (i.e. share of population holding a tertiary degree), high accessibility and high receptivity (i.e. the capacity of the region to interpret and use external knowledge (proxied by the degree of networking, measured as 5th Framework Program funding per capita; Figures 2.1.4-2.1.6). These regions are mostly located in Germany, with the addition of Wien, Brussels, and Syddanmark in Denmark.

An applied science area (pattern 1b), made of strong knowledge producing regions characterized by applied science, with a high degree of knowledge coming from regions with a similar knowledge base. R&D activity is high also in this cluster of regions. Similarly to regions in the European science-based area, these regions show high level of knowledge creation and acquisition pre-conditions, although to a lesser extent (Figures 2.1.4-2.1.6). This type of regions is mostly agglomerated and located in central and northern Europe, namely in Austria, Belgium, Luxembourg, France (i.e. Paris), Germany, Ireland (i.e. Dublin) Denmark, Finland and Sweden with some notable exceptions at East such as Praha, Cyprus and Estonia and at South such as Lisboa and Attiki.

A smart technological application area (pattern 2a), in which a high product innovation rate is registered, with a limited degree of local applied science, and a high creativity which allows to translate external basic science and applied science knowledge into innovation. R&D endowment is much lower than in the previous two cases. Although regional pre-conditions for knowledge creation and acquisition are not as much concentrated as in the previous two groups, these regions show not negligible level of scientific and highly educated human capital, as well as receptivity, and more importantly, not negligible level of creativity and entrepreneurship, which are considered as regional pre-conditions for innovation creation and acquisition from other regions (Figures 2.1.4-2.1.6). This group of regions includes mostly agglomerated regions in EU15, such as the northern part of Spain and Madrid, Northern Italy, the French Alpine regions, the Netherlands, Czech Republic, Sweden and the UK.

---

[10] For the list and the methodology for the identification of the territorial patterns of innovation, see Chapter 2 in Volume 1 of the Scientific report.

Figure 2.1.4. Regional preconditions for knowledge and innovation creation

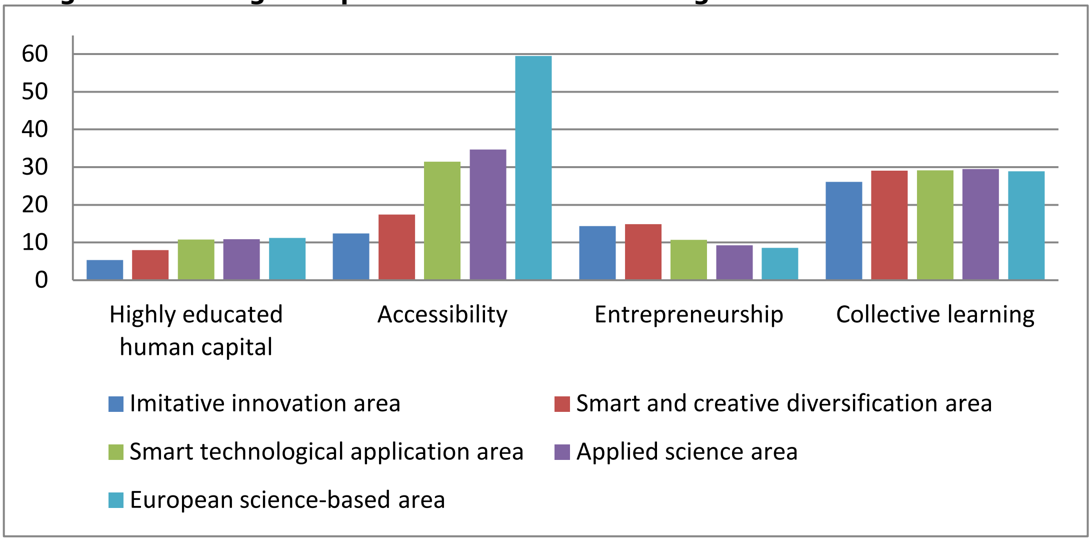


Figure 2.1.5. Regional preconditions for knowledge and innovation acquisition

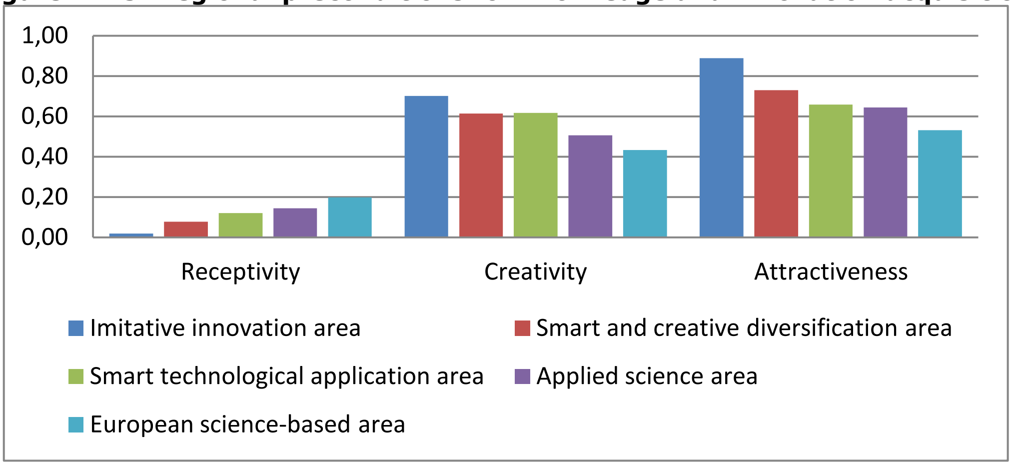
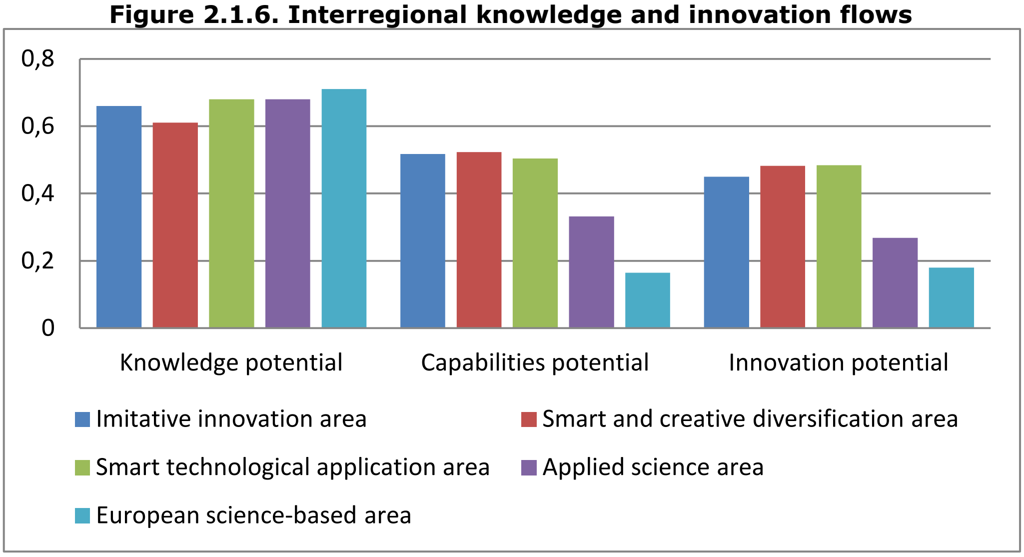
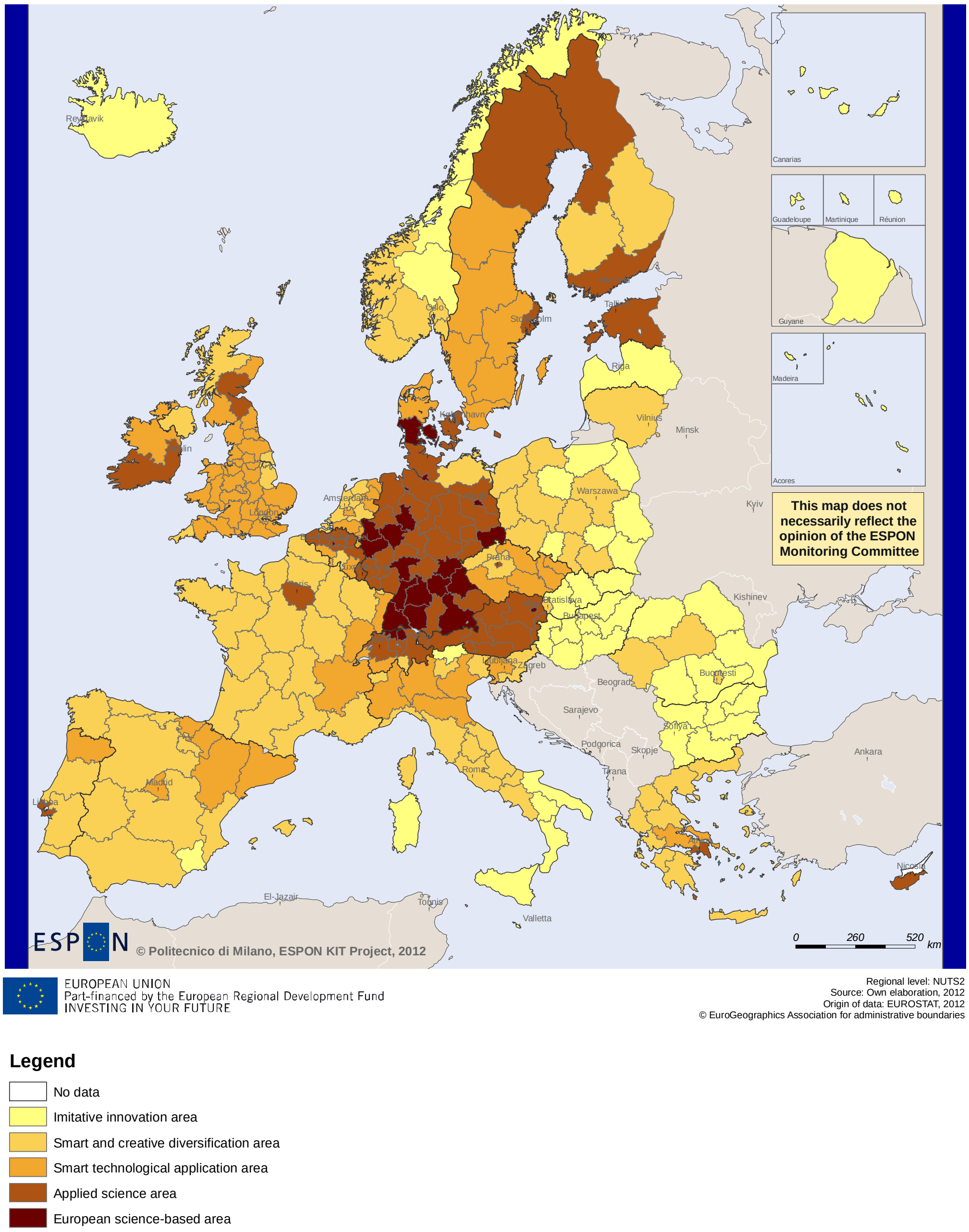


Figure 2.1.6. Interregional knowledge and innovation flows





Map 2.2.1. Territorial patterns of innovation in Europe

A smart and creative diversification area (Pattern 2b), characterized by a low degree of local applied knowledge, some internal innovation capacity, high degree of local competences, which suggest that the not negligible innovation activities carried out in the area mainly rely upon tacit knowledge embedded into human capital. Moreover, regions in this area are strongly endowed with characteristics such as creativity and attractiveness that help to absorb knowledge and to adapt it to local innovation needs. These regions are mainly located in Mediterranean countries (i.e. most of Spanish regions, Central Italy, Greece, Portugal), in agglomerated regions in Slovakia and Poland, a few regions in northern Europe, namely in Finland and the UK.

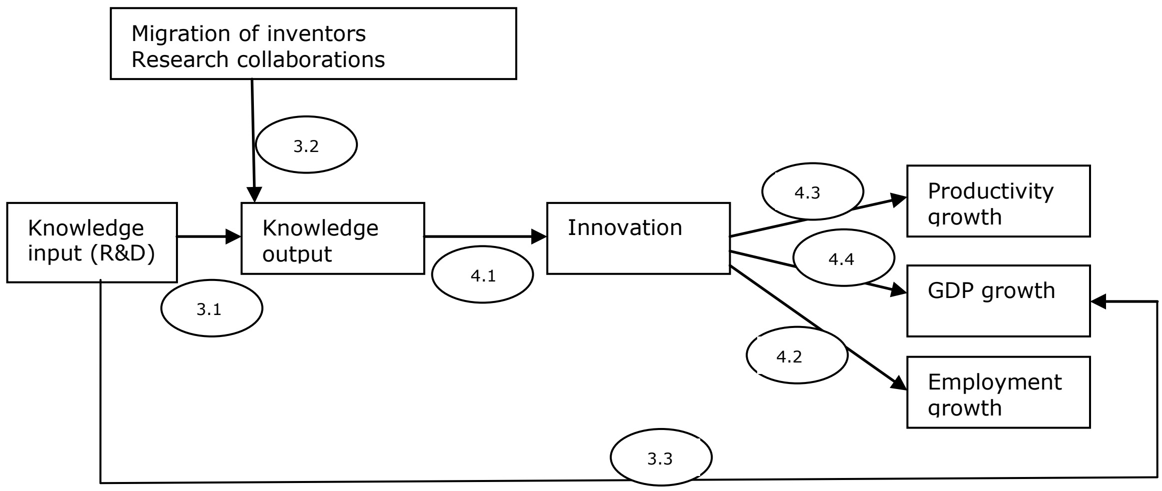
An imitative innovation area (pattern 3), in which one measures a low knowledge and innovation intensity, entrepreneurship, creativity, a high attractiveness and a high innovation potentials, that can be considered as local pre-conditions enabling the acquisition of external innovation (Figures 2.1.4-2.1.6). Most of these regions are in EU12 such as all regions in Bulgaria and Hungary, Latvia, Malta, several regions in Poland, Romania, and Slovakia, but also in Southern Italy.

It is worth remarking that this description captures average behaviour in each group. In fact, in each of the five areas identified, there can be better performing regions with a greater knowledge and innovation propensity and regions that show a less knowledge- and innovation-intensive profile. Also, this typology has been elaborated at NUTS2 level. It can be well the case that within each NUTS2 region different NUTS3 regions show different knowledge and innovation attitude and especially capital NUTS3 regions are most likely to display greater performances. Additionally, this description does not take into account softer elements, much harder to be captured in measurable indicators, that could enable local innovation, such as the socio-economic mentality, the general culture of innovativeness and the education system, that could represent the target of important policy actions aimed at fostering innovation.

The variety of innovation patterns explains the failure of a "one size fits all" policy to innovation, like the thematically/regionally neutral and generic R&D incentives; the latter are not suitable for the widespread development of a knowledge economy. On the contrary, innovation patterns typical of each specific area have to be identified, on which ad-hoc and targeted innovation policies can be drawn, and on which the "smart specialization" concept, put forward by the EU, can be applied to innovation policies. Policies shall in particular target most innovative NUTS2 regions, or on the most innovative NUTS3 regions within each NUTS2.

To move in this direction, the measurement of efficiency and effectiveness of each pattern of innovation on growth is necessary; our impression is that none of these patterns is by definition superior to another and, on the contrary, each territorial pattern may provide an efficient use of research and innovation activities generating growth. But this statement calls for empirical analysis. In particular, we are interested to understand **the efficiency of each territorial pattern of innovation in**:

a) producing new knowledge from both internal and external knowledge inputs (sec. 3);
b) generating economic growth from knowledge input (R&D and human capital), capturing which regions benefit the most from an increase in R&D, as suggested by the Lisbon and Europe2020 Agenda (sec. 3);
c) exploiting knowledge for producing innovation (sec. 4);



Legend: numbers refer to the sections in which particular questions are addressed, namely:
3.1. What is the return of R&D expenditures and human capital endowments to knowledge production (sec. 3.1)?
3.2. What is the role knowledge spillovers in creating local knowledge (sec. 3.2)?
3.3. Do R&D and human capital have an additional positive impact on regional production (sec. 3.3)?
4.1. Which is the capacity of formal knowledge to generate innovation activity (sec. 4.1).
4.2. Which is the impact of product and process innovation on employment growth (sec. 4.2)?
4.3. Which is the impact of knowledge (both formal and informal) and innovation on the efficiency of the economic system (i.e. on total factor productivity) (sec. 4.3)?
4.4. lastly, which is the impact of knowledge and innovation on GDP growth (sec. 4.4)?

Figure 2.1.7. Logic of the impact analysis and questions addressed

d) generating or destroying employment: is innovation a real labour saving activity or are there situations in which it generates jobs (sec. 4)?;

e) exploiting innovation to increase regional growth and to achieve higher productivity levels. This is an important step to highlight the efficiency of each territorial pattern of innovation (sec. 4).

The overall logic of the impact analysis is presented in Figure 2.1.7, with the main questions addressed and the sections in which questions are answered.

3. Knowledge and regional performance

The scientific literature has achieved a large consensus on the fact that regional competitiveness – and consequently regional growth – is not entirely dependent on traditional production factors endowment, such as physical capital and labour, but is strongly related to the presence of local intangible resources such as competence, innovative activity and knowledge. Moreover regional performance is strictly related to its capacity to benefit from knowledge spillovers coming from neighboring regions. These ideas have strongly influenced normative strategies that pushed towards the reinforcement of knowledge capabilities at achieve higher competitiveness and growth, at both national and regional level. The Lisbon Agenda, reinforced by the Europe2020 Agenda, has declared the importance of achieving 3% of R&D to GDP to guarantee a competitive and smart growth in Europe. Is this normative strategy valid? What is the return of R&D to GDP? The main aim of this section is to reply to such questions, by observing and interpreting the impacts that the creation of local knowledge and knowledge spillovers have on the economic performance of regions.

The main questions answered here are:

1) What is the return of R&D expenditures and human capital endowments to knowledge production?
2) What is the role of knowledge spillovers in creating local knowledge?
3) Do R&D and human capital have an additional positive impact on regional production once we control for the traditional inputs?

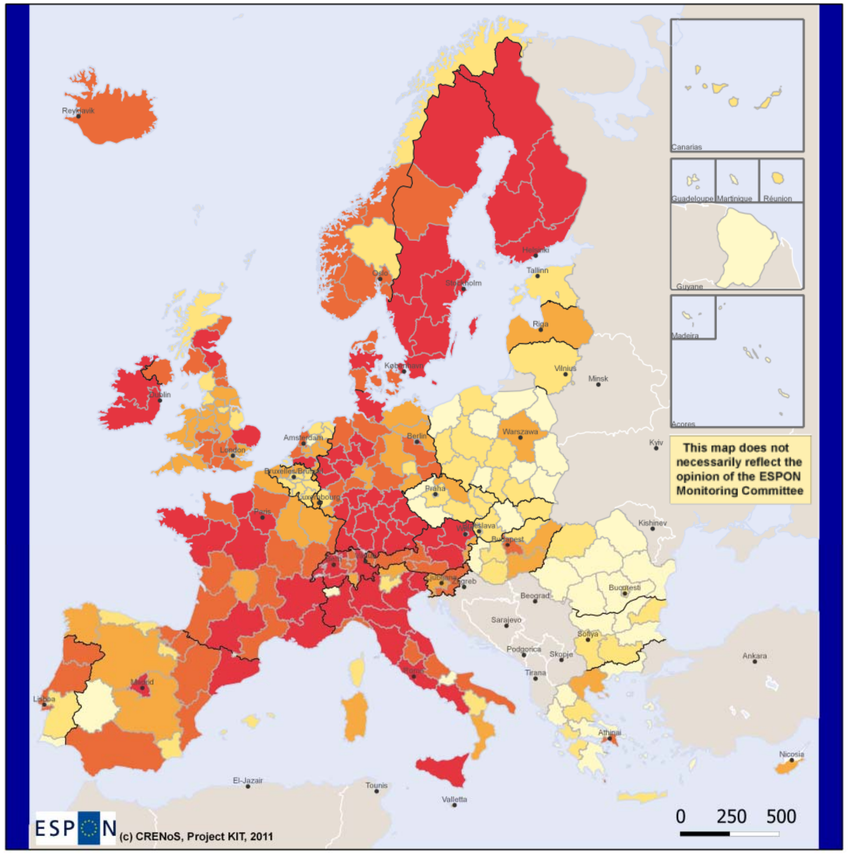
3.1. R&D, human capital and knowledge creation

To analyse the role played by the intangible assets on the regional innovative capacity we employ a framework based on a knowledge production function (Griliches, 1979). In addition to the traditional R&D input, we also consider the human capital endowment as a determinant of the inventive activity since some authors have emphasize that the effectiveness of R&D investments depends crucially on the absorptive capacity of a territory, which, in turn is linked to the availability of highly skilled human capital (Cohen and Levinthal, 1990).[11]

The first issue tackled in the analysis is the measurement of the effects of local knowledge (measured by R&D and human capital) in producing new knowledge (measured by patents).[12] Looking at the average results for the whole Europe, results show the higher effectiveness of human capital with respect to R&D expenditures: an increase of 1% in the human capital endowment induces a increase of 0.63% points for patent activity while the same increase in the R&D expenditures induces only a 0.43% increase of patents.

Given the well-known heterogeneity of the European territories, we try to assess its relevance by relaxing the assumption that the effects are the same across all the 287 regions. The evidence found for the human capital individual regional impacts of R&D on patents is depicted in Map 3.1.1: the highest values are concentrated in the centre of Europe and in the Scandinavian peninsula. More specifically, the presence of a large endowment of graduate population produces its largest impact in regions belonging to Finland and Sweden but also

[11] The data, methodology and econometric specifications are described in details in Chapter 3, Volume 1 of the Scientific report.
[12] For technical details see the Scientific report, Volume 1 Chapter 3.



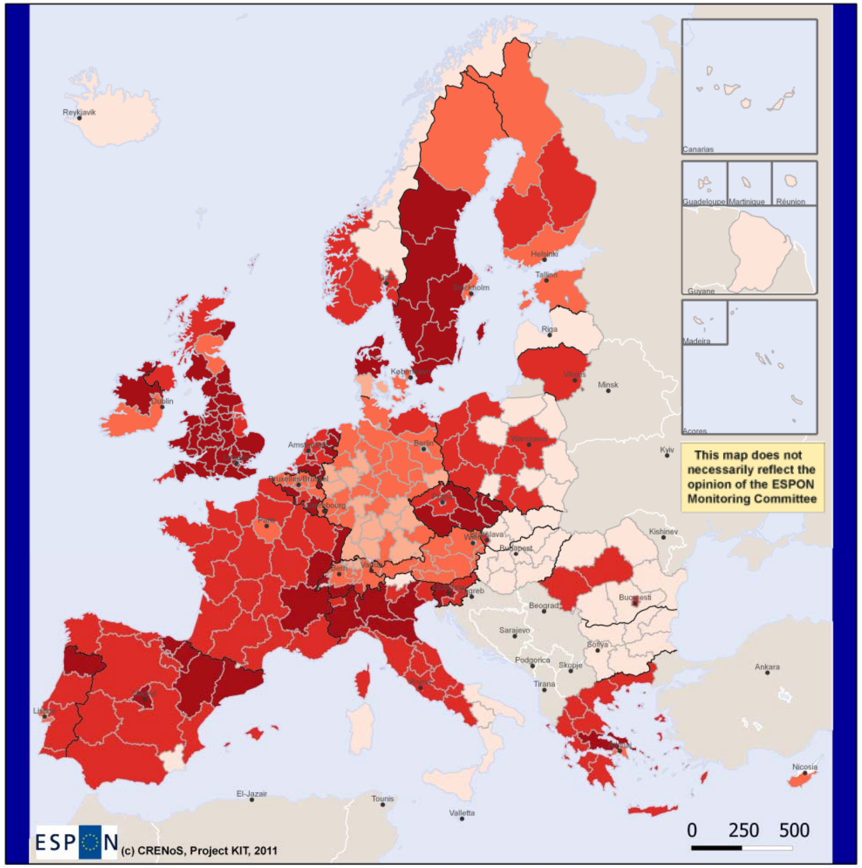
EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: CRENoS elaboration, 2011
Origin of data: Eurostat
Regional level: NUTS 2

Legend

- no data
- <0.70: Low elasticity
- 0.71 - 0.89: Medium - low elasticity
- 0.9 - 0.99: Medium elasticity
- 1.0 - 1.10: High elasticity
- >1.10: Very high elasticity

Map 3.1.1. Elasticity of knowledge production to human capital for the individual regions (average 2000-2007)



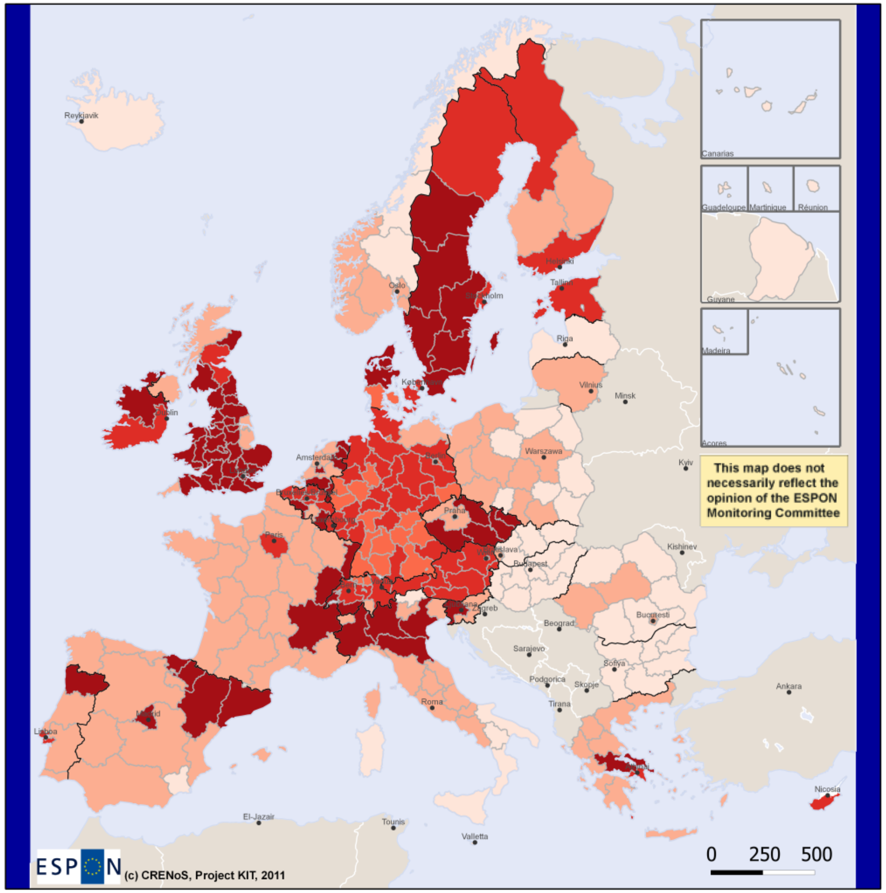
EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: EUROSTAT
Origin of data: Author's elaboration
Regional level: NUTS 2

Legend

- no data
- Imitative innovation area = 0.360
- European science-based area = 0.414
- Applied science area = 0.423
- Smart and creative diversification area = 0.469
- Smart technological application area = 0.476

Map 3.1.2. Elasticity of knowledge production to R&D by patterns of innovation (average 2000-2007)



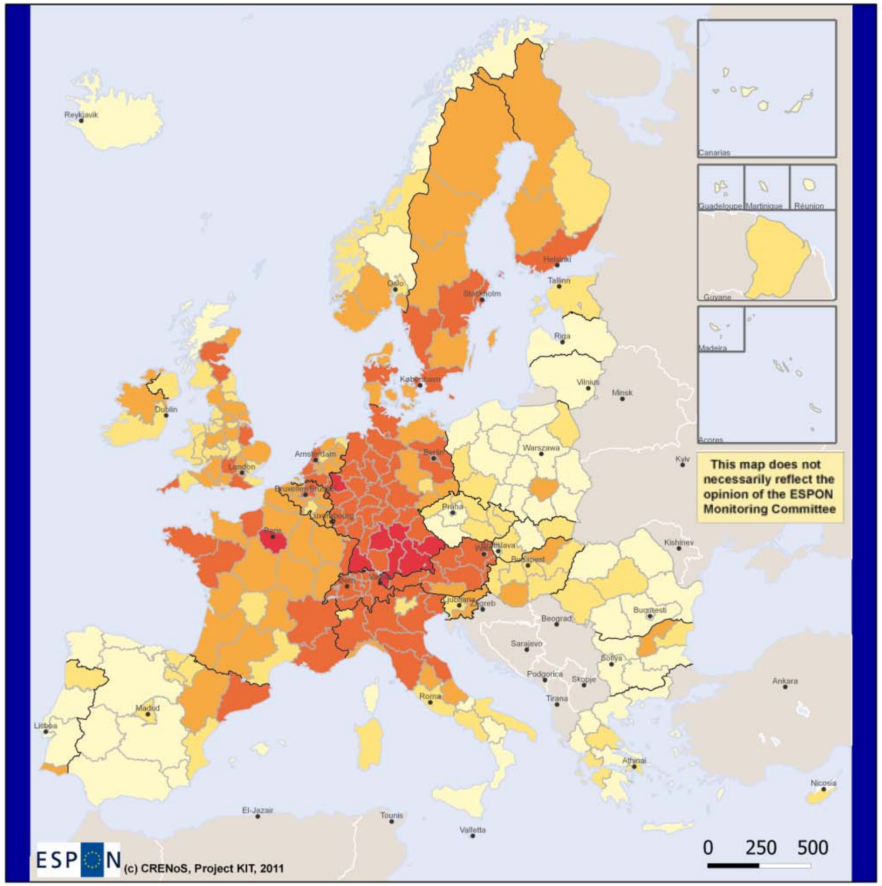
EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: EUROSTAT
Origin of data: Author's elaboration
Regional level: NUTS 2

Legend

- no data
- Imitative innovation area = 0.3345
- Smart and creative diversification area = 0.4370
- European science -based area = 0.4385
- Applied science area = 0.4392
- Smart technological application area = 0.4586

Map 3.1.3. Elasticity of knowledge production to human capital by patterns of innovation (average 2000-2007)



EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: CRENoS elaboration, 2011
Origin of data: Eurostat
Regional level: NUTS 2

Legend

- no data
- 0.1 - 6.9: Low efficiency (68)
- 6.9 - 15.6: Medium-low efficiency (68)
- 15.6 - 30.2: Medium efficiency (68)
- 30.2 - 99.9: High efficiency (73)
- 100.0: Highest efficiency (10)

Map 3.1.4. Efficiency level of knowledge production for the individual regions (DEA methodology, 2007)

France, North of Italy, Germany, Spain, Denmark, Austria and the Netherlands. We can observe that among these regions there are strongly specialized territories on the manufacturing sector like Emilia-Romagna, Lombardia, Veneto, Piemonte for Italy, Rhône-Alpes for France and Stuttgart for Germany. Moreover in the highest elasticity group there are regions where very important cities are located like Stockholm, Île de France, Cataluña, Düsseldorf, Wien, Berlin, Lazio, Köln, Comunidad de Madrid, Hannover. It is also worth remarking that in these same towns very important universities are located. Lowest values are instead strongly spatially concentrated on regions belonging to New Entrants countries, mainly in the Eastern part of Europe.

Among these regions there are also territories with other specialization than the manufacturing sector like overseas territories like Região Autónoma da Madeira and Região Autónoma dos Açores for Portugal, Valle d'Aosta for Italy, Guyane, Martinique, Guadeloupe for France, Ciudad Autónoma de Melilla and Ciudad Autónoma de Ceuta for Spain. Overall, we can conclude that returns to human capital, in terms of knowledge production, are likely to accrue in those regions where a critical endowment of human capital is already concentrated.

In order to analyze whether also the effects of R&D change across territories, overcoming the degrees of freedom problem, we chose to permit a lower degree of regional heterogeneity by making use of the territorial patterns of innovation taxonomy described in Section 2. It is worth remarking that the coefficient of human capital and R&D, is pretty robust with respect to the inclusion of the other input five interactive terms; the estimates are in fact quite similar to the average elasticities described above. Focusing on the R&D impact (Map 3.1.2), we can observe that the areas of "Smart technical application" and "Smart and creative diversification area" present the highest R&D coefficients (0.48 and 0.47), while the lowest value is shown by the "Imitative innovation" group (0.36). These results suggest that the R&D expenditures effort has its largest impact on knowledge production in those regions with a strong orientation towards product innovation but in which the endowment of knowledge and innovation variables is smaller than the EU average. This result confirms that the knowledge endowment relies upon tacit knowledge and that it is embedded into human capital, entrepreneurial and creative attitudes. Moreover, if we look at Map 3.1.2, we see that the lowest R&D elasticity coefficients are in regions belonging to the "Imitative innovation" group, mostly concentrated in the Eastern part of Europe and among New Entrants countries. Similar results are found for human capital endowment. Map 3.1.3 shows that the most knowledge and innovation intensive groups of regions display the highest elasticity values: "Smart technological application area" (0,458), "Applied Science Area" (0,439) and "European science-based area" (0,438).

Therefore, **both R&D and human capital are less effective in the regions with the lowest knowledge endowment, witnessing that a certain degree of knowledge is required to generate new knowledge**. **This is true up to a certain threshold, when increasing returns turn into decreasing returns.**

Map 3.1.4 shows the geographical distribution of the regional efficiency measures **in the use of all knowledge inputs** at the same time for the final year of the time period considered for the analysis (2007).[13] Fully efficient regions, in terms of converting R&D and human capital inputs into knowledge (patents), have a technical efficiency score of 100 (red colored in the maps); these are the best performing areas in knowledge activity and therefore they define the production possibility frontier.

Map 3.1.4 shows that the most efficient territories exhibit a great deal of heterogeneity. The majority of the efficient regions are located in the most central or economically strategic areas of the continent, as it is the case for Île de France, Stuttgart or the Dutch Noord-Brabant. However, due to DEA methodology which selects efficient units also for low endowments, we find high efficiency scores also in small and peripheral regions (i.e. Åland). The most efficient regions are followed by a group of German and North Italy regions, which are pretty close to the frontier as they show high technical scores. On the contrary, the lowest scores are shown by regions located in European peripheral areas, especially in the new accession countries.

This analysis confirms the presence of a dualistic – centre vs periphery – pattern in knowledge inputs exploitation. This calls for specific policies, which should target the latter

[13] In Chapter 3, Volume 1 of the Scientific report the DEA results are also presented for the initial year 2000.

group of regions, in order to support them - not with additional resources - but with the provision of organizational and structural assistance that should enable them to exploit all the potential of their relatively abundant inputs in delivering higher levels of knowledge output, which in turn is expected to ensure better long run economic performance

It is worth comparing the results of the capacity to produce knowledge previously discussed for the European case with those obtained for the case of USA, China and India which are characterized by distinct regional knowledge creation dynamics. In China, patenting activity is concentrated in denser, richer regions; the knowledge system appears to be driven by the density-R&D nexus, and more broadly by traditional agglomeration factors – partly reflecting a state-driven economy. In India the creation of knowledge largely depends on R&D, both local and of neighbouring regions, in a large number of urban cores. Unlike China, knowledge spillover, migration and wider social and institutional conditions are important for patenting. In the US, innovation occurs largely in self-contained zones relying on their own R&D inputs, favourable local socio-economic environments and on large pools of skilled individuals. The common ground of the modelling framework for the different countries is that it draws on elements of endogenous growth theory, new economic geography and innovation systems literatures, which contextualizes the descriptive findings and forms the basis of the regression analysis.

To facilitate the comparison, the estimation results for the four areas are reported in Figure 3.1.1.

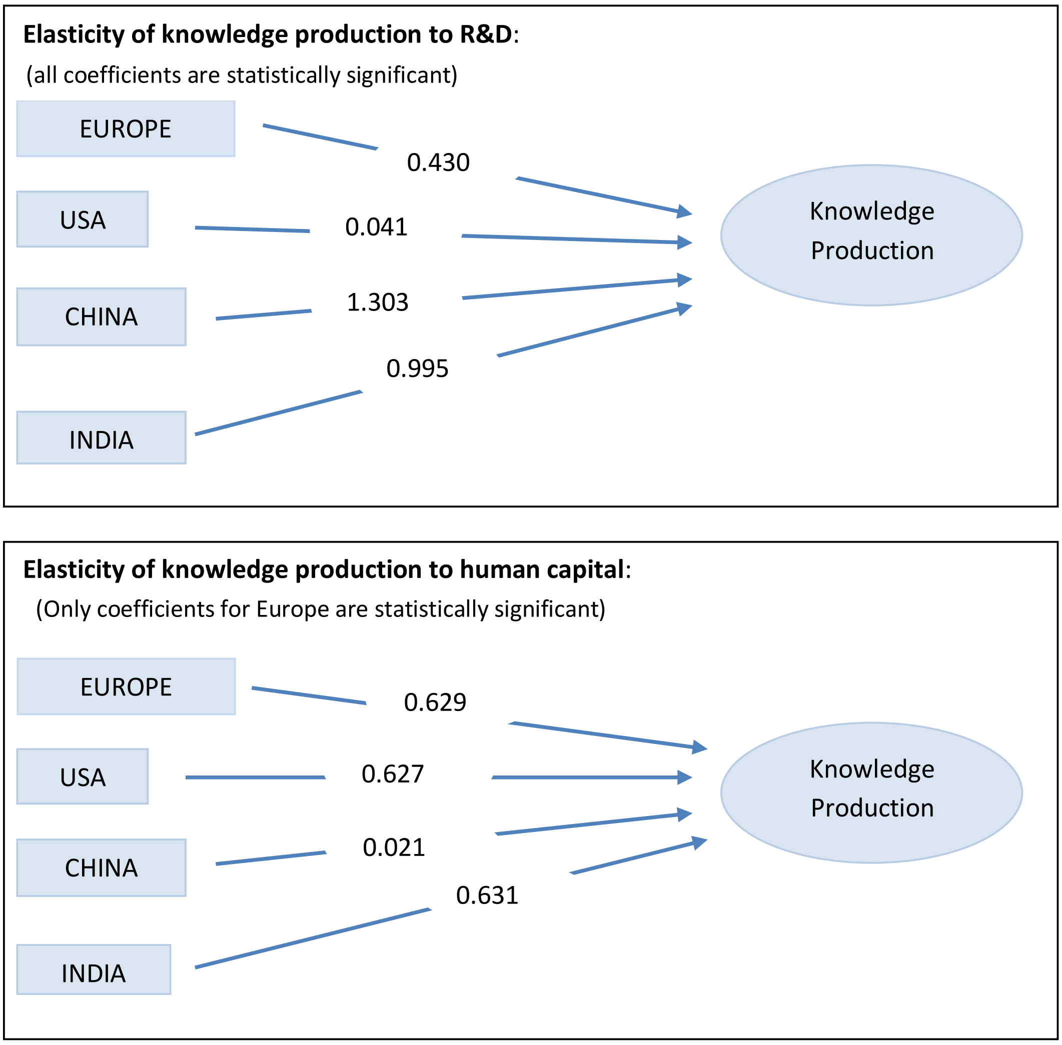


Figure 3.1.1. International comparisons among knowledge production elasticities

The regional knowledge production function links patenting activity to R&D expenditures, human capital and, to control for the region's size, resident population.[14] The most striking result is that R&D expenditures turns out to be positive and significant in all macro areas considered, although it displays huge differences in the elasticity levels which follow a clear decreasing returns pattern. Indeed, the lowest elasticity of knowledge production to R&D expenditures is shown by USA which is the area where R&D investments are higher.[15] The European average elasticity is equal to 0.43, while a much higher return is found for China (1.3) and India (0.99) that is the two developing economies which have just started the process of investing specific resources in formal inventive activities.

The second important result is that **human capital exerts a relevant role on knowledge production only in Europe while it appears not significant in the other areas**. However it has to be considered that when human capital is not included alone in the regression but is combined with other socio-economic elements that form the so-called "social filter" (Crescenzi and Rodriguez-Pose 2009), then it plays a relevant role also for the case of USA, China and India. It means that in the European regional innovation model the availability at the local level of an adequate endowment of highly educated labour forces plays a key role per se in influencing the process of knowledge creation. On the other hand, in other territorial frameworks it is the combination of elements that compose the socio-economic conditions which positively enhances the creation of knowledge.

3.2. Knowledge spillovers and regional knowledge creation

3.2.1. Internal knowledge flows and local knowledge creation

The importance of looking at the role of intra-regional inventors' mobility and internal co-patenting in generating local knowledge comes from the need to criticize the idea that all kind of R&D efforts will systematically lead to a larger number of inventions. This argument overlooks the importance of a set of factors that actually account for how knowledge is generated at the regional level (Rodriguez-Pose and Crescenzi, 2008). Hence, in this section we study the capacity of a region to generate formal knowledge (measured in terms of levels of patent production) due to intra-regional inventors' mobility and scientific networks (as promoted by the European Commission through Marie Curie programs or the Framework Program Projects), beyond regional R&D endowments and other traditional explicative elements. By doing so, we also demonstrate that the location in a region producing knowledge is not enough to access private pools of knowledge within regions. Rather, knowledge diffuses within the region by means of structured and defined channels, such as networks and labour mobility of human capital, whose spatial distribution explains a sizeable part of patent production heterogeneity across regions.

In order to meet these goals, the estimation of the impact of internal inventors' mobility and internal co-patenting (connectedness) on knowledge creation is measured.[16] Among the results, we highlight that both labour mobility and the scale of the networks (no matter the indicator used) have a significant and positive impact on the patenting activity of the regions. Thus, we can conclude that **both collaborative research networks of inventors and the mobility of inventors within the local labour market of a region enhances local knowledge creation**. It is worth remarking the significant, but negative effect of the strength of the local network (measured by network density) on regional knowledge performance. **It seems that in the European case, overly strong interpersonal ties might well hamper knowledge because of the fact that, at some point, the information flowing across those ties becomes redundant.** In short, the empirical analyses undertaken here support the hypotheses concerning the importance of labour mobility and networks in the local labour market for the creation of regional innovations. That is, the degree of *embeddedness* of the local community of skilled workers influences the spatial variation in regional knowledge

[14] Details on data and model specifications can be found in the Scientific Report, Volume 1, Chapter 4.
[15] It should be borne in mind that the estimated coefficient for US BEA-EAs makes reference to private R&D only and has to be considered as a lower-bound estimate due to potential attenuation bias as discussed in the Scientific Report, Volume 1, Chapter 4.
[16] Methodological details on indicators and econometric models and specifications implemented to analyse the relationship between labour mobility, research networks and knowledge are fully provided and commented in Chapter 5, Volume 1 of the Scientific report.

performance. There seems to be however threshold effects at place since too much over-embedded and strong local networks might be harmful for new knowledge production.

However, the results for the whole of the European regions may mask substantial regional variation in the returns to knowledge creation with respect to mobility and networking. In order to analyse this variability, we have estimated the different impact that is obtained for the different typologies of territorial innovation pattern.

Figure 3.2.1 displays the impact of intra-regional inventors' mobility on knowledge by patterns of innovation. Results show that there is not a direct relationship between the level of knowledge existing in the regions and internal knowledge mobility. **Inventors' mobility is more efficiently used (i.e. shows a greater impact) in the "European science-based area" and in the "Smart technological application area".** In both cases, the results would suggest that the regions in these two areas are able to translate internal knowledge into new science or new specific commercial applications, and that part of the external knowledge could come from workers coming from other local enterprises. On the contrary, a clear result is that regions characterised by low levels of R&D spending as well as a rather narrow inventive profile (belonging to "Imitative innovation area") do not benefit from the local mobility of skilled workers, being the impact of labour mobility non-significant in this case. Also, the benefits of intraregional mobility look concentrated in EU15 while they are negligible in EU12 or EFTA countries. Similarly, competitive regions benefit more from intraregional mobility in terms of inventive capacity than transition and convergence regions.

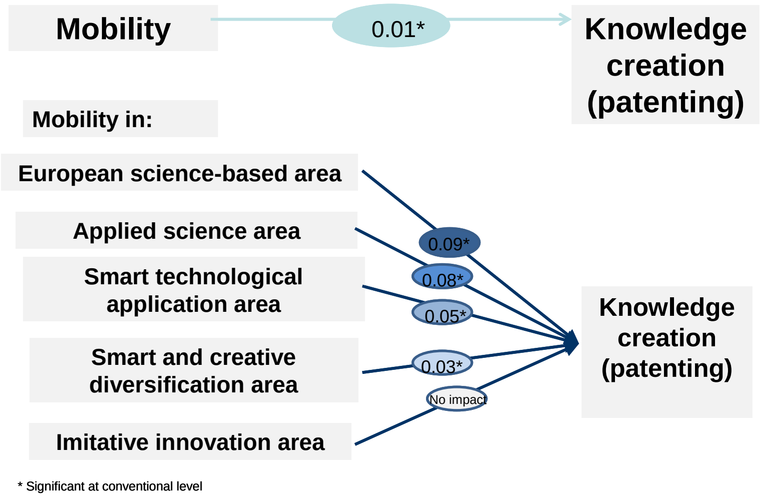


Figure 3.2.1. Impact of intra-regional inventors' mobility on knowledge creation by patterns of innovation

Similarly, the average effect of internal co-patenting hides a great variety of behaviours across regions (Figure 3.2.2). Having an important share of inventors participating in research networks is more efficiently used (i.e. shows a greater impact) in regions that outperform the others in terms of their propensity to networking, such as those in the "European science-based area", in the "Smart technological application area" and in the "Applied science area". It must be signalled, though, that the impact in the case of the regions of the "Smart and creative diversification area" and the "Imitative innovation area" also show positive and significant impacts, although of lower magnitude, even one third of that obtained in the "Smart technological application area". This can be explained by their rather narrow knowledge and innovation profile. Moreover, another interesting result is the lower spatial variance among the impact of internal co-patenting than in the case of inventors' mobility. This result means that internal co-patenting produce advantages also in regions with lower internal knowledge creation capacity.

To sum up, as labour mobility and internal co-patenting have been obtained to be a fundamental factor in the creation of knowledge, the unequal distribution of such features in the territory could explain regional differences in innovation performance and economic development. In this sense, policies aimed at encouraging the mobility of high skilled workers or enhancing co-patenting, especially in less innovative regions, may play a critical role in the creation of knowledge, and subsequent economic growth. However the effectiveness of such policies, as shown by the results of this section, crucially depends on each region's capacity to give returns to such labour mobility and co-patenting. To this respect, we have provided evidence that those regions that are more knowledge intensive obtain higher impacts since they are able to translate internal and external knowledge into new specific commercial applications more efficiently than the less innovative regions. Similarly to intraregional mobility, the benefits of intraregional connectedness look greater in EU15 than in EU12 or EFTA countries. Similarly, competitive regions benefit more from intraregional connectedness in terms of inventive capacity than transition and convergence regions.

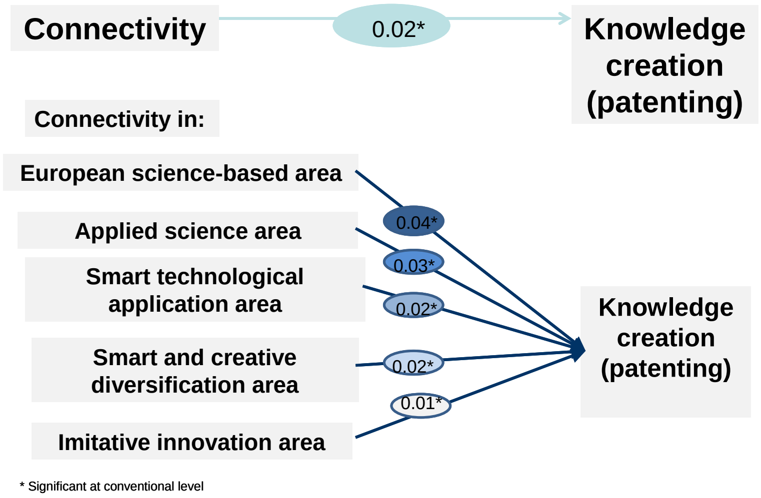


Figure 3.2.2. Impact of internal co-patenting (internal research networks) on knowledge creation by patterns of innovation

3.2.2. External knowledge flows and regional knowledge creation

A second important contribution stems from taking into account the impact of external linkages with other regions in the production of internal knowledge. As it has been argued in the literature, we claim that cross-regional co-patenting and movements of skilled workers across regions act as main channels through which knowledge is transferred throughout the space (Fratesi and Senn, 2009). As stated by Bathelt et al. (2004) and Owen-Smith and Powell (2004), firms in regions build 'pipelines' in the form of alliances to benefit from knowledge hotspots around the world. In a similar vein, as Breschi et al. (2010) put it, 'knowledge always travels along with people who master it. If those people move away from where they originally learnt, researched, and delivered their inventions, knowledge will diffuse in space. Otherwise, access to it will remain constrained in bounded locations'. Based on these considerations, we examine in detail the role of external-to-the-region research alliances in the likelihood to patent at the regional level, as well as the influence exerted by the geographical mobility patterns of knowledge workers.

Inter-regional mobility of inventors and cross-regional collaborations in patenting are the two variables used to capture the knowledge and scientific linkages among regions.[17] The results corroborate the importance of the spatial mobility of skilled-workers for a regional economy, since inventors' migration rates (measured either as net migration rate, or inward migration rate and gross migration rate) present positive and significant impacts. Thus, **the greater the number of inventors moving into a region, the greater the knowledge creation of such region.** Only the rate of outward migration seems not to be related to patenting activity, which would point to the fact that **once the workers have moved to other regions, either they break their ties with their former fellows or the contacts they maintain with them do not seem to play a significant role in the patenting activity of a region.**

Looking at spatial heterogeneity in the impacts of cross-regional inventors' mobility on knowledge creation (patenting activity), a strong spatial variance occurs. Map 3.2.1 shows the geographical distribution of the regional impact of cross-regional mobility on knowledge

[17] Methodological details on indicators and econometric models and specifications implemented to analyze the relationship between labour mobility, research networks and knowledge are fully provided and commented in Chapter 5, Volume 1 of the Scientific report.

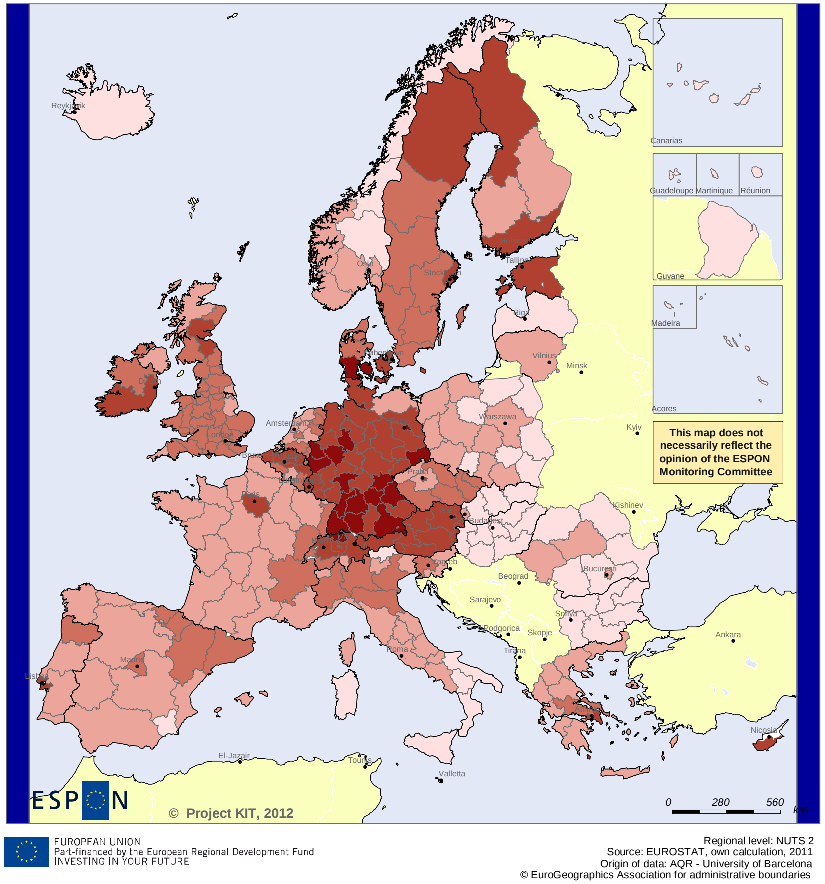
creation by patterns of innovation. The highest effect is registered for the European-science based area and the Applied science area, followed by the Smart technological application area although with a much lower impact. What is interesting is that the "Smart and creative diversification" area does not get any advantage in their knowledge creation by inventors' mobility; the latter is even of detriment to internal knowledge production in the "Imitative innovation area". Interestingly, competitive regions benefit more from inter-regional mobility in terms of inventive capacity than transition and convergence regions.

Two major results come out from these estimates. Firstly, in order to benefit from external formal knowledge, a region has to have a certain amount of internal knowledge. A normative intervention for supporting inventors' mobility in areas with reduced formal knowledge capability is worth for strong scientific regions. The second, less intuitive, result is the nature of the "Smart technological application area" compared to the "Smart and creative diversification area". As they have been conceptually conceived, they both pertain to a pattern of innovation in which local preconditions to have an internal production of knowledge in the region are not present in a critical mass. They both rely on external knowledge. However, the difference between the two patterns is that the "Smart technological application area" has a certain level of internal formal knowledge that allows taking advantage from external formal knowledge, and with a mix of internal and external knowledge, they generate new applications and produce innovation. The "Smart and creative diversification area" misses the basic "absorptive capacity" to turn external formal knowledge into innovation, and therefore rely on local knowledge - interpreted as abilities, capabilities, methods, creativity and persistency in identifying and solving problems - to collect, select, interpret and apply external knowledge and information.

This result adds something important to the debate on "smart specialization" in the field of innovation policies; in this debate the idea is to push the "periphery" (intended not in geographical terms but in terms of internal knowledge production capabilities) to identify and exploit the potential advantages of general purpose technologies to regenerate the targeted economic domain through the co-invention of application (Foray et al., 2009). Our results underline that the periphery is a multifaceted domain, in which some areas could really take advantage of a co-application innovation strategy. There are "peripheral areas", however, where even knowledge spillovers coming from outside the region are unable to push the innovative milieu towards a technological co-application activity. As we will see afterward, for these regions more targeted interventions are required, able to keep their abilities, capabilities, methods and creativity strongly alive.

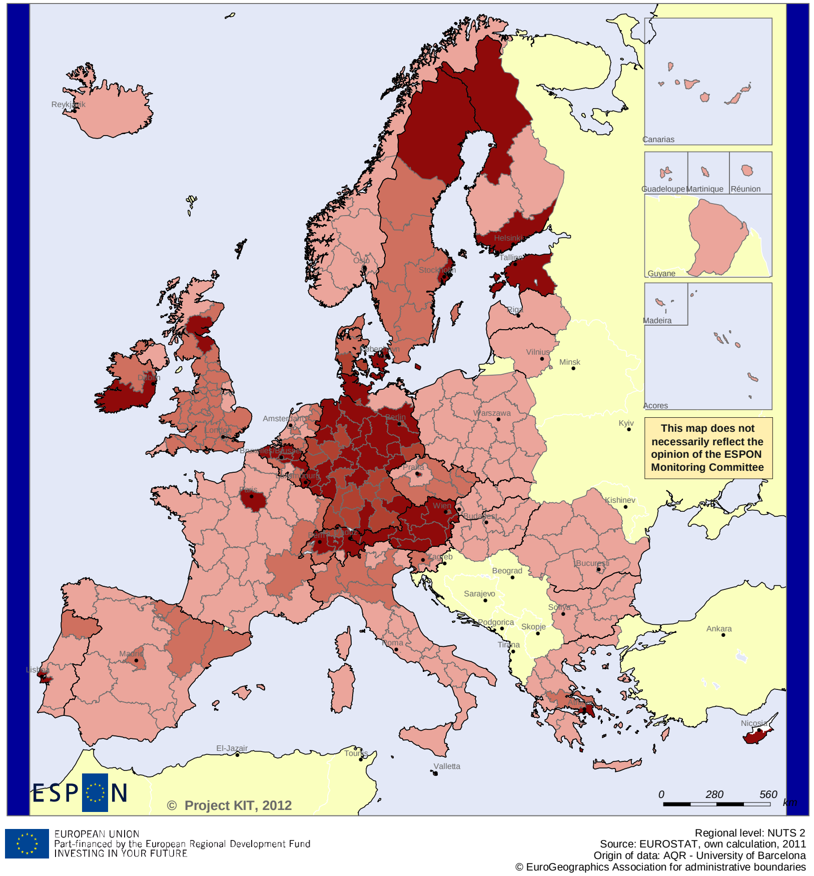
Similar results are achieved when we analyze spatial heterogeneity of the role of co-patenting activities. Map 3.2.2 shows the impact of cross-regional co-patenting on knowledge creation, where it is observed that regions taking advantage of co-patenting activities are those regions that already patent a lot. The "European science-based area", the "Applied science area" and the "Smart technological application area" register a positive and significant impact of cross-regional patenting on knowledge creation. This is not the case for the other two types of regions, where no critical mass of knowledge exists. Also, the benefits of co-patenting look concentrated in EU15 while they are negligible in EU12 or EFTA countries. Similarly, competitive regions benefit more from co-patenting in terms of inventive capacity than transition and convergence regions.

Finally, from a policy perspective, these results and those of the previous sub-section flesh out empirically pivotal pillars of the Smart Specialisation strategy put recently to the fore by the European Commission. Thus, the concepts of local *embeddedness* of the local networks and labour market, as well as the degree of *connectedness* to external sources of knowledge, constitute core ideas of the Strategy (McCann and Ortega-Agilés, 2011). Our results, however, tell us that innovation policies based on both concepts of embeddedness within the region and connectedness to outside the region have to be translated into effective actions taking the characteristics of single "innovation patterns" into account.



- Imitative innovation area = -0,10
- Smart and creative diversification area = No impact
- Smart technological application area = 0,02
- Applied science area = 0,06
- European science-based area = 0,05
- No data

Map 3.2.1. Elasticity of knowledge production to cross-regional inventors' mobility by patterns of innovation



- Imitative innovation area = No impact
- Smart and creative diversification area = No impact
- Smart technological application area = 0,14
- European science-based area = 0,26
- Applied science area = 0,31
- No data

Map 3.2.2. Elasticity of knowledge production to cross-regional co-patenting by patterns of innovation

3.3. R&D, human capital and regional performance

The aim of this section is the measurement of the effects of R&D and human capital on regional output, so to measure the elasticity of GDP to R&D and to human capital. This analysis has important policy implications, since it measures the effects of the Lisbon and Europe 2020 Agenda strategy (increase to 3% of R&D / GDP) on regional growth.

Through a particular econometric approach (the estimate of a spatial autoregressive SAR model), GDP is made dependent on traditional production factors with the addition of knowledge (in the form of R&D and human capital), and the estimate of the impact of the knowledge factors R&D and human capital is thus obtained[18]. In particular, the impact of R&D (0.131) and human capital (0.297) turns out to be higher than the traditional physical capital input (0.035). Moreover, the human capital coefficient is more than twice the R&D expenditures one. The availability of highly educated labour forces is confirmed to play a crucial role also in the regional economic performance. Finally, the significance and magnitude of the coefficient associated with the spatially lagged dependent variable indicates the effectiveness of knowledge spillovers and the importance of spatial interaction among the regions: **the closer is a region to the most economically advanced areas, the higher the local externalities moving across borders.**

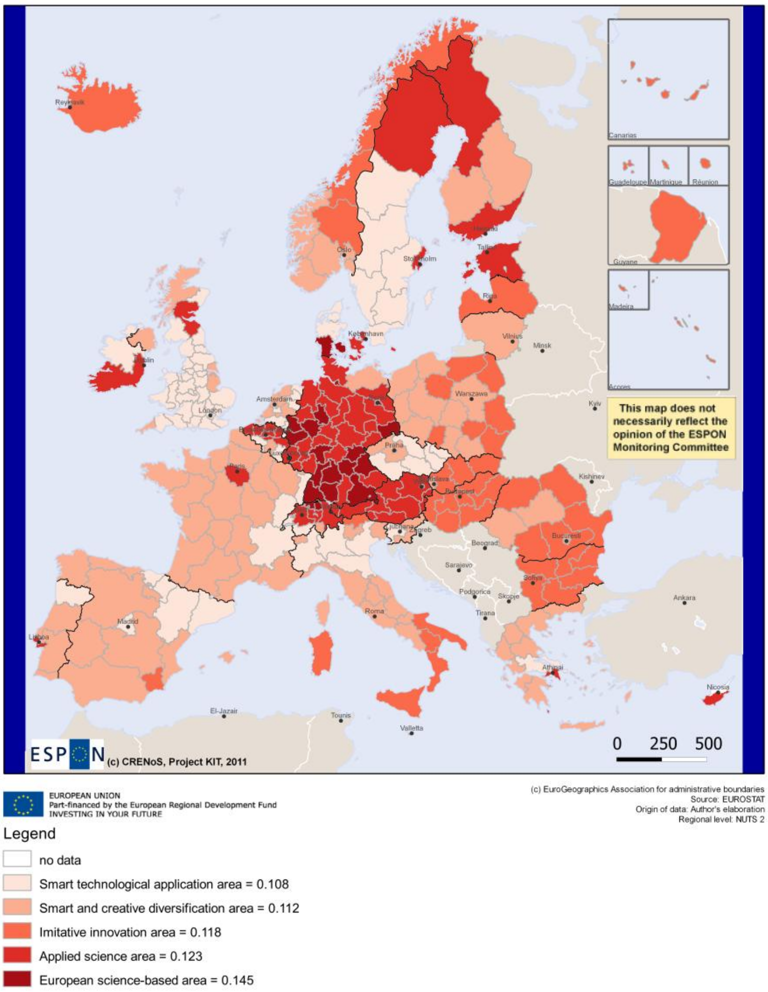
The estimated coefficients for the whole set of production factors, tangible and intangible, have so far been considered as average estimates for all Europe. By relaxing this assumption we try to assess the hypothesis of heterogeneous impacts with respect to the two intangible assets, that is human capital and R&D.

It is worth remarking that the coefficient of human capital and the one for R&D are pretty robust with respect to the inclusion of the other five interactive terms, one for each pattern; the estimates are, as a matter of fact, quite similar to those obtained from previous general specification. Whereas, on average, 1 percentage point increase in R&D yields 0.13% increase in regional production, this is not the case across all types of regions. In fact, **R&D is more efficiently used (i.e. shows a greater elasticity) in those regions that considerably invest in R&D, such as those in the "European science-based area"**. On the contrary, regions characterised by lower levels of R&D spending, have little benefit from further investments in R&D to improve their economic performance being their elasticity of innovation to R&D below the European average. The elasticity of GDP to R&D has a U-shaped form. We report these results in Map 3.3.1. These results have strong normative implications. The message stemming out of these results is that R&D has an important impact on GDP when it is present in large quantities. A Lisbon Agenda for regions with a low level of R&D endowment seems to produce rather limited effects on growth.

Results and interpretation are different when human capital elasticities are allowed to vary with respect to the five patterns reported above. The highest elasticity value is shown by the "Smart technological application area" (0.312) and the "Imitative innovation area" (0.309). This result highlights that human capital impact on regional production in weak knowledge performers is more important than R&D impact. In other words, human capital is a more important pre-condition for growth in weak regions than R&D**.** Results for the "Smart and creative diversification area" and the "Imitative innovation area" are quite similar (respectively 0.302 and 0.309) and also in this case we can interpret the result saying that human capital impacts on the economic performance are higher for those territories characterized by a lower endowment of knowledge and innovation variables. Conversely, the two groups of regions which are the most knowledge intensive and are also well endowed with highly educated population and scientific human capital, the "European science-based area" and "Applied science area" group, present lower elasticity value (0.167 and 0.255, respectively).

These results are displayed in Map 3.3.2 where we can see that regions presenting highest values for human capital elasticity belong to Belgium, Switzerland, Denmark, Spain, France, the north of Italy, Nederland, Sweden and United Kingdom. Conversely, most part of regions showing the lowest elasticity values belong to Germany. **This suggests that human capital shows strong decreasing returns: in regions where it is present in large quantities, its effects on growth are limited.**

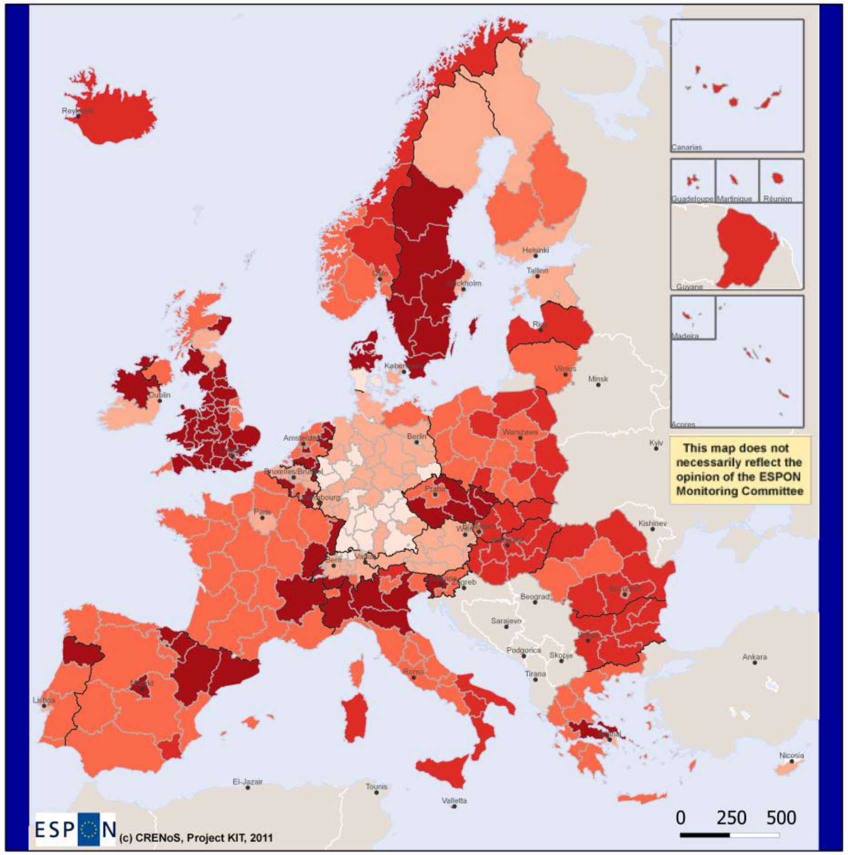
[18] For technical details, see Chapter 3, Volume 1 of the Scientific report.



Map 3.3.1. Elasticity of GDP level to R&D by territorial patterns of innovation (average 2000-2007)

An analysis is also run on the efficiency on the use of all production inputs on GDP. The 2007 efficiency levels are depicted in Map 3.3.3.[19] The production frontier is defined by 32 most efficient regions (red colored). **The spatial distribution of the efficiency scores exhibits a high degree of dispersion in terms of demographic characteristics and geographical location**. More specifically, the efficient regions group includes both small and low densely populated regions, mostly located in peripheral areas (Ciudad Autónoma de Ceuta, Illes Balears, Corse, Åland or Valle d'Aosta) and large, densely populated central regions, such as Île de France, Inner and Outer London. This apparently contradictory picture is expected with the DEA methodology, since it selects efficient units at all possible scales and may therefore reveal high efficiency scores also for small and peripheral regions. Nonetheless, similarly with the case of the previous methodology (the estimate of elasticities through a knowledge production function), **the least efficient territories are mostly located in the Eastern Europe**. Dark areas now emerge also in Central- countries, especially in Belgium, Bulgaria, Germany, Czech Republic, Spain, Finland and UK. In a tentative comparison of the ranking obtained on the basis of knowledge production inputs with that obtained on the basis of the production inputs, we register a much higher level of heterogeneity in terms of knowledge efficiency with respect to production efficiency. Efficient combination and use of knowledge inputs are much more difficult than efficient combination and use of production factors. As suggested above, innovation policies should also be oriented towards the reinforcement of the efficient combination of knowledge production factors, rather than on the reinforcement of single separate knowledge inputs.

[19] In the Scientific report, Volume 1 Chapter 3, the DEA results are also presented for the initial year 2000.



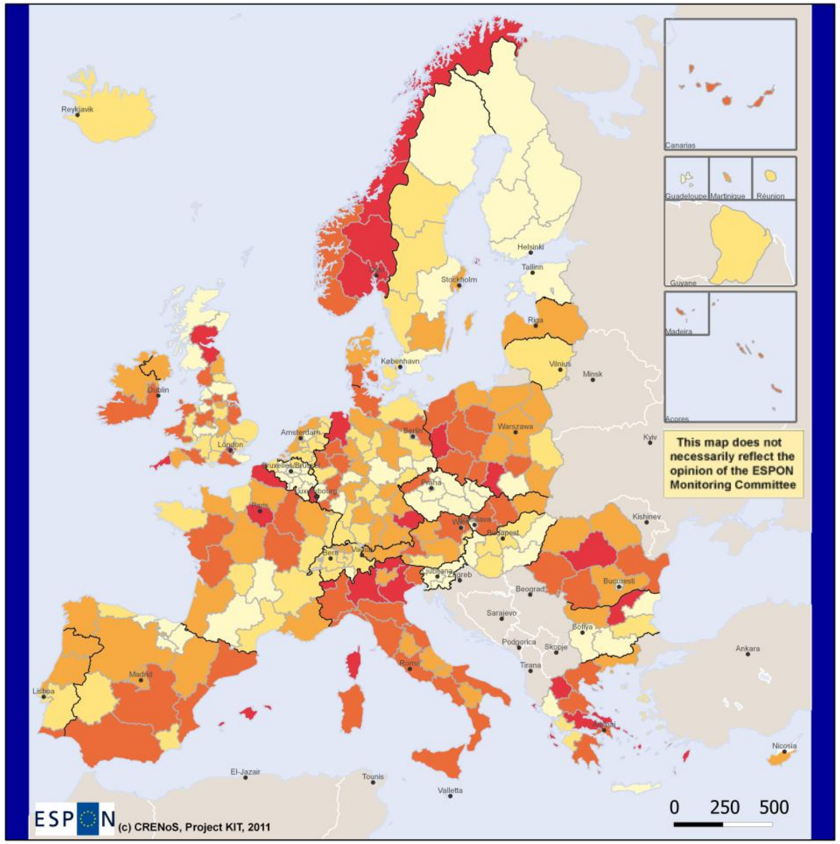
EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: EUROSTAT
Origin of data: Author's elaboration
Regional level: NUTS 2

Legend

- no data
- European science-based area = 0.168
- Applied science area = 0.255
- Smart and creative diversification area = 0.303
- Imitative innovation area = 0.309
- Smart technological application area = 0.313

Map 3.3.2 - Elasticity of GDP level to human capital by Territorial Patterns of Innovation (average 2000-2007)



EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

(c) EuroGeographics Association for administrative boundaries
Source: CRENoS elaboration, 2011
Origin of data: Eurostat
Regional level: NUTS 2

Legend

- no data
- 33.4 - 51.9: Low efficiency (62)
- 51.9 - 62.9: Medium-low efficiency (64)
- 62.9 - 74.0: Medium efficiency (64)
- 74.0 - 99.9: High efficiency (65)
- 100.0: Highest efficiency (32)

Map 3.3.3 – Efficiency level of production function for the individual regions (DEA methodology, 2007)

4. Innovation and regional performance

One of the main issues of the KIT project is the identification of the role played by knowledge and innovation on regional performance, while controlling for the national context, measured in terms of employment growth, total factor productivity (i.e., TFP) and GDP growth. The main questions answered here are:

1) which is the impact of product and process innovation on employment growth?
2) which is the impact of knowledge (both formal and informal) and innovation on the efficiency of the economic system (i.e. on TFP)?
3) lastly, which is the impact of knowledge and innovation on GDP growth?

Before replying to these questions, an intriguing aspect is empirically addressed, namely which is the capacity of formal knowledge to generate innovation activity.

4.1. Knowledge, human capital and innovation

As discussed in Section 2, knowledge, innovation and diffusion are not necessarily intertwined, even at the local level, as factors that enhance the implementation of new knowledge can be quite different from the factors which stimulate innovation. The notion of territorial patterns of innovation, in fact, questions the view equating knowledge to innovation, that implicitly drives the current policy efforts of making Europe the most competitive knowledge-based economy by raising investments in R&D up to 3% of GDP as stated in the Lisbon Agenda and next re-launched in the EU2020 strategy.

Whereas formal knowledge, either measured as R&D investments or patent applications, is, on average, a crucial enabler of superior innovative performances, this relationships becomes more and more complex when the greater variety of knowledge and innovation behaviours across regions is considered. Figure 4.1.1 displays the elasticity of innovation (here measured as the share of firms introducing product and/or process innovation) to R&D (i.e. R&D expenditures as percentage of GDP). Whereas, on average, 1 percentage point increase in R&D yields 0.09% increase in innovation, this is not the case across all types of regions.[20] In fact, R&D is more efficiently used (i.e. shows a greater elasticity) in those regions that considerably invest in R&D, such as those in the "European science-based area", and, to a lower extent, in the "Smart technological application area" and in the "Applied science area". On the other hand, regions characterised by low levels of R&D spending, little benefit from further investments in R&D to improve their innovation performance being their elasticity of innovation to R&D nil, if not negative. These results, thus, point to two key messages. First, **returns to R&D (in terms of innovation performance) are likely to accrue in those regions where a critical mass of R&D efforts and investments is already concentrated**. Second, regions differ considerably in their sources of knowledge for their innovative activities. **Some regions strongly link their innovative performance to their large science and formal knowledge base, others are more likely to rely upon diverse sources of knowledge, possibly embedded in technical and managerial capabilities** (e.g. "Smart and creative diversification area").

The effect of knowledge embodied in human capital (measured as the share of population holding a tertiary degree) is comparable to that of R&D. On average, the elasticity of innovation to human capital is positive; in particular, 1 percentage point increase in human capital leads to 0.18% increase in innovation. Again, this average effect hides a greater variety of behaviours across regions (Map 4.1.1). In fact, knowledge embodied in human capital is more efficiently used (i.e. shows a greater elasticity) in regions endowed with a larger share of graduates, such as those in the "European science-based area", in the "Smart technological application area" and in the "Applied science area". Regions highly endowed of human capital should keep this record in order to maintain their innovative performance. Normative choices that limit such investments risk to put under stress **the innovative profile of the regional economies in the medium to long run**.

[20] Methodological details on indicators and econometric models and specifications implemented to analyse the relationship between knowledge, human capital and innovation are fully provided and commented in Chapter 6, Volume 1 of the Scientific report.

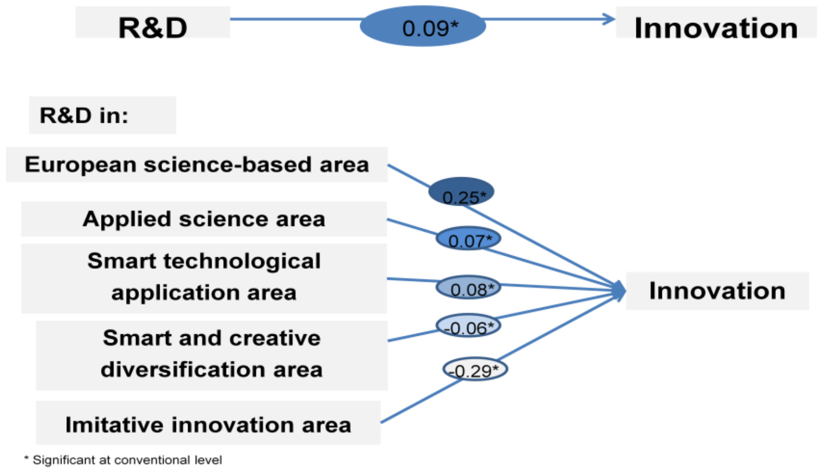
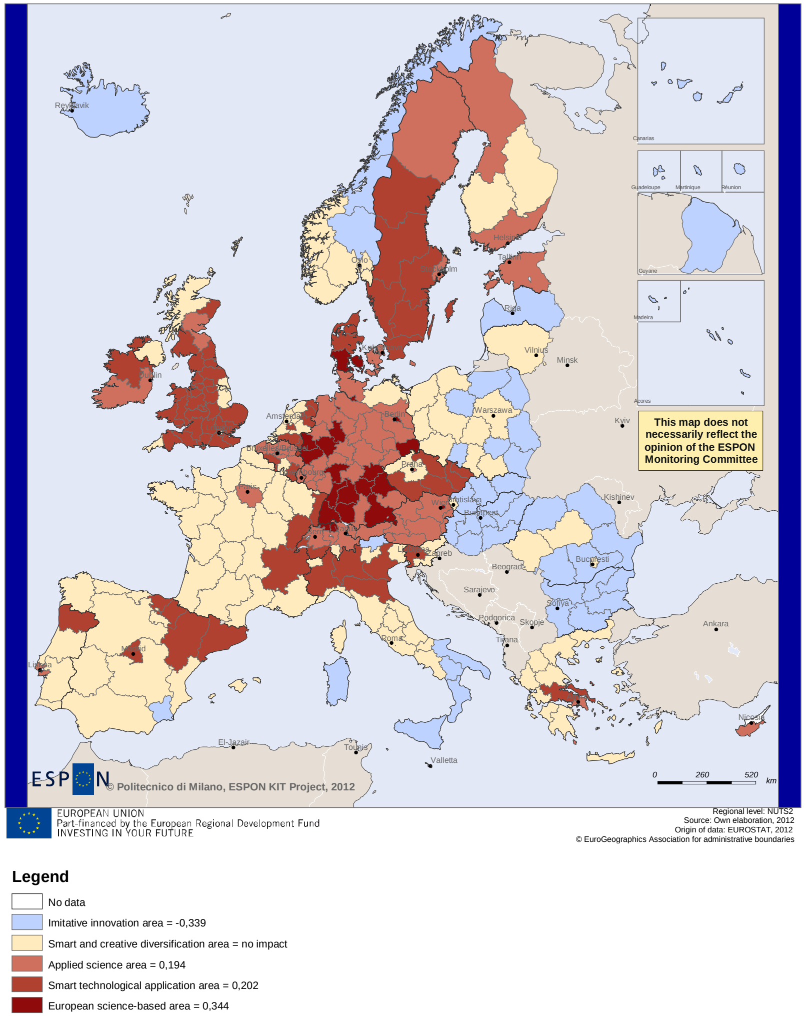


Figure 4.1.1. Elasticity of innovation to R&D by patterns of innovation



Map 4.1.1. Elasticity of innovation to human capital by patterns of innovation

On the other hand, regions characterised by a lower share of tertiary educated population benefit less (in terms of increased innovative performance) from an increase in the share of tertiary educated population being their elasticity of innovation to human capital nil, if not negative (such as in the "Smart and creative diversification area" and in the "Imitative innovation area", respectively). Moreover, the innovation benefits stemming from additional investments in R&D and education are unevenly distributed among EU member states and specifically accrue to EU15 countries, being negligible in EU12 countries. Similarly, competitive regions look more efficient in translating R&D and human capital into innovations than transition and convergence regions, where additional R&D and human capital do not yield increases in innovation level (if not a decrease). Lastly, especially metropolitan areas seem to benefit from additional R&D and human capital to improve their innovative performance.

The two sets of results are largely consistent within each other. R&D expenditures and the share of tertiary educated population, in fact, show a relatively large correlation index (0,5).All in all, the results confirm that the relationship between formal knowledge and innovation is actual but, importantly, the results allow to better qualify their interplay. In fact, on the one hand, investments in knowledge creation appear to be characterised by scale advantages and their returns are better exploited in areas characterised by a critical mass of knowledge resources. On the other, different knowledge sources from formal knowledge can be made available and exploited to engage in and to sustain innovation creation processes.

4.2. Innovation and employment growth

The relationship between technical progress and employment is an old topic that dates back to classical economists like Say (1803), Ricardo (1821) and Marx (1867). The labour saving nature of innovation has since the beginning been identified and conceptualized, but at the same time the compensation effects of technical change have been stressed, suggesting that the relationship is not so straight forward. In the debate, two distinct views have emerged. On the one hand, an optimistic view has always stressed the capacity of innovation to generate new job opportunities. On the other hand, the pessimistic view has always underlined the "market failure" which can limit these compensation effects, and has always theorized the negative impact of technical change on employment. In fact, process innovations tend to substitute workers with new machineries and equipment whereas the extra employment due to new productions does not necessarily compensate for the losses due to old productions being dismissed (Vivarelli, 1995; Spiezia and Vivarelli, 2002). Also, technological change effects cumulate to rather different aspects, such as macroeconomic and cyclical conditions as well as labour market regulation, institutional and regulatory mechanisms that differ substantially at macro, industry, regional and firm level within the same country, and among different countries.

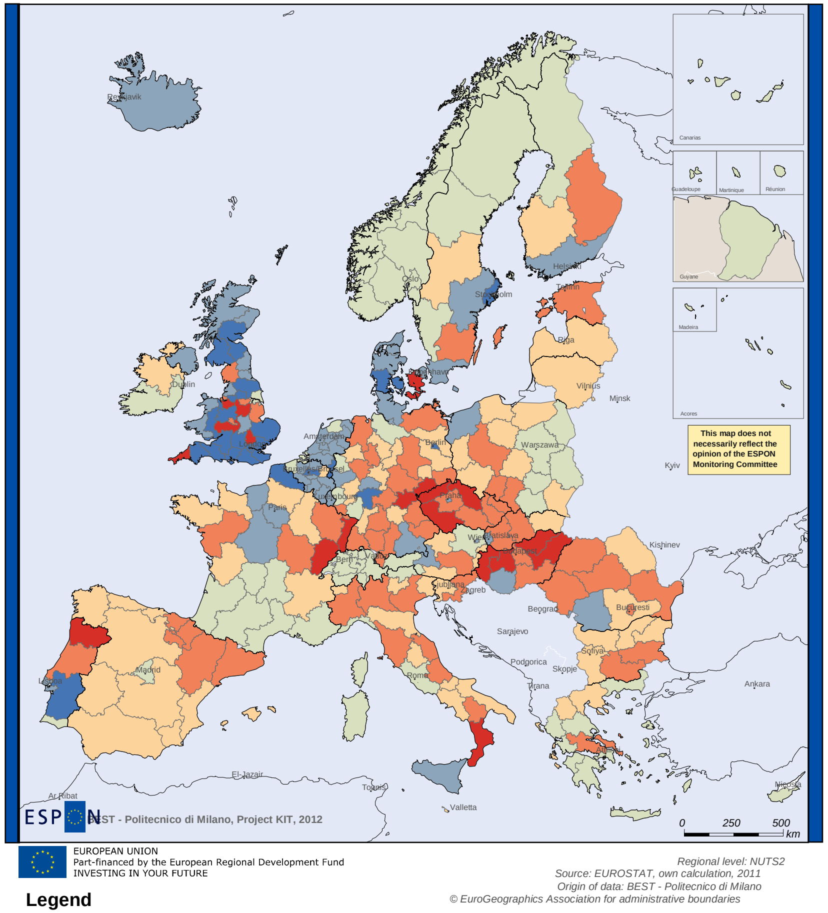
Our results suggest that innovation (either only product or only process innovation) is, in general, labour saving.[21] However, **this result is not space invariant**; specific territorial characteristics, namely the functional specialization and the settlement structure of a region, turn to influence and to moderate the relationship between technical change and employment dynamics.

As Map 4.2.1 shows, **the functional specialization, in the form of a larger presence of blue collars professions, seems to mitigate** (and to turn the effect from negative to a positive one) **the impact of product innovation on employment dynamics**. This supports the idea that the positive effects of producing new goods unfold where production activities are located.

As to process innovation, the labour displacement effects look especially concentrated in specific types of regions, namely in the "Smart technological application area", in the "Smart and creative diversification area" and in the "Imitative innovation area". In detail, Figure 4.2.1 shows the elasticity of employment growth to process innovation. The average direct effect of process innovation is nil, and so also in the more science oriented patterns of innovation (namely in the "European science-based area" and in the "Applied science area"). However,

---

[21] The direct average effects tend to vanish as other controls are introduced in the analysis. For methodological details on indicators and econometric models and specifications implemented to analyse the impact of innovation on employment growth see Chapter 6, Volume 1 of the Scientific report.



Legend

- No data
- < -0,250000 } Share of blue collars = 18%
- -0,24 - -0,05
- -0,04 - 0 } Share of blue collars = 24%
- 0,01 - 0,05
- 0,06 - 0,25 } Share of blue collars = 30%
- > 0,25

Map 4.2.1. Elasticity of employment growth to product innovation at different levels of blue collars functions

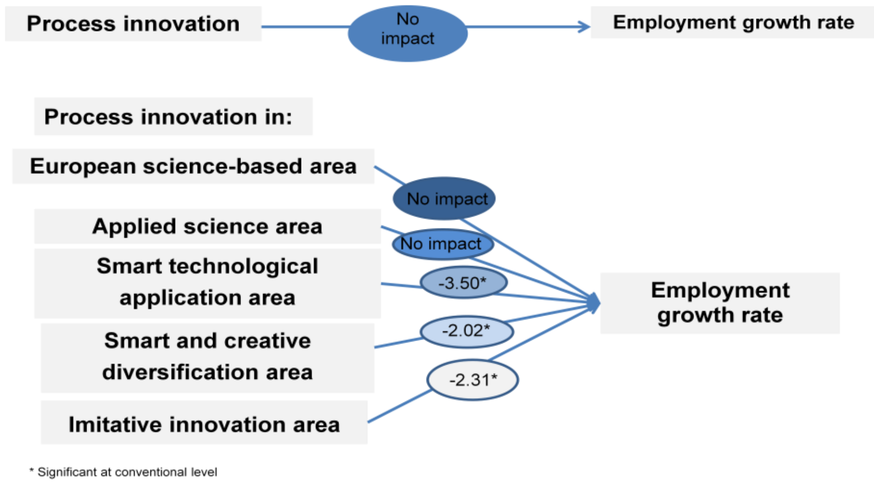


Figure 4.2.1. Elasticity of employment growth rate to process innovation by territorial patterns of innovation

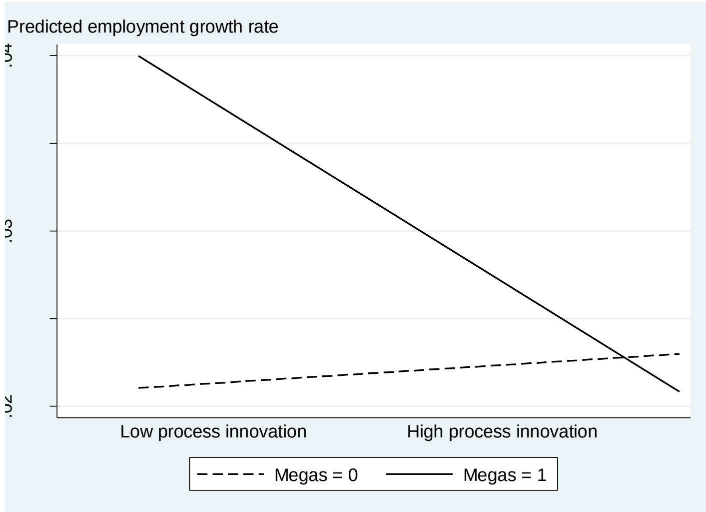


Figure 4.2.2. Elasticity of employment growth rate to process innovation for megas and non megas regions

the compensation effects on the negative employment levels do not take place in the three patterns less endowed of technological and formal knowledge; possibly, the absence (or limited presence) of new machine production effect does not absorb that part of the job displacement generated by process innovation.

Lastly, the labour-saving effects of process innovation look amplified in metropolitan settings (Megas)[22], even after controlling for interregional interdependencies (Figure 4.2.2).In fact, the negative impact of process innovation on the predicted employment growth rate is more detrimental in metropolitan areas (as captured by the steeper negative slope of the dark line) than in other types of regions (as captured by the relatively positive slope of the dashed line). Despite cities being key engines of economic dynamics (and, consequently, of employment growth), they show higher density of service activities which have a higher propensity to introduce process innovations, leading to magnified labour-displacing effects of process innovation.

In conclusion, these results highlight that the relationship between technological change and employment is not spatially invariant and emphasize the moderating effects of territorial characteristics in determining the final outcome of the interplay between innovation and employment growth.

4.3. Innovation and total factor productivity

Interestingly, the efficiency level of European regions (here measured in terms of TFP level[23]) is not only linked to the strength of the local formal knowledge base.

Map 4.3.1 displays the TFP level in the different territorial patterns of innovation. As expected, the "European science-based area" reports the highest efficiency level; however, **the efficiency ranking does not strictly reflect the knowledge ranking, either in the form of R&D expenditures or in the form of number of patent applications**. In fact, despite relatively limited R&D efforts and patent intensity, the "Smart and creative diversification area" comes second in the efficiency ranking of European regions, followed next by the "Smart technological application area", the "Applied science area" and the "Imitative innovation area", which show comparable efficiency levels. In particular, regions in the "European science-based area" show almost 30% higher efficiency level than regions in the bottom three groups.

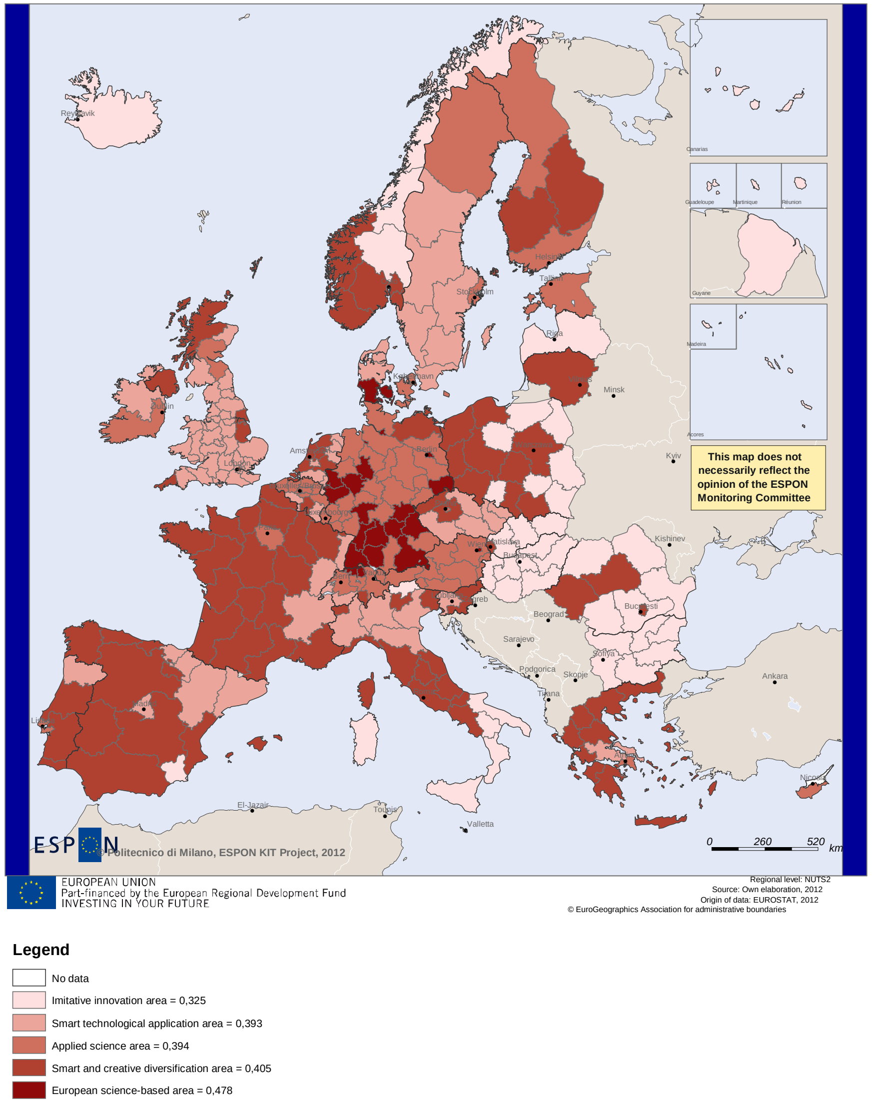
This result suggests that formal knowledge is not the only and chief driver leading to higher efficiency performances. Rather, a tight relationship between knowledge and efficiency level seems to be at place only in those groups of regions in which the local knowledge base is already quite developed and rich. Figure 4.3.1. supports this interpretation. In fact, the elasticity of TFP level to knowledge (as measured by patents), on average positive but quiet limited in size (0.047%), maintains its positive and significant effect in those groups of regions strongly endowed with formal knowledge, namely the "European science-based area" and the "Applied science area", where it strongly increases TFP level. In particular, 1 percentage point increase in R&D expenditures leads to 0.154% and 0.078% increase in TFP level in the "European science-based area" and the "Applied science area", respectively. Differently, in the other groups, TFP level does not seem to react to increases in formal knowledge. Interestingly, TFP seems to benefit more from increase in knowledge in EU12 rather than in EU15; however, especially competitive regions look better able to turn additional knowledge into efficiency gains. Lastly, both metropolitan and, especially, non metropolitan areas benefit from an expansion of the knowledge base.

On parallel, the efficiency level in the "Smart and creative diversification area" is linked to informal and tacit knowledge embedded in managerial and technical capabilities rather than to formal knowledge. In fact, 1 percentage point increase in capabilities leads to 0.05% increase in TFP level (Figure 4.3.2.). However, this mechanism is not at place in all the other types of regions. In fact, the average impact of capabilities on TFP is negligible, and only the "European

---

[22] Metropolitan areas are here captured by a dummy variable taking value 1 if a region includes at least one of the 76 'MEGAs' - FUAs with the highest scores on a combined indicator of transport, population, manufacturing, knowledge, decision-making in the private sectors.

[23] Methodological details on the computation of TFP, the indicators used and econometric models and specifications implemented to measure its main drivers and characteristics (and differences) across territorial patterns of innovation are fully provided and commented in Chapter 6, Volume 1 of the Scientific report.



Map 4.3.1. TFP level by territorial patterns of innovation

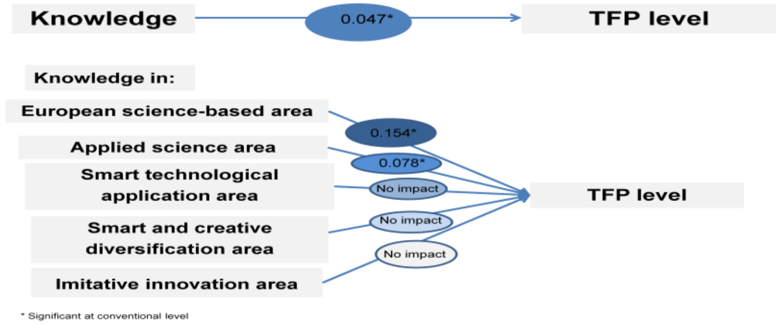


Figure 4.3.1. Elasticity of TFP level to knowledge by patterns of innovation

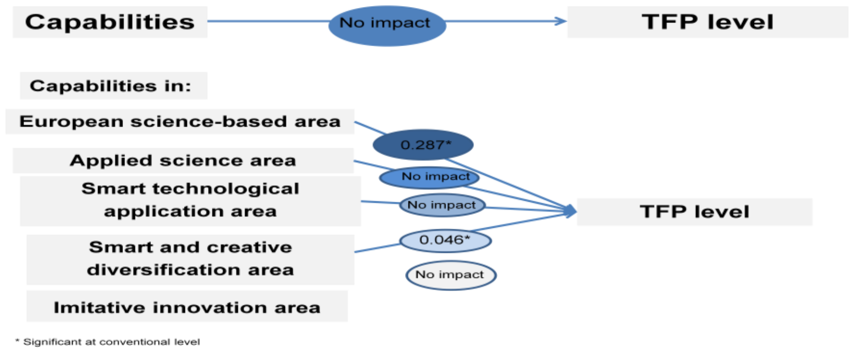


Figure 4.3.2. Elasticity of TFP level to capabilities by patterns of innovation

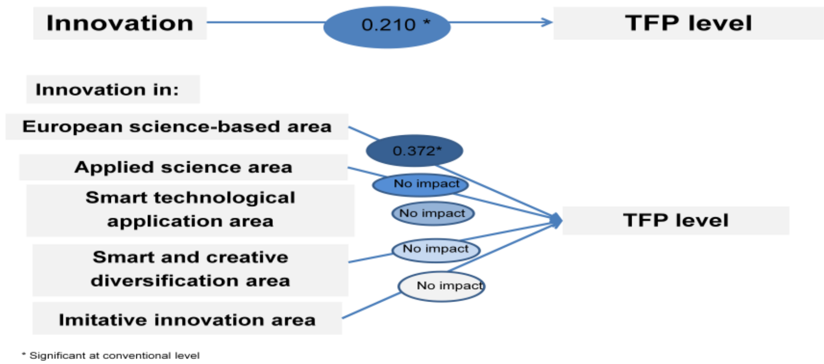


Figure 4.3.3. Elasticity of TFP level to innovation by patterns of innovation

science-based area" seems to experience efficiency gains from increases in the local capabilities level. The impact of capabilities is not much different in EU12 (nil) and EU15 (close to zero but negative); however, it is especially positive and large in transition regions, and moderately, in convergence regions. This supports the idea that efficiency gains can be achieved not only from further investments in formal knowledge, but also from further investments in tacit and embodied knowledge into human capital and professions. Lastly, increase in capabilities look better translated into efficiency gains in metropolitan settings.

Lastly, innovation (here measured as the share of firms introducing product and/or process innovation) looks, on average, crucial to achieve higher efficiency levels; on average, 1 percentage point increase in innovation leads to 0.21% increase in TFP level (Figure 4.3.3.). **However, these benefits are likely to be unevenly reaped by the different groups of regions**. In particular, only regions in the "European science-based area" seem able to benefit from innovation increases, whereas in the other regions innovation does not seem to bear a considerable impact on efficiency increases. Interestingly, TFP seems to benefit more from increase in innovation in EU12 rather than in EU15; however, especially competitive regions look better able to turn additional innovation into efficiency gains.

4.4. Innovation and GDP growth

As to the relationship between R&D and innovation, on the one hand, and regional growth, on the other, we study R&D and innovation impact on absolute regional growth rates. Contrary to a differential approach to regional growth, this does not take into account the fact that there may be regions growing faster than their own countries and that can grow faster than slowly growing regions in fast growing countries. Still, controlling for national economic performance does not alter our findings.[24]

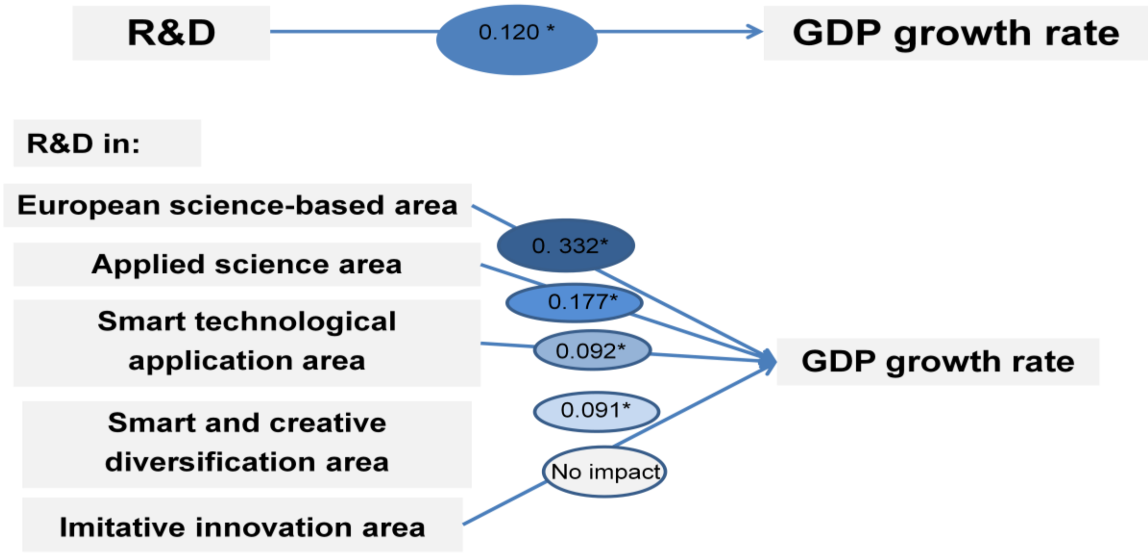
Our results indicate that both knowledge and innovation do play a crucial role in explaining growth patterns in European regions, thus supporting the efforts to enlarge and strengthen the European knowledge base proposed in the Lisbon Agenda and EU2020 strategy. Importantly, our findings also suggest some caution in the interpretation of these results.

Increasing the average R&D spending at the EU level is certainly beneficial to achieve superior GDP growth rates. **On average, 1 percentage point increase in R&D spending yields a 0.12% increase in GDP growth rate (Figure 4.4.1.). However, this mechanism takes place with different intensity across different groups of regions**.[25]

Not surprisingly, the "European science-based area" regions are better positioned to reap the growth benefits stemming from extra investments in R&D being their GDP growth rate elasticity to R&D greater than 0.3%. "Applied science area" regions gain higher than average benefits from additional expenditures in R&D being their elasticity higher than the average value (0.177%). Whereas "Smart technological application regions" and "Smart and creative diversification regions" can benefit from an expansion of their knowledge base (although less than the average, being their elasticity close to 0.09%), "Imitative innovation area" regions do not look to experience a sizeable impact from extra investments in formal knowledge. All in all, these results support the idea that further investments in new formal knowledge creation should be concentrated in those regions that are able to take the greatest advantages from it

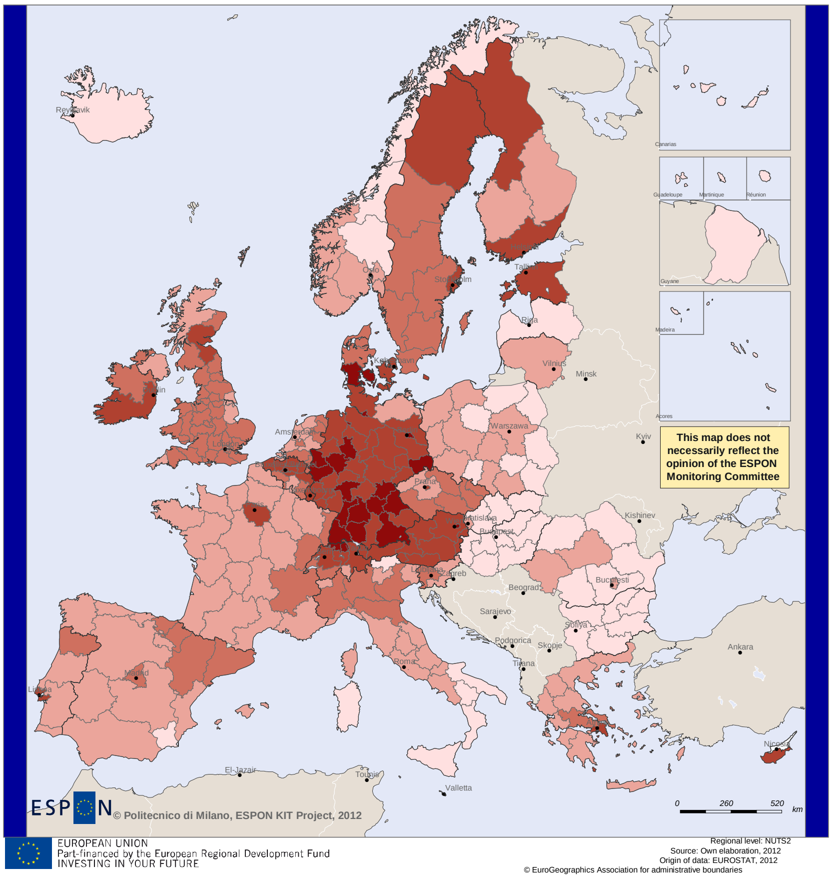
The effect of innovation (here measured as the share of firms introducing product and/or process innovation) on GDP growth rate are comparable to that of R&D, although of larger magnitude and geographical dispersion. The elasticity of GDP growth rate to innovation is, on average, 0.42%, 3.5 times greater than that of R&D. Importantly, the growth benefits stemming from innovation are spatially more distributed than those stemming from formal knowledge (Map 4.4.1). In fact, the differences in the elasticity of GDP growth rate to innovation across the five patterns of innovation are not as noticeable as those in the elasticity of GDP growth rate to R&D. Whereas this partly reflects a more spatially distributed nature of innovation in comparison with knowledge (as Maps 1.3.1, 1.3.2, and 1.4.2. show), this also suggests that the different groups of regions are similarly efficient in translating innovation.

[24] In the econometric analysis, we included a control for the national growth rate in the previous period. The main results are unaffected.
[25] Methodological details on indicators and econometric models and specifications implemented to analyse the impact of knowledge and innovation on GDP growth are fully commented in Chapter 6, Volume 1 of the Scientific report.



* Significant at conventional level

Figure 4.4.1. Elasticity of GDP growth rate to R&D by patterns of innovation



Legend

- No data
- Imitative innovation area = no impact
- Smart and creative diversification area = 0,425
- Smart technological application area = 0,434
- Applied science area = 0,632
- European science-based area = 0,810

Map 4.4.1. Elasticity of GDP growth rate to innovation by patterns of innovation

benefits into higher GDP growth rate. Nonetheless, the ranking of the GDP growth rate elasticity to innovation is similar to the ranking of the GDP growth rate elasticity to R&D. One difference only stands out. In this case, in fact, also "Smart and creative diversification area" regions show above the average value of elasticity of GDP growth rate to innovation. This indicates that even in absence of a strong knowledge base, innovation can yield sizeable impact on GDP growth rate. Importantly, innovation as well appears to show some sort of scale advantages and to require a certain critical mass to unfold its full potential. It seems likely that regions in the "Imitative innovation area" have not reached yet a critical mass of innovation to be able to turns its benefits into higher growth rate and, possibly, should implement measures in order to raise innovation levels to engage into faster growth path. Especially competitive regions benefit from an increase in both in R&D and innovation, whereas convergence regions little benefit from R&D and, even less, from innovation; similarly to the TFP case, transition regions do not show considerable advantages in expanding their knowledge base.

4.5. Innovation and regional performance: some concluding remarks

All in all, these results suggest that innovation can be labour-saving and can negatively affect employment dynamics (section 4.2.). However, the overall positive effects on GDP growth rate (section 4.4) are achieved through increases in efficiency levels (section 4.3) that, likely, more than offset employment losses.

The spatial distribution of these gains is uneven and does not only depend upon the strength of the local formal knowledge (as developed through R&D activities and patents). Formal knowledge is crucial but not exhaustive. In fact, higher than average efficiency levels can be achieved also by taking advantage of local informal, tacit and embodied knowledge creatively and successfully translated into commercially viable innovations

5. Knowledge creation and acquisition: a case study approach

5.1. Scope of the case studies analysis

The case studies examine learning and innovation patterns within firms in different regions of Europe. Their goal is to increase the depth of quantitative analysis in order to highlight the territorial preconditions characterizing knowledge creation and knowledge acquisition best practice.[26] In concert with the general approach of the KIT project, the case studies adopt a multidimensional definition of the knowledge economy, which refers to a combination of industrial, functional and networking perspectives. The preconditions of knowledge creation and knowledge acquisition are in fact analyzed in different industries and local contexts. Such preconditions can strongly influence processes of knowledge creation and acquisition. The case studies also recognise that knowledge is created not only through R&D activities, but is distributed throughout the many functions and activities of firms and other economic actors within a region and, hence, that the knowledge economy is not synonymous with a scientific economy, nor that innovation support is provided exclusively in terms of R&D investments.

Different contextual conditions are found for each combination of region and sector, as policies, agencies and stakeholders combine in influencing development patterns. The main characteristics of the chosen case studies are summarized in Table 5.1.1, and focus on sectors that may be differentiated as high-, medium- and low-tech, and additionally in knowledge intensive service sectors. Firms are examined for the way in which they create, acquire, and exchange knowledge, and studies are differentiated as instances of knowledge creation and knowledge spillover, and in some cases as combinations of these processes. The case studies comment on how knowledge processes may affect the innovative activity of the firms, the form of which is observed to include product, process, marketing, and organisational innovation. The analytical approach employed by the case studies have been useful in providing real examples of the three patterns of innovation, namely endogenous, creative application and imitative territorial patterns – as proposed in Section 2 of this report – and of the local conditions to move from one pattern of innovation to another.

---

[26] The detailed reports of the case studies on knowledge creation and knowledge acquisition are contained in the Scientific report respectively in Volumes 2 and 3.

The sectors contain different segments and firms that may have little in common apart from their sectoral identification. This diversity challenges the capacity of the studies to provide overarching industrial descriptions in particular regions, and this is indeed not the aim. Findings conflict on this basis reflecting the primacy of the territorial aspects over the industrial ones in knowledge creation and acquisition. One can find firms that do not perform according to an average model for the region or sector, but the case studies are focused on the combination of firm-level knowledge processes, sectoral and territorial characteristics. The case studies may be differentiated according to what may be considered as traditional or advanced sectors, which have tended to correspond to those regions that are presented as more specialized or diversified respectively. This correspondence may be found in all three countries included in the study. Hence, the traditional sectors of Food Production and Wood Processing, for example, are each located in regions that have relatively non-diversified economies, while the advanced sectors of Biotech, ICT, automotive, and TV and digital media are located in diversified regional economies.

5.2. Case studies: sectors and territorial contexts

5.2.1. Sectoral characteristics

Diversity within sectors is most pronounced in the high-tech sectors, including the biotech and ICT sectors (see Table 5.1.1). The biotech sector includes firms that are active in drug development and discovery, medical technology, laboratory equipment, diagnostics, contract research activities, bioinformatics, and laboratory supplies. The ICT sector covers perhaps an even greater range of sub-sectors with those in Cambridge including telecommunications, photonics, printing, and IT services; in Tuscany the design and manufacturing of electronic systems, chip making, sensors, and lasers; whilst in Lombardy firms are active in a lengthy list of NACE 2 industries. In Kosice the ICT sector are predominantly software firms, whose products are used in mobile phones, in medical applications, manufacturing control systems and in data systems.

Middle high-tech sectors are more homogenous and examples included in the case studies are the automotive sectors in both Piedmont and Bratislava, and in each of these cases the range of firms include vehicle assemblers and component companies. In the low-tech sector of food, smaller companies specialise in types of food but also in different production stages, manufacture, distribution and food service, and retail. Viticulture (in Arezzo) and wood processing (in central Slovakia) may be described as being the most homogenous of all sectors, although there is variation in the type of wine, and the sector may also encompass wine makers and distributors, whilst production in wood processing ranges from manufacturing of paper to production of furniture. For knowledge intensive services we examine just one sector, namely the TV and media sector in Cardiff, and while there is a range of companies represented, they have largely similar products. The exception in this case are those companies engaged in interactive digital media; however, here the process of technological convergence means that firms across this sector are becoming more closely related.

5.2.2 Territorial contexts

The regions selected for the case studies include different types of regions and different institutional contexts across three European states. The choice of a small number of states place four case studies within each of the national institutional settings avoiding, by not spreading case studies over a greater number of European countries, 'national effects' becoming significant. The three countries in which the case studies were undertaken, namely Italy, Slovakia and the UK, differ in terms of institutional and governance frameworks for knowledge production and innovation. In addition to the differences between these states, the case studies considered internal differentiation, which may be manifested in terms of differences in local governance, for example in the UK where there is some devolution of powers to authorities such as the Welsh Assembly; to differences between sectors centred in urban and rural regions (as in all the case studies); and in terms of the degree of peripherality of the region to the national and European centres of economic activity.

Table 5.1.1. Summary of case studies characteristics and designations

Case study	Sector	Technology Designation	NACE Rev 1.1	NACE Rev 2	Advanced/ Traditional sectors	Diversified/ Specialised local economies	Pattern of innovation	Case study knowledge type
1	Biotech, UK	High tech	24.4	21	Advanced	Diversified	Endogenous	Creation
2	ICT, Italy (Lombardy)	High tech	30; 32; 33	26	Advanced	Diversified	Adoptive	Acquisition
3	ICT, Italy (Tuscany)	High-tech	30; 32; 33	26	Advanced	Specialised	Endogenous	Creation
4	ICT, UK	High tech	30; 32; 33;	26	Advanced	Diversified	Endogenous	Creation
5	ICT, Slovakia (Bratislava)	High-tech /Knowledge Intensive Services	32, 64, 72	26, 61-63	Advanced	Diversified	Endogenous	Creation
6	ICT, Slovakia (Kosice)	Knowledge Intensive Services	32, 64, 72	26, 61-63	Advanced	Specialised	Adoptive	Creation
7	Automotive, Italy (Piedmont)	Medium-High tech	34; 35	27-29	Advanced	Diversified	Endogenous	Creation
8	Automotive, Slovakia	Medium-High tech	34	27-29	Advanced	Diversified	Imitative	Acquisition
9	Food, UK	Low-Tech	15-22	10-17	Traditional	Specialised	Adoptive/ Imitative	Acquisition
10	Wood Processing, Slovakia	Low-Tech	15-22	10-17,31	Traditional	Specialised	Imitative	Acquisition
11	Viticulture, Italy	Low-Tech	15-22	10-17	Traditional	Diversified	Adoptive	Acquisition
12	TV/ Digital Media, UK	Knowledge intensive Services	92	58-63	Advanced	Diversified	Adoptive	Acquisition

Source: Authors compiled from individual case study reports

5.3. Case studies findings: knowledge creation

5.3.1. Internal sources of knowledge creation

Internal channels within firms are the most important ones in terms of the firm's innovative activity, and, for smaller science based companies (e.g. the Tuscany ICT industry), R&D functions can constitute the core and the raison d'être of the firm. For smaller and R&D-dominated firms, internal knowledge exchange channels are informal and direct, while larger firms maintain more formal internal channels, particularly in the case of those MNCs that have acquired local SMEs, or in the case of those larger firms that act as the main customer for local suppliers. For MNCs knowledge exchange channels may cross regional or national borders. Local channels for knowledge exchange with other companies can be limited by confidentiality considerations, and in many cases firms, again particularly at research-intensive stages, target their choice of collaborating partners with great care. Collaborative projects in most cases must align closely to the firms' existing activities and objectives, whether the firm is a research-led company developing, for example, new drugs in the biotech sector, or is an engineering based company, for example, developing new data management and transfer systems, as in the ICT sector. Research projects funded by some state or supranational organisation (e.g. EU FP7), or charity (e.g. Wellcome Trust) may bring firms together in collaborative activity; however, this form of interaction is not common, and is considered as over-burdened by bureaucratic requirements by many, especially the smaller firms.

Scientific knowledge is in all case studies underlined as a crucial source of innovation, but is elaborated within firms in different ways, through engineering, technical design, bench level, and manufacturing knowledge. In many firms in the case studies, bench level technical knowledge, engineering and design increase in importance as the firm progresses from initial innovation, or as the company matures (in the case of spin-offs), toward later phases of process and product development and manufacture. In addition, as firms mature and as they may become more engaged in final product manufacturing, the more their commercial and technical management expertise is developed, and this process of maturation feeds back into research activity. This process has been shown particularly for the biotech sector, as product design becomes a strong guideline and constraint for further research activity. Knowledge of the market and of customer requirements is prominent, constituting a major channel of learning to develop innovations, and becomes more integrated with the firm's R&D the closer the firm's innovative activities are to the market. This combination may be expressed as a manifestation of the entrepreneurial capability of the firms, allowing creative use of knowledge to produce product and process innovation. In a number of companies in which research continues to be a major activity, such as the biotech sector and segments of the ICT sectors, some understanding of commercial imperatives are a requirement for R&D staff and firms express a demand for more commercial training aimed at such staff.

5.3.2. Local sources of knowledge creation

Local sources (i.e. within the local area) very much depend on the size of firms as well as the local conditions. Micro- or small-sized spin-off firms, more prominent in the Biotech sector in Oxford, the ICT in Cambridge and the electronics and optics sector in Toscana, are closely related to **local universities**, which are major sources of basic and general purpose knowledge. Interestingly, our findings suggest that as firms mature and as they develop initial research projects into new products and processes, their links with research groups at universities may become less important. The main sources of local knowledge are replaced by **more specific linkages with suppliers, customers and corporate collaborators**. Universities, and to some extent other research institutions, continue to be important sources of new knowledge, but firms in these areas are also knowledge generators in their own right.

A different perspective comes from the Kosice and the Bratislava ICT sectors, in which the main sources for product innovation are the **local sites of foreign-owned firms**, although a profound evolution is taking place in these areas in relation to knowledge sources. In addition to flows from elsewhere knowledge and innovations are being developed within **the subsidiaries of MNCs located in the region and within locally situated firms** (contributing to bi-directional exchanges). The Bratislava automotive sector is a very good example in this respect. When the first MNC started producing cars in the Bratislava region, the innovative pattern was a typical imitative pattern. Innovation was mainly produced in the parent companies, and transmitted to local subsidiaries, which could add a certain degree of creativity in the imitative process. Following the creation of local suppliers with specific competences, **the innovation pattern moved away from an imitative pattern**; innovation processes can increasingly derive from the knowledge of the subsidiary, which contributes to knowledge generation and has strong interaction with the parent company, e.g. by sending its labour force for periods of training, and by developing strong linkages with suppliers outside the area. The innovative pattern in this area is increasingly becoming **a creative application pattern**.

In Piedmont, an interesting finding pertains to the informal channels through which technical knowledge is generated in **the exchange of information between firms that are placed upstream in the production chain**. Suppliers of the large automotive MNCs interact both with the final customers, as well as with other suppliers, with the aim to solve technical problems, thereby enhancing a virtuous circle of knowledge generation which contributes to the efficiency of the endogenous pattern of innovation.

5.3.3. Territorial elements supporting knowledge and innovation creation

The positive effects of clustering provide firms with local supplies of a suitable, **well qualified and, in many respects, experienced workforce**. In research intensive regions such as Oxford, Cambridge and Toscana, there is a well established research culture, which pervades the locality and is manifested in acquaintance with the requirements of research active firms. A similar **cultural identity** is found where there is a history of innovation within firms based on manufacturing, as in Piedmont. Frequent and meaningful interaction between firms, the local universities, and local or regional government also supports the positive effects of clustering and agglomeration effects.

The availability of **sources of finance** is among the most important of the more general elements that support knowledge and innovation creation. Venture capital is of great importance to support entrepreneurial activity among micro and small firms, and the most obvious example of this is the biotech sector in Oxfordshire, where research active firms require support for extended periods of time before they are able to enter phases of revenue generation. In addition good levels of general education as well as the provision of high standards at technical and advanced university level institutions are regarded as necessary throughout the case study examples.

It is notable that supportive conditions for knowledge creation and innovation come about over an extended period of time and cannot be achieved quickly. **Stable relationships between different elements of the local economy**, investments support, and governance frameworks allow networks to build up that enable both specific sectoral, as well as infrastructural development that may benefit a wide spread of sectors, to occur. In some of the case study areas (e.g., Piedmont), networking is relatively informal, but in other areas networking organisations dedicated to particular sectoral concerns have developed along with those that deal with wider industrial conditions in the region. Dedicated networking structures provide the means whereby firms, both on a sectoral or more general basis, may represent their views or define their needs to various levels of government. These structures are well developed and operate on quite an extensive and formal basis in the biotech and ICT sectors in the UK. However, in other regions this kind of lobbying tends to be more general, for example, in Kosice where networks tend to operate much more on an individual and informal basis.

5.3.4. Local governance supporting knowledge and innovation creation

Even where there are well organised sectoral representative bodies firms report that **there has not been a history of targeted programmes to support high-tech sectors**. To some extent this lack of direct support is rationalised on the basis that successful sectors do not require such support, but it is also observed that government programmes are often unable to respond swiftly enough to fast moving and competitive sectors. Where specific programmes may have been available, such as in the case of EU or nationally based research grants, high administrative burdens and the slow pace of decision making in awarding support compared to the rapid pace of technological progress discourage firms from participation. Firms continue to express the need for general support, e.g. with regard to education, and a particular expression of this in the UK was in relation to commercial and managerial training of scientific and technical staff. In Italy and in the ICT sectors in Slovakia better university-industry collaboration was identified, that may be understood primarily as a need for a closer relationship between scientific and applied research.

Government institutions have been more successful at providing general support to sectors. This kind of support ranges from the 'hardware' support provisions, of more permissive physical planning regulations to allow industrial development, to encourage dedicated science and industrial parks to develop, and to improve transport and other physical infrastructure links; to 'softer' support in terms of facilitating networks and encouraging entrepreneurial activity. Local levels of government are by necessity more closely involved in this type of industrial support, while national state level initiatives are aimed at broader concerns. Both the ICT and biotech sector (in the UK) are located in areas where relatively restrictive planning approaches have contributed to high land prices that affect industrial development land as well as housing and general living costs for the workforce.

5.4. Case studies findings: knowledge acquisition

5.4.1. Innovative Profile and Sources of External Knowledge

As in the case of knowledge creation case studies there is a range of sector types, company size, and capacity for, and types of innovation. Sectors in different case studies may be said to be in different states of development where, for example the TV and digital media sector in Cardiff is undergoing rapid change due to technological convergence and company mergers; ICT in Lombardy, as part of a dynamic and innovative global sector, is also reshaping internally through company mergers and acquisition; and the automotive sector in Bratislava is being reshaped under the influence of FDI. In contrast the Wood Processing sector in Slovakia, although also in the process of similar FDI driven reshaping is changing more slowly; whilst the food sector in Wales has become differentiated into small artisanal companies (which have a range of entrepreneurial strategies) alongside large multi-locational enterprises in response to long-term restructuring of agri-food industries. Viticulture in Arezzo has maintained a relatively stable industrial profile, but is also showing signs of reform on the basis of imported knowledge and expertise.

Scientific knowledge (originated from outside) is available to different degrees in these case studies and employed in its technical application within firms. Example where knowledge is explicitly related to laboratory based scientific knowledge may be found throughout the case studies and is particularly clear within the food and wine sectors in the need to master food technology, safety and hygiene, and within the ICT sector in Lombardy where firms employ under-exploited technologies to address perceived market gaps. Firms innovate on the basis of their ability to adapt, translate and manipulate basic general knowledge in their own specific contexts, and the ability to manage this process is important. Much of the expertise employed may be described as practice and craft knowledge, while organisational, strategic niche management, and marketing knowledge, is central. The TV and digital media sector in Cardiff is a good example of such combinations of knowledge, technical expertise, and commercial awareness as firms operate within rapidly changing technological context, which has strong repercussions on market structures and on the regulatory environment.

Firms in these case studies access sources that are external to the region for important areas of knowledge. Major sources are **parent companies** for those firms that are local subsidiaries of larger corporate organisations, suppliers such as equipment and machinery producers, customers and market level information providers. Locally, business level collaboration is often more important than collaboration based on core technologies and activities, and this kind of collaboration is facilitated by trade associations that may extend beyond the local region.

Specialists play important roles in conveying knowledge as, for example, in the case of 'star' oenologists who provide expertise on a visiting basis to firms in the Arezzo region. At least at the early stages of the modernisation process of the wine sector, local innovation activity has been relatively dependent on the consultancy services of external knowledge workers such as star oenologists with international reputation and experience, frequently external the area. External knowledge has been rapidly absorbed at the local level by creatively adapting it to local needs and by initiating a process of learning centred within local firms.

5.4.2. Territorial elements supporting knowledge and innovation acquisition

The most important precondition in most of these cases is **the quality and price of the labour force**, whilst the labour market structure may also be significant. In some cases such as the wood processing and the food sector studies the local labour force is long standing and embodies valuable knowledge about the practices employed in the industry. In these cases the structure of the labour market has been stable, although periods of restructuring have affected the size of the local labour pool as, for example, in the dairy processing sub-sector in Wales in which employment levels in the dairy industry have declined substantially. In other cases, mobility within the sector is important. In the TV and digital media sector **freelance workers**, working at a number of different operational levels, constitute a large component of the workforce. In each of these two cases more flexible working structures allows knowledge to be brought into, and to circulate within, the local sector.

Clustering effects may be identified in some of the cases, and there are conscious attempts made to reinforce such effects by encouraging **network development** (both local and external). Public sector institutions are often important in this activity, with **universities and other educational and training facilities** being central to improving the quality of local labour market. Specific examples in this respect might include the development of links between firms and university departments whereby staff from the firms act as visiting lecturers and students may gain direct practical experience by working on projects relevant to the firms. Interactions of this kind are found in the TV and digital media, and the food case studies.

5.4.3. Local governance supporting knowledge and innovation acquisition

Local government and other agencies participate to varying degrees in the promotion and support of sectors located in their regions. Where involvement is strong the focus has been on establishing the perception of a region as hosts to sectors with particular strengths. The local government authority in west Wales is an example of strong public sector support focussed on developing a perception (and the reality) of expertise and culture within the food sector, and a similar approach is adopted by state bodies in promoting the products of the wine sector in Arezzo. The media sectors in Cardiff are also recognised and designated as important areas for future growth by the local and regional governments. Such local policy support is manifested in concrete actions, for example, by supplying advisory and other support officers, in facilitating land planning systems to allow for industrial development, and in encouraging clustering effects. Support in developing business networks, both locally and with external regions is seen as important in all the case studies. In Slovakia's wood processing sector this is seen as particularly important to improve levels of local collaboration and co-operation, and in Slovakia in general there is an expressed need to develop better systemic or generic support measures rather than to focus on one-off and specific projects.

A very interesting finding relating to the failure of insufficient innovation investments and poor governance is the ICTs sector in Lombardy, which shows a **passage from an endogenous to an adoptive pattern of innovation**. While at least until the early 1990s, this sector was a good example of an endogenous pattern of innovation, encompassing within the regions the knowledge and innovation capabilities needed to generate product advancements, it now presents deficiencies in GPTs specific for this industry, thereby showing the need to resort to externally-produced knowledge to innovate. This sector registers attempts to launch new policies, in particular with regard to interesting and promising experiences concerning the production of vouchers for cooperative behaviour in innovation activities by the regional board.

Throughout the case studies knowledge and innovation generation and acquisition are shown to be shaped and managed by a range of different actors and by multiple levels of governance within both private and public institutions. Interactions between firms, universities, and local or regional government support the positive effects of clustering and agglomeration. For example, the public provision of education and training systems support and enhance the innovative activities of firms, build local capabilities, and encourage sympathetic research and work cultures. In this respect the local labour supply may be regarded as a relevant contributing actor and its character, in terms of its quality, price, flexibility and adaptability, is a significant factor. The role of local government in maintaining and encouraging the quality of the labour supply and, the long term relationships between different elements of the local economy, investment support, and governance frameworks encourage networks that enable further development. Networks, and organisations dedicated to supporting network activity, perform as important actor that represent the views of firms and develop dialogue with various levels of government.

The interaction between the multiple actors and levels of governance described may be seen to differ according to the pattern of innovation discerned in each case study. Hence, for cases where endogenous patterns of innovation are identified, firms, often high-tech and R&D intensive, exhibit more restricted and focussed engagement with other actors, both in the private and public sector. Where adoptive innovation patterns occur, firms show more extensive networking activity and seek more engagement with specific public sector actors. Lastly, where patterns of innovation appear imitative, firms develop extensive relationships with public sector and network actors to access and acquire new knowledge, and greater dependency on external public and private sector actors to source various forms of support.

Finally, multiple levels of governance effectiveness looks strongly country-specific (e.g. more developed in the UK then in Italy), mostly shaped by the competencies allocation within country, maturity and tradition of multi-layered government structure.

5.5. Conclusions: value added of the case studies

The case study analysis has brought a decisive contribution to the quantitative analysis of the KIT project under many respects.

A first added value of the case study analysis is the relatively larger importance of territorial, rather than industrial, characteristics have in shaping territorial patterns of innovation. This is particularly evident as case studies show that the same industries in different regions can yield radically different innovation patterns, according to the territorial specificities of the regions analyzed, in line with the project's quantitative findings.

A second crucial result of the case study analysis lies in the qualitative assessment of the dynamic aspects of territorial patterns of innovation. Whilst, for most industry-regions case studies stable situations can be captured from the case studies, the Bratislava automotive case study provides evidence of a switch of regime, from an imitative to an adoptive territorial pattern of innovation. In this case thanks to the local availability of entrepreneurial skills, local actors may reverse engineer the knowledge embedded in products traded with MNCs. An opposite case of change from an endogenous to an adoptive, pattern of innovation characterizes the ICTs in Lombardy case, where local firms, once fully capable of bringing new products to the market thanks to the availability of GPTs, and innovative capacity, must now look for scientific knowledge that is sourced from outside the region in order to innovate.

A third major finding of the case study analysis concerns the in-depth analysis of the territorial elements shaping the territorial patterns of innovation. In fact, a qualitative assessment of such crucial innovation and knowledge-enhancing factors is needed in order to match the quantitative analysis carried out. The case studies provide in some sense the micro-foundations for the quantitative analysis in the rest of the KIT project. These case studies provide an inductive proof that the territorial elements conceptually identified as crucial in shaping the territorial patterns of innovation are indeed fundamental for the way in which regions innovate.

6. Policy recommendations

6.1. The inappropriateness of a "one-size-fits-all" innovation policy

The general aim of increasing European competitiveness through knowledge and innovation is a strategic and rightly formulated goal. However, the vast empirical analysis - both qualitative and quantitative – developed in this project has highlighted under many respects the inappropriateness of the "one-size-fits-all" policy which could be derived from a fast and superficial reading of the Lisbon and Europe 2020 Agendas.

When a regional perspective is adopted, in fact, an aggregate policy goal of 3% of the EU's GDP (public and private) to be invested in R&D/innovation shows its fragility in supporting the increase of the innovation capacity of each region in Europe, since:

- in order to have a substantial **impact of R&D over GDP**, a critical mass of R&D spending has to be present in the region, and this is not the case in most regions in Europe. Moreover, also in those areas where R&D activities are developed, new R&D funds have to be targeted to new fields, in order to avoid the decreasing returns that accompany R&D spending;
- similarly, formal knowledge, in the form of R&D and patents, generates **innovation** only in those areas that register a critical mass of this kind of knowledge;
- human capital, intended in terms of highly educated population, requires a critical mass to create new knowledge (patents). However, notwithstanding the decreasing returns associated to this knowledge input, the elasticity of new knowledge to human capital is higher than to R&D spending. This reminds us that R&D spending *tout court* is a too narrow policy tool to enhance knowledge creation;
- R&D spending on its own does not guarantee high efficiency level in the production of new knowledge; it is instead the efficient combination of different knowledge inputs that guarantees high efficiency levels in knowledge production;
- external knowledge (in the form of inventors' attraction and scientific research collaborations) contributes to the creation of local knowledge in regions in which a high level of knowledge is already present. The idea that R&D spending and knowledge

production in general spill-over to neighbouring regions is not so evident in the absence of a certain level of receptivity to exploit external knowledge.

All these messages highlight unconventional policy warnings with regard to:

- the high expectations put on R&D expenditures as the right policy tools to develop new knowledge, innovation and growth;
- the general belief that if a knowledge economy is developed, this gives rise to the same growth opportunity everywhere;
- the idea that knowledge produced outside the region can easily and automatically be used in an efficient way by other regions;
- the general belief that an innovation-driven economy is necessary linked to a knowledge economy;
- the idea that formal knowledge is the main and most strategic knowledge asset on which a knowledge economy rests.

These unconventional policy warnings suggest that European innovation policies have to move away from a thematically/regionally neutral and generic innovation strategy; they require instead to be based on a *thematically/regionally focused innovation policy* approach.

6.2. Thematically/regionally focused innovation policies

6.2.1. Smart innovation policies

Our empirical analysis has shown that the pathways towards innovation and modernization are differentiated among regions according to local specificities. In fact, territorial innovation patterns exist, that differ one another in terms of the different modes of combining knowledge and innovation, due to different territorial (context) conditions that support the creation / diffusion of knowledge and innovation.

In front of this, a single overall strategy is likely to be unfit to provide the right stimuli and incentives in the different contexts; it is instead on these different territorial innovation patterns that ad-hoc, thematically/regionally focused innovation policies have to be designed.

Smart innovation policies may be defined as those policies able to increase the innovation capability of an area by boosting effectiveness of accumulated knowledge and fostering territorial applications and diversification, on the basis of local specificities and the characteristics of already established innovation patterns in each region.

The logical pathway towards 'smart innovation' policies is drawn in Figure 6.2.1. The Reform of the EU Regional Development Funds can be assumed – and in fact was explicitly intended – as a "key means of turning priorities of Innovation Union Flagship Initiative into practical action on the ground" (EC, 2010b, p. 2). Along similar lines, the contribution provided by this project, with its detection of five, conceptually differentiated innovation patterns, may pave the way towards a renewed, spatially sound inclusion of the smart specialization strategy in R&D policies into an appropriate regional innovation policy framework.

The two key concepts of "embeddedness" and "connectedness" – put forward in the recent smart specialization debate – are a useful starting point on which to build smart innovation policies. However, smart innovation policies adapt the two concepts to the specificities of each pattern of innovation, and look for ad-hoc interventions - appropriate for each single territorial innovation pattern - with the aim to reinforce the virtuous aspects that characterize each pattern, and increase each pattern's efficiency (Table 6.1).

Regional innovation policies for each pattern should differ first of all in terms of **policy goals**.

A) **The maximum return to R&D investments** is the right policy goal for regions belonging to the "European science-based" and the "Applied science" patterns, characterised by a sufficient critical mass of R&D endowment already present in the area. Regions characterised by these two innovation patterns can in fact exploit the indivisibilities associated to research activity and take advantage from additional R&D funding. Given their different research specialization, the two patterns can reinforce their efficiency when innovation policies are devoted to the reinforcement of the regional research specificities: in the "European science-based area" the maximum return of R&D spending is obtained through policy actions devoted to R&D spending in GPTs, and a strong specialization is fundamental in these regions to achieve a critical mass of research. Applied scientific fields of research should instead absorb much of the R&D funds in the "Applied science area", diversifying their efforts in related sectors of specialization. This leads us to claim that the disagreement on specialization in favour of specialised diversification, highlighted in the recent debate (McCann, Ortega-Argilés, 2011), is applicable to some - but not all - regions. The right policy level to support and achieve this normative goal is the national one, complemented by European funds. National research funds should in fact be devoted for the development of national excellences, of unique research centres able to achieve a critical mass of researchers in general purpose technologies or in applied technologies.

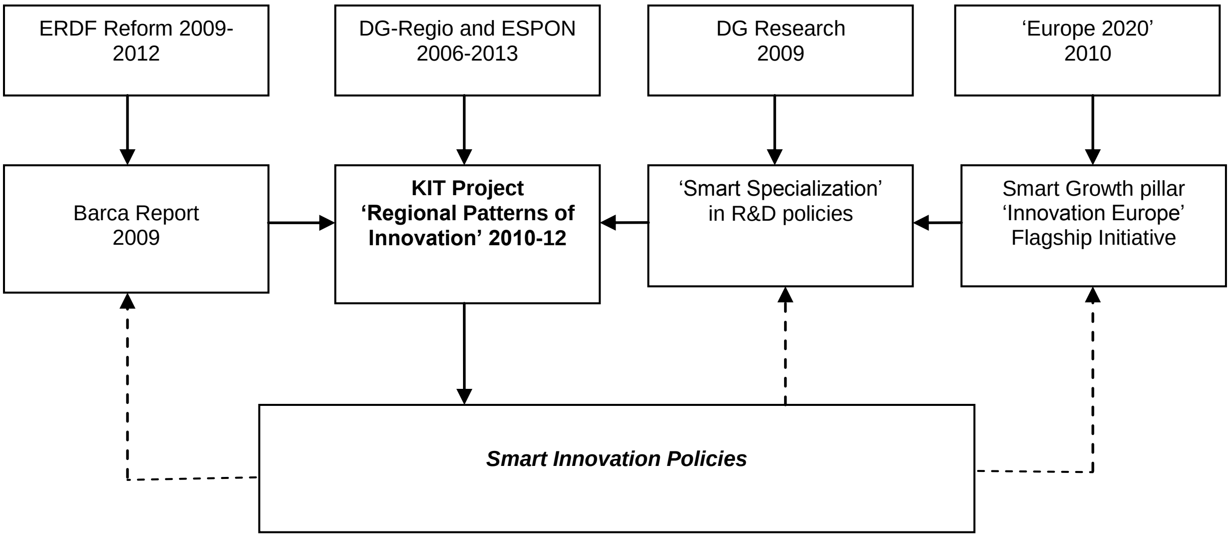


Figure 6.2.1. Logical pathway and contributions to Smart Innovation Policies

B) **Support to basic research** is not the most natural policy goal for the 'Smart technological application' and the 'Smart and creative diversification' patterns. In these areas the relatively low R&D endowment does not guarantee the presence of a critical mass of R&D in order to exploit economies of scale in knowledge production: returns to R&D of such kind of policy are modest. Innovation policy aims in these patterns can be found in the maximum return to new applications and to inter-regional co-operation in applications, deeply linked to the ability of regions to change rapidly in response to external stimuli (such as the emergence of a new technology) and to realize creative search processes concerning product and market diversification. The relevant policy level changes in this case to a regional one, which is much more suitable to identify local specializations and expertise on which to insist.

To achieve such a goal, support to creative application, shifting capacity from old to new uses, improving productivity in existing uses, are the right policy tools for maximising the return to co-inventing application. In a word: support to 'D', and to co-operative 'D' rather than to 'R'.

In the first case (Pattern 3) policy actions for the achievement of such goals can take into account incentives to technological projects that foresee new and creative use of existing scientific knowledge; in the second case (Pattern 4), support and incentives to search in products / markets diversification and to entrepreneurial creativity look more appropriate.

C) Finally, in the 'Imitative innovation' area the aim has to be devoted to the achievement of **the maximum return to imitation**, through fast diffusion of already existing innovation, strengthening of local receptivity to innovation (or reducing social/psychological or institutional barriers to change) and supporting favourable negotiations between local firms and MNCs on complementary projects and innovative, specialized subcontracting. In this case, the relevant policy level are both the national and local ones. In these areas, policies on intangible assets, like the quality of institutions, of the education system, and of human capital in general (not measured in this study but nevertheless important in defining the propensity of adopting and exploiting innovation), are strategic policy actions, that can be developed at both national and regional level.

Table 6.1. Smart innovation policies by territorial patterns of innovation

	Territorial patterns of innovation				
Policy aspects	**European science-based area (Pattern 1)**	**Applied science area (Pattern 2)**	**Smart technological application area (Pattern 3)**	**Smart and creative diversification area (Pattern 4)**	**Imitative innovation area (Pattern 5)**
Policy goals	Maximum return to R&D investments		Maximum return to applications and co-operation in applications		Maximum return to imitation
Policy actions for local knowledge generation **(Embeddedness)**	Support to R&D in:		Support to creative application, shifting capacity from old to new uses, improving productivity in existing uses, through:		Fast diffusion of existing innovation Enhancing receptivity of existing innovation
	New basic fields General Purpose Technologies	Specialized technological fields Variety in applications	Incentives to technological development and upgrading Variety creation	Identification of international best practices Support to search in product/market diversification Support to entrepreneurial creativity	Support to local firms for complementary projects with MNCs Support to local firms for specialized subcontracting
Policy actions for exploitation of knowledge spillovers **(Connectedness)**	Incentives to inventors attraction and mobility Support of research cooperation in:		Incentives for creative applications through:		Incentives for MNCs attraction
	GPT and trans-territorial projects (ERA)	specific technologies and trans-territorial projects (ERA), in related sectors/domains Encouraging of labour mobility among related sectors/domains	Co-operative research activities among related sectors Co-operative search for new technological solutions	Participation of local actors to specialized international fairs Attraction of "star" researchers even for short periods Work experience in best practice Knowledge creation firms of the same domains	Bargaining on innovative 'local content' procurement by MNCs
Relevant policy level	National level (also with EU funds)	National level (also with EU funds)	Local level (also with EU funds)	Local level (with also EU funds)	National and local levels (with also EU funds)
Policy style	Reach a critical mass in R&D activities through concentration of public support Priority to triangular projects by Universities-Research Centres-Enterprises Peer assessment of R&D research programmes Support to knowledge and technological transfer mechanisms to related sectors Thematical/ regional orientation of R&D funding:		Ex-ante careful assessment of innovation and differentiation strategies and projects Continuity in public support, subject to in-itinere and ex-post assessment of outcomes Support to bottom-up identification of industrial vocations, by raising awareness on local capabilities and potentials ('strategic industrial planning') Thematical/regional orientation of innovation funding, in order to:		Favour local spill-overs of managerial and technological knowledge from MNCs Support to co-operation projects between MNCs and local firms
	in general purpose technologies	in specific fields of research and technological specialization of the area	strengthen present formal and tacit knowledge through co-operation with strong external partners in the specialization sectors	enhance local technological receptivity, creativity and product differentiation capability in specializ. sectors	Support to technological transfer and diffusion
Beneficiaries	University, research centers, large local firms		Local firms	Local entrepreneurs	Local firms

The policies on intangible assets like education and training and quality of institution, or even the development of an innovation-prone society, through the development of a digital society and therefore of social innovation, should be interpreted as horizontal intervention policies, from which regions belonging to each pattern may get advantage, as rightly pointed out by the Seventh Progress Report (EU, 2011). However, our analysis warns about general education and training policies since: i) also human capital suffers from decreasing returns, and therefore it generates advantages on GDP growth at decreasing rates; ii) the most efficient regions register a *mix* of human capital and formal knowledge. In policy terms, these elements suggest: i) that education and training policies are the highest returns where human capital is present in a limited way; ii) that education and training policies should be developed following the knowledge domain in which the region hopes to excel.

Beyond the previous policy recommendations aiming to foster the creation of local knowledge, often policy interventions can be suggested for knowledge acquisition from outside the region, what has been called connectedness. As has been the case for embeddedness, also in the case of connectedness its implementation varies according to the specificities of the different patterns of innovation".

A - In the two patterns where external science-based knowledge is merged with local knowledge, the policy tools **to attract external knowledge are incentives to inventors attraction, and support of research cooperation in GPT and trans-territorial projects**, for what concerns the "European science-based area", and in related sectors belonging to specific fields of technological specialization for the "Applied science area". This suggestion is in line with the creation of the European Research Area (ERA) put forward by the European Commission, an area composed of all research and development activities, programmes and policies in Europe which involve a transnational perspective. The "Applied science area" could also be favoured by the encouragement of regional and inter-regional labour mobility between related sectors, which makes skills and experience moving around across sectors and regions.

B - Policy tools for knowledge acquisition in the "Smart technological application area" and in the "Smart and creative diversification area" are incentives for creative applications. For such a purpose, **cooperative research activities in related sectors** in those regions where a little applied science base exists are an efficient policy tool for the "Smart technological application area". **Participation of local actors to specialized international fairs, the attraction of "stars" even for short periods of time, or a work experience in best practice knowledge creation firms of related sectors** are right incentives to stimulate innovation in the "Smart and creative diversification" area whose innovation capacity lies in the brightness of their entrepreneurs to find outside the area the right applied science on which to innovate and move towards a specialized diversification in related sectors.

C - The traditional incentives **to attract MNCs** remain the most efficient tool to attract new knowledge in areas with very limited – formal or informal, scientific or technical – knowledge.

The policies suggested require **renewed styles** in their design-to-delivery phases in order to enhance efficiency and effectiveness (Camagni, 2008). As in more general regional development policies, a strong attention should be devoted to the following elements:

- Transparency, which means clear justification of the spatial allocation of funds in the different measures, from spatial concentration in some cases (reaching a critical mass in R&D, particularly in Innovation Patterns 1 and 2) to spatial pervasiveness in others (tapping local creativity, diversification and adoption capabilities: Patterns 3 to 5);
- Control on local strategies followed, in order to avoid rent seeking attitudes by local élites (in politics, in the economy, but also in the high education and research fields). This means favouring active co-operation among main local actors: universities, research centres and firms. The internal strategies of the single actors in the research and innovation fields, perfectly lecit, may not be the best ones for the entire regional community, or the most appropriate in terms of risk assumption by the public sphere; therefore, programmes and projects presented jointly by all three main actors should be solicited and given high priority (especially in Patterns 1 and 2);
- Peer ex-ante assessment of main R&D and innovation projects presented to public support;

- Knowledge transfer, knowledge diffusion through inter-sectoral and inter-regional co-operation and general knowledge dissemination should be favoured, in order to boost productivity of the publicly supported R&D;
- Favour continuity over time in public support decisions – a crucial precondition for local learning processes – at the condition of fair and effective intermediate and ex-post assessment of outcomes;
- Build a formalized, but flexible, organizational model for supporting the identification of regional specializations, in R&D and production, and for strengthening the search process of new thematic application fields and diversification areas, inside and outside the present technological and production domains: a local, participatory model that could be labelled as 'strategic industrial planning';
- Favour creativity and entrepreneurial spirit in all regional conditions. This means, on the one hand, to detect and support present local skills, traditions, social values, positive attitudes towards the environment and local culture, solidarity and cultural diversity (especially in Pattern 3 and 4); on the other hand, to create an innovation-friendly business environment, reduce barriers or resistance to change, enhance receptivity to external stimuli and opportunities, discover new local potentials through the engagement of insufficiently utilised local resources (in Patterns 3 - 4 and especially 5).

Favour the strengthening of local spillovers from large firms and MNCs present in the different regional contexts, in the field not just of technical knowledge and research potential but also in the field if production organization and managerial styles and practices, mainly through local subcontracting and co-operation with local firms.

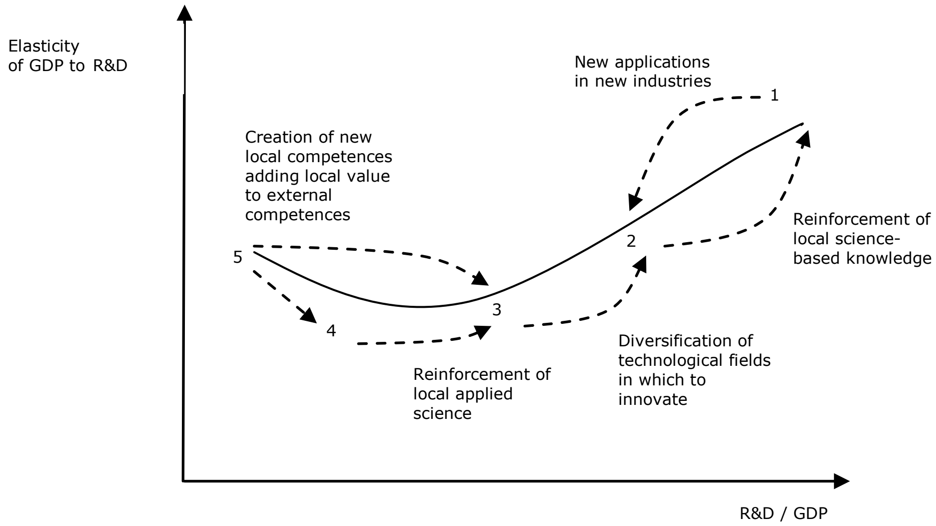
Beneficiaries of these policy recommendations differ among patterns; university, research centres and large R&D laboratories of private firms are the natural beneficiaries of the "European science-based" area and of the "Applied science area". Local firms are the natural recipients of "Smart technological application area" policies; entrepreneurs and small firms are the natural recipients of policies devoted to the "Smart and creative diversification area". Local firms are thought to be the right subjects for the "Imitative innovation area" policies.

6.2.2. Smart evolutionary innovation policies

The previous policy suggestions are meant to increase the efficiency of each pattern. However, within each pattern, regions exist that are more advanced than others, in the sense that they show a strong efficiency with respect to other regions in the same pattern, due to good policy strategies and actions, or due to particularly dynamic economic actors. For these regions, evolutionary policies can be foreseen, devoted to the achievement of more efficient innovation patterns.

Figure 6.2.2. shows the relative position of each pattern in terms of the elasticity of GDP to R&D. As shown by our empirical analysis, R&D levels require a certain critical mass to become effective; when this is reached, increasing returns start. Figure 6.2.2 represents the dynamic trajectories (and the associated policies that support these trajectories) that the most efficient regions should follow to move away from their innovation pattern and achieve higher efficiency rates.

The most efficient regions in the "Imitative innovation area" could be pushed towards either a "Smart and creative diversification area" or a "Smart technological application area" through **the support in the creation of new local competences adding local value to external competences**. The case study of the automotive industry in Bratislava is a right example in this respect; following the creation of local suppliers with specific competences, the innovation pattern moved away from an imitative pattern; in fact, innovation processes increasingly derive from the knowledge that local subsidiaries have cumulated through strong interaction with the parent company. The innovative pattern in this area is increasingly becoming a "Smart technological application pattern".



Legend: 1 = European science-based area; 2 = Applied science area; 3 = Smart technological application area; 4 = Smart and creative diversification area; 5 = imitative innovation area

Figure 6.2.2. Evolutionary trajectories and policies by patterns of innovation

The most efficient regions in the "Smart and creative diversification area" can be supported in order to move towards a "Smart technological application area" through **the reinforcement of local applied science**; in this way higher efficiency levels are achieved.

The 'European science-based area' could be stimulated to avoid some evidence on decreasing returns of R&D activities in terms of knowledge creation, by diversifying research into new application fields in new industries, merging aspects of the 'Applied science area'. On the other hand, some regions belonging to the latter area could strengthen their science base in GPT fields, if already present with some critical mass, moving towards the first Pattern, namely the 'European science-based' one.

Finally, efficient regions belonging to the "Smart technological application area" could overcome the decreasing returns of R&D activities developed in limited specialized sectors by **diversifying the specialized technological fields in which to innovate**. In so doing, they would move towards an "Applied science area".

Evolutionary policies find a fertile ground on which to produce their virtuous effects in regions that show a strong efficiency with respect to other regions in the same pattern, and especially in regions that demonstrate an already clear policy orientation towards the increase of returns to knowledge and innovation.

If it is true that in some cases innovation is the result of unforeseeable events, of totally unexpected creative disruptions of existing innovation trajectories, it is also rational to claim that regional innovation policies based on public funds can only support clearly defined innovation trajectories, holding the lowest likely risks and the highest expected returns.

The complementary actions of static and evolutionary smart innovation policies - targeted on each innovation pattern - would certainly be the right policy mix to implement the "smart specialization policies" in the field of innovation - called for by the EU in its official document *Regional Policy Contributing to Smart Growth in Europe* (EU, 2010) - and to achieve a "smart growth" in the years to come.

7. Roadmap for future research avenues

The KIT project has introduced quite a number of novelties in the analysis of knowledge and innovation, and has highlighted important unconventional policy warnings to take into account for the development of sound policy recommendations in the field of knowledge and innovation.

As is the case in all research analysis, the project has also highlighted a roadmap for future research activities in this field, that is here presented.

The overall conceptual approach of KIT is the importance to keep the two concepts separate. This project has encountered a great limitation in data availability for what concerns innovation, and has spent much time in estimating the regional dimension of the CIS 4 wave. A similar effort on other CIS waves would be extremely useful to understand the trends in innovation adoption, and develop a time series analysis on the impact of innovation over time. This could allow to analyse, for example, how has the role of innovation as driver of growth changed since the period of economic crisis started.

Moreover, the useful concept of territorial patterns of innovation would need a more spatially disaggregated analysis, at NUTS3. Especially in the case of the Eastern Countries, huge differences exist in innovation capacities between the metropolitan NUTS3 area and its surroundings that form a NUTS2. In the "imitative innovation areas" there are in fact some remote rural areas that deserve specific innovation policies, oriented to the reinforcement of household innovation adoption and of process innovation in agricultural activities.

The comparison between European spatial development of knowledge and innovation with other advanced and emerging countries is in this project only partially developed (it was not even asked in the project references). It would be extremely useful to develop further comparative analyses on the way innovation develops in Europe in front of the accelerating globalization of knowledge. Specific case studies on how different industries suffer from innovative behaviours of emerging countries would be extremely useful.

The KIT project has chosen to develop a reasoning only on measurable elements that affect knowledge and innovation creation at regional level. We have sometimes speculated on the intangible elements, like the quality of institutions, of educational system, the cultural system and the type of governance behind national and local innovation policies, but an in-depth analysis of these elements would be very useful to get a broader view on the success factors behind spatial innovation processes and their efficiency.

The role of SMEs in explaining a successful innovative business environment is another extremely important field of research, not directly touched in the KIT project. A broader definition of new knowledge can be given, that comes from two already existing pieces of knowledge that, combined in a new way, respond to a new business need. In this way, the role of SMEs in developing new knowledge would certainly be strengthened than the one they have in the KIT project, where new knowledge is mostly (even not only) intended as R&D activities.

A diachronic analysis of territorial patterns of innovation (requiring time series data of all the complex indicators used to develop such a cluster analysis) would be extremely useful to identify which regions have been able in the past to move from one pattern to another: complemented by an in-depth case study analysis, an approach like this would highlight the real success factors and the right policy actions that allow regions to move to higher patterns of innovation, and to develop their own knowledge economy able to support an innovation-driven economy. Also the analysis of knowledge networking regions would benefit from a diacronic perspective. As a continuation of the work done within the KIT umbrella, and in order to complement the abovementioned analysis, it is our aim to enrich the KNR indicators by using other relational data, such as cross-regional collaboration in European research projects (FP6, FP7), scientific co-publications between individuals and institutions located in different regions, mobility of researchers (post-docs, temporal visiting,…), and so on. However, obtaining these data is not straightforward, and requires certain assumptions and complementary efforts.

An important issue that has been overlooked in the project is the strong heterogeneity in the ways in which knowledge is produced, appropriated, and diffused across different technological/economic sectors. In this sense, it is our intention to include the sectoral dimensions in as many studies as possible. Data restrictions are strong in this respect, and call for appropriate data collection on sectoral R&D also by national statistical offices in the years to come.

References

Bathelt H., Malberg A., Maskell P. (2004) Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28: 31-56

Breschi S., Lenzi C., Lissoni F., Vezzulli A. (2010, "The geography of knowledge spillovers: the role of inventors' mobility across firms and in space", in Boschma R. and Martin R. (eds), *The Handbook of Evolutionary Economic Geography*, Cheltenham: Edward Elgar: 353- 369

Cohen W.M. and Levinthal D.A. (1990) Absorptive capacity: a new perspective on learning an innovation, *Administrative Science Quarterly*, 35, 128-152

Crescenzi R. and Rodríguez-Pose A. (2009), "Systems of innovation and regional growth in the EU: endogenous vs. external innovative efforts and socio-economic conditions", in Fratesi U. and Senn L. (eds.), *Growth and innovation of competitive regions: the role of internal and external connections* (pp. 167-192). Berlin: Springer-Verlag

EU (2010), *Regional Policy Contributing to Smart Growth in Europe,* COM(2010)553, Brussels

EU (2011), *The Urban and Regional Dimension of Europe 2020*, Seventh Progress report on Economic, Social and Territorial Cohesion, Brussels

Foray D., David P. and Hall B. (2009), "Smart Specialisation - the Concept", *Knowledge Economists Policy Brief* , n. 9

Fratesi U. and Senn L. (2009), "Regional Growth, Connections and Economic Modelling: An Introduction", in Fratesi U., Senn L. (Eds) Growth and Innovation of Competitive Regions: the Role of Internal and External Connections, pp. 3-28. Springer-Verlag, Berlin

Griliches Z. (1979), "Issues in assessing the contribution of research and development to productivity growth", *The Bell Journal of Economics*, 10: 92-116

Licht G. (2009), "How to Better Diffuse Technologies in Europe", in Research Commissioner Janez Potočnich's Extert Group, *Knowledge for Growth*, Brussels

Marx K. (1961) *Capital*, Moscow: Foreign Languages Publishing House, first edn 1867

McCann P. and Ortega-Argilés R. (2011), "Smart specialisation, regional growth and applications to EU cohesion policy", Document de treball de l'IEB 2011/14, Institut d'Economia de Barcelona

OECD (2010), *Typology of regional innovation systems*, 20th session of the working party on Territorial Indicators

OECD (2011), *Regions and Innovation Policy*, Organization for Economic Growth and Development, Paris

Owen-Smith J. and Powell W.W. (2004), "Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community", *Organization Science*, 15(1): 5-21

Ricardo D. (1951) Principles of Political Economy, in Sraffa P. (ed.), *The Works and Correspondence of David Ricardo*, Cambridge: Cambridge University Press, vol. 1, 3rd ed. 1821

Rodríguez-Pose A. and Crescenzi R. (2008), "Research and Development, Spillovers, Innovation Systems, and the Genesis of Regional Growth in Europe", *Regional Studies*, 42: 51-67

Say J.-B. (1964), "A Treatise on Political Economy or the Production, Distribution and Consumption of Wealth", New York: Kelley, 1st edition, 1803

Spiezia V. and Vivarelli M. (2002), "Innovation and Employment: a Critical Survey", in N. Greenan, Y. L'Horty and J. Mairesse (eds.), *Productivity, Inequality and the Digital Economy: a Transatlantic Perspective*, Cambridge (Mass.): MIT Press

Vivarelli M. (1995) *The Economics of Technology and Employment: Theory and Empirical Evidence*, Elgar Edward, Aldershot

www.espon.eu

The ESPON 2013 Programme is part-financed by the European Regional Development Fund, the EU Member States and the Partner States Iceland, Liechtenstein, Norway and Switzerland. It shall support policy development in relation to the aim of territorial cohesion and a harmonious development of the European territory.

ISBN 978-2-919777-11-2