KIT
Knowledge, Innovation, Territory

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Executive summary

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 achieving this aim, the KIT project enters the debate on "smart specialization" strategies in the field of innovation by overcoming the simplistic dichotomy – proposed 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 patterns of innovation is essential to build targeted normative strategies efficient for a cohesion policy goal.

The discrepancy between knowledge and innovation that emerges 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. In this project, a map of what we call the "territorial patterns of innovation" in Europe is provided, in which regions are grouped according to a combination of territorial context conditions and of specific modes of performing the different phases of the innovation process.

Through the concept of patterns of innovation the project analyses the impact of knowledge and innovation on regional performance. The richness of the results obtained are strategic 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. 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. Spatial patterns of the knowledge economy in Europe

The knowledge economy can manifest itself in different forms on the territory, forms that sometimes complement each-other and sometimes substitute each-other. A multidimensional definition of the knowledge economy (namely, 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 measure to support a knowledge economy.

Technologically-Advanced Regions (TAR) are those regions which present simultaneous specialization in both medium high-tech manufacturing and knowledge intensive sectors. The geography of technology in Europe turns out to be 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, 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 scientific activity and a higher than average high-quality human capital. Scientific regions are concentrated in the centre and in the north of Europe, most of them in Western countries. All research activity indicators that are used for one of the two pillars that define scientific regions constantly show a high spatial concentration. In 2007, R&D spending on GDP, one of the Lisbon objectives for the achievement of a knowledge economy, interestingly shows a strong regional variation, from lower than 0.5% values to more than 6%. A very small number of regions in Europe reaches 3% of R&D expenditures on GDP, witnessing that a smart growth called for by the EU2020 Agenda with the achievement of 3% of the EU's GDP (public and private) invested in R&D/innovation is still an ambitious aim. A comparison with US and with emerging countries, India and China, shows 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.

Knowledge networking regions can be understood as regions that rely on external sources of knowledge and on facilitating interactive learning and interaction in innovation. This knowledge diffusion can take place through diffusive patterns based on spatial proximity (henceforth "spatial linkages") and/or through intentional relations based on a-spatial networks or non-spatially mediated mechanisms ("a-spatial linkages"). To identify knowledge networking regions two synthetic indicators are built, a first one capturing "spatial knowledge linkages" and a second one measuring "a-spatial knowledge linkages"; knowledge networking regions are those regions that have values for both indicators higher than the average. Results show 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 New Member Countries 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). More curious is the fact that a higher number of regions belong to the category of Knowledge networking regions (123) with respect to TAR and scientific regions. This results is rather important, telling us that external sources of knowledge, in the form of spatial spillovers or scientific networking, is a very diffused channel for local knowledge accumulation, even more diffused than the internal production of knowledge.

1.2. Spatial patterns of innovation in Europe

Innovation shows rather differentiated spatial patterns depending on the type of innovation analyzed. Product innovation only is characterized by a relatively high spatial concentration. 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. Concentrated spatial patterns characterize product innovation trends not only across country, but also within countries; in fact, capital regions tend to display higher product innovation rates, with some notable exceptions of regions also registering consistent innovation performance despite not hosting the capital city (e.g. Rhone-Alps and Toulouse in France).

A completely different spatial trend is depicted for what concerns process innovation, which displays on average higher values in Southern European countries, namely, Cyprus, Spain, France, Greece, Italy, Malta, and Portugal than in the rest of the Europe, by about two percentage points. The variance associated with process innovation 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 (New Member States), that are unexpectedly characterized by homogeneous spatial trends.

Finally, it is interesting to notice the synergic nature of product and process innovation rates. In fact, on average, regions with higher tendencies to innovate in product also innovate in process. However, the performance of top accomplishers in each category deviates from this trend and points at particular specializations either in product, or process innovation.

A quite different perspective on innovation is provided by the marketing and organizational innovation spatial trend. In this case, non-material forms of technological 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. Results show 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.

1.3. The relationship between knowledge and innovation

If one measures the spatial relationship between knowledge creation and innovation activity, some interesting results emerge. As expected, the highest difference lies between knowledge economy regions and others. The former definitely show a higher innovation performance, whatever definition is adopted.

What is striking in the results is that one would have expected the regions with high 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 regions.

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, is 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 paradigmatic jump in interpreting regional innovation processes lies nowadays in the capacity to build 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, as is the case in the literature nowadays, 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 has been introduced. 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:

1. 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;

2. 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;

3. 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.

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.

The empirical results report 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:

A European science-based area (pattern 1a), characterised by strong knowledge and innovation producing regions, specialized in general purpose technologies (i.e., GPTs), with a high generality and originality of science-based local knowledge, and a high degree of knowledge coming from regions with a similar knowledge base. R&D endowment is high in these regions. 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. 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. The target of this group of regions is to achieve specialized diversification across related technologies in diversified technological fields of competence. 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.

A smart and creative diversification area (pattern 2b), characterised by a low degree of local diversified applied knowledge, internal innovation capacity, high degree of local competences, high degree of creativity and entrepreneurship, external knowledge embedded in technical and organizational capabilities. These regions are mainly located in Mediterranean countries (i.e. most of Spanish regions, Central Italy, Greece, Portugal), in EU12 agglomerated regions in Slovakia and Slovenia, Poland and Czech Republic, few regions in northern Europe, namely in Finland and the UK.

A creative imitation area (pattern 3), in which one measures a low knowledge and innovation intensity, entrepreneurship, creativity, a high attractiveness and a high innovation potentials. 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.

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 specific of each area have to be identified, on which ad-hoc and targeted innovation policies can be drawn.

To move in this direction, the measurement of efficiency and effectiveness of each pattern of innovation on growth has been necessary. The main results are presented in Sections 3 ad 4.

3. Knowledge and regional performance

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 (sec. 3.1)?
2) What is the role knowledge spillovers in creating local knowledge (sec. 3.2)?
3) Do R&D and human capital exert an additional positive impact on regional production once we control for the traditional inputs (sec. 3.3)?

3.1. R&D, human capital and knowledge creation

The analysis on the efficiency of both human capital and R&D, traditional inputs for knowledge creation, shows that there is a high spatial heterogeneity in the way regions exploit R&D and human capital to generate new local knowledge. In particular, the main result is that 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.

The result that R&D suffers from decreasing returns is also demonstrated by an international comparison. 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, followed by Europe, and then by the two developing economies which have just started the process of investing specific resources in formal innovation activities.

Moreover, interesting results emerge on the spatial heterogeneity in exploiting both knowledge inputs at the same time. The geographical distribution of the regional efficiency measures in the use of all knowledge inputs at the same time confirms the presence of a dualistic – centre vs. periphery – pattern in knowledge inputs exploitation. This calls for specific policies, which should target the latter 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.

3.2. Knowledge spillovers and regional knowledge creation

The importance of looking at the role of intra-regional inventors' mobility and internal research networks 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. Our empirical analyses demonstrates that 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 knowledge creation heterogeneity across regions.

Looking at spatial heterogeneity in elasticities of knowledge creation (patenting activity) to knowledge spillovers, a strong spatial variance occurs, signaling that, the greater the knowledge created internally to the region, the higher the impact of external knowledge spillovers moving into a region on the knowledge creation of such region. These results tell us that 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.

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. 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.

3.3. R&D, human capital and regional performance

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. These results have high normative implications in that the message that stems out of these results is that R&D has an important impact on GDP when it is present in high quantities. A Lisbon Agenda for regions with a low level of R&D endowment seems to produce rather limited effects on growth.

When efficiency of human capital to regional production is measured, interesting results emerge, namely: i) human capital has a higher impact on regional production than R&D; ii) the highest impacts are registered where human capital is present in a very limited way, demonstrating that human capital is a more important pre-condition for growth in weak regions than R&D. Moreover, human capital shows strong decreasing returns: in regions where it is present in high quantities, its effects on growth are limited.

The spatial distribution of the efficiency scores exhibits a high degree of dispersion in terms of demographic characteristics and geographical location. 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.

4. Innovation and regional performance

One of the main issue of the KIT project is the identification of the role played by knowledge and innovation on regional performance, measured in terms of employment growth, total factor productivity and GDP growth. The main questions answered here are:

1) which is the impact of product and process innovation on employment growth (sec. 4.2)?
2) 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)?
3) lastly, which is the impact of knowledge and innovation on GDP growth (sec. 4.4)?

Before replying to these questions, an intriguing aspect is empirically addressed, namely which is the capacity of formal knowledge to generate innovation activity (sec. 4.1).

4.1. Knowledge, human capital and innovation

Whereas formal knowledge, either measured as R&D investments or patent applications, is, on average, a crucial enabler of superior innovative performances, this relationship becomes more and more complex when the greater variety of knowledge and innovation behaviours across regions is considered. Two important messages come out. Firstly, 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. Secondly, 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 (like in the "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; however, this average effect hides a greater variety of behaviours across regions. Knowledge embodied in human capital is more efficiently used 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.

4.2. Innovation and employment growth

By trying to understand whether innovation has a labour saving nature, our results tell that in general this is true: innovation (either only product or only process innovation) is, in general, labour saving. However, this result is not space invariant; specific territorial characteristics, like the functional specialization and the settlement structure of a region, turn to influence and to moderate the relationship between technical change and employment dynamics. In particular:

- the functional specialization, in the form of a larger presence of blue collars professions, mitigates the impact of product innovation on employment dynamics (and turns the effect from negative to a positive one). This supports the idea that the positive effects of producing new goods unfold where production activities are located;

- metropolitan settings (Megas) amplify the labour-saving effects of process innovation. 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.

4.3. Innovation and total factor productivity

Interestingly, the efficiency level of European regions (measured in terms of total factor productivity – TFP - level) is not only linked to the strength of the local formal knowledge base. 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.

Moreover, 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 0.18% increase in TFP level. 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.

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.

4.4. Innovation and GDP growth

Our results indicate that both knowledge and innovation 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. However, our findings also suggest some caution in the interpretation of this result.

The elasticity of GDP growth rate to innovation is, on average, 0.35%, 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. 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, this also suggests that the different groups of regions are similarly efficient in translating innovation benefits into higher GDP growth rate.

The spatial distribution of innovation 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. Case studies: value added of the qualitative analysis

The case study analysis has brought a decisive contribution to the quantitative analysis of the KIT project, and many additional results have been added to the quantitative results.

A first lesson from the case study analysis is the relatively larger importance that 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 (from pattern 3 to pattern 2a previously described). In this case thanks to the local availability of entrepreneurial skills, local actors may reverse engineer the knowledge embedded in products traded with multinational corporations (i.e., MNCs). An opposite case of change from an endogenous to an adoptive pattern of innovation (from pattern 1b to pattern 2a) 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

Smart innovation policies

Our empirical results demonstrate that 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 built.

Smart innovation policies are defined as those policies able to increase the innovation capability of an area and to make local expertise in knowledge and innovation more efficient, acting on the local specificities and on the characteristics of already established innovation patterns in each region. 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.

B - R&D support 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. The return to R&D of such kind of policy are modest in these areas. The innovation policy aim in these patterns can be found in the maximum return to co-inventing application (the typical Schumpeterian profits), which deeply depends on the ability of regions to change rapidly in response to external stimuli (such as the emergence of a new technology). To achieve such a goal, supports to creative application, shifting capacity from old to new uses, deepening or improving productivity in existing uses, are the right policy tools for maximising the return to co-inventing application. 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 for the "Smart technological application area". On the other hand, support devoted to the identification of international best practice, and to entrepreneurial creativity are more in favour of an innovation pattern like the one of the "Smart and creative diversification area".

C - Finally, in the "Creative imitation" pattern the aim has to be devoted to the achievement of the maximum return to imitation, through a creative adaptation of already existing innovation, via adoption processes driven by creative ideas on the way already existing innovation can be adopted to reply to local needs. The maximum return to imitation is supported by incentives to local firms for the development of creative projects with MNCs.

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 **connectivity**. Also in the case of connectivity 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 some attention in their design phase in order to be efficient. A **policy style** is necessary for R&D spending. R&D funding has to be provided with a critical mass, and should also be accompanied by stimuli to knowledge transfer mechanisms in related sectors, in order to guarantee permeability of new knowledge. Moreover, the efficiency of R&D funding is dependent on the identification of thematic and regional scientific specializations. For what concerns the support to creative application, its efficiency is guaranteed through a bottom-up identification of local industrial vocations, raising awareness of local capabilities. When imitation is the stake, the efficiency of the policies is dependent on the stimulation of cooperation projects between MNCs and local firms.

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, and that potentially could move to a different pattern. For these regions, evolutionary policies can be foreseen, devoted to the achievement of more efficient innovation patterns. As shown by our empirical analysis, R&D levels require a certain critical mass to become effective; when this is reached, increasing returns start. The most efficient regions in the "Creative imitation 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".

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 decreasing returns that are linked to R&D activities, by diversifying its R&D activities through the identification of new applications in new industries, and moving in this way towards an "Applied science area". Some regions belonging to an "Applied science area", on their turns, could be specialized enough in GPT fields to move to the "European science-based area" by **strengthening the local science base, if already present in a certain critical mass**. 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".

The application of the evolutionary policies requires the identification of the most efficient regions within each pattern. These regions have to show a strong efficiency with respect to other regions in the same pattern, and especially should demonstrate an already clear policy oriented towards the increase of returns to knowledge and innovation. In this way, evolutionary policies would find a fertile ground on which to produce their virtuous effects.

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 Europe" in the years to come.

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

i) the spatial trends of the knowledge economy;

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

iii) the measurement of the impact of knowledge and innovation on regional economic performance for differentiated territorial modes of innovation;

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.

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. 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 is obtained by the case study approach (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 (spatially or a-spatially) with other economies.

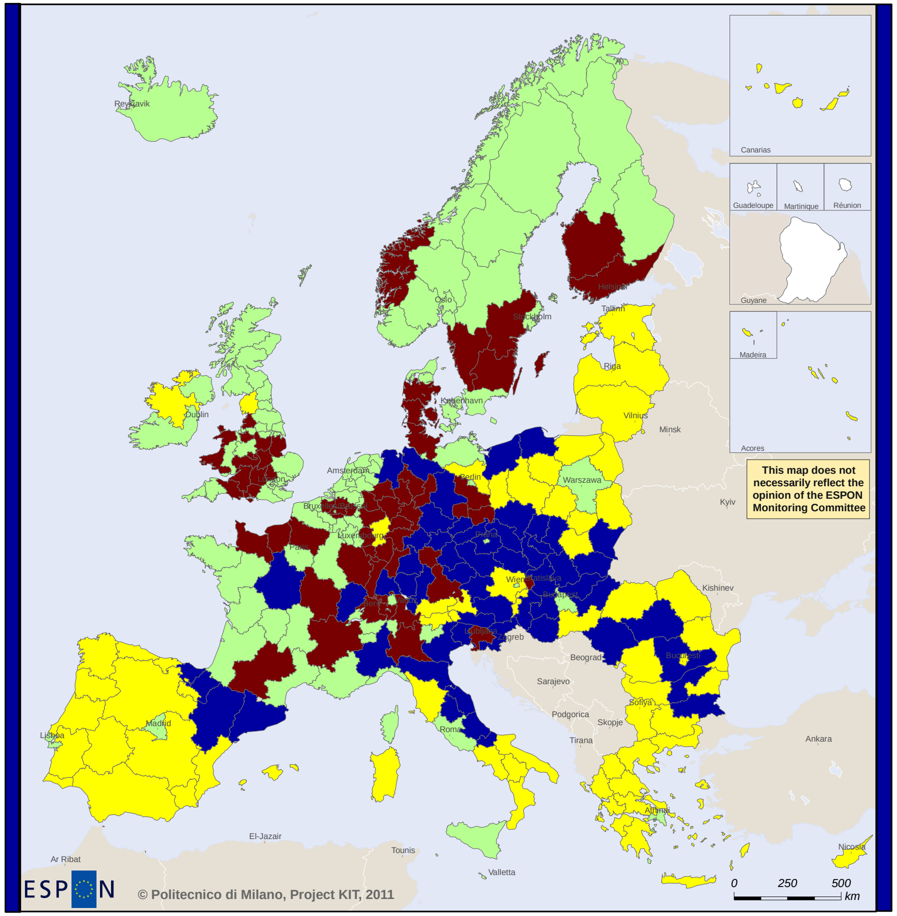
We therefore analysed the EU territory according to the presence of "science-based" or high-technology sectors; regions hosting these sectors are considered as regions helping the transformation of the economy, and labelled **"technologically advanced regions".** However, this approach is far too simplistic, 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 MHHT and KIS industries. 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.

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



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Regional level: NUTS2
Source: Politecnico di Milano, 2011
Origin of data: EUROSTAT employment in high-tech sectors
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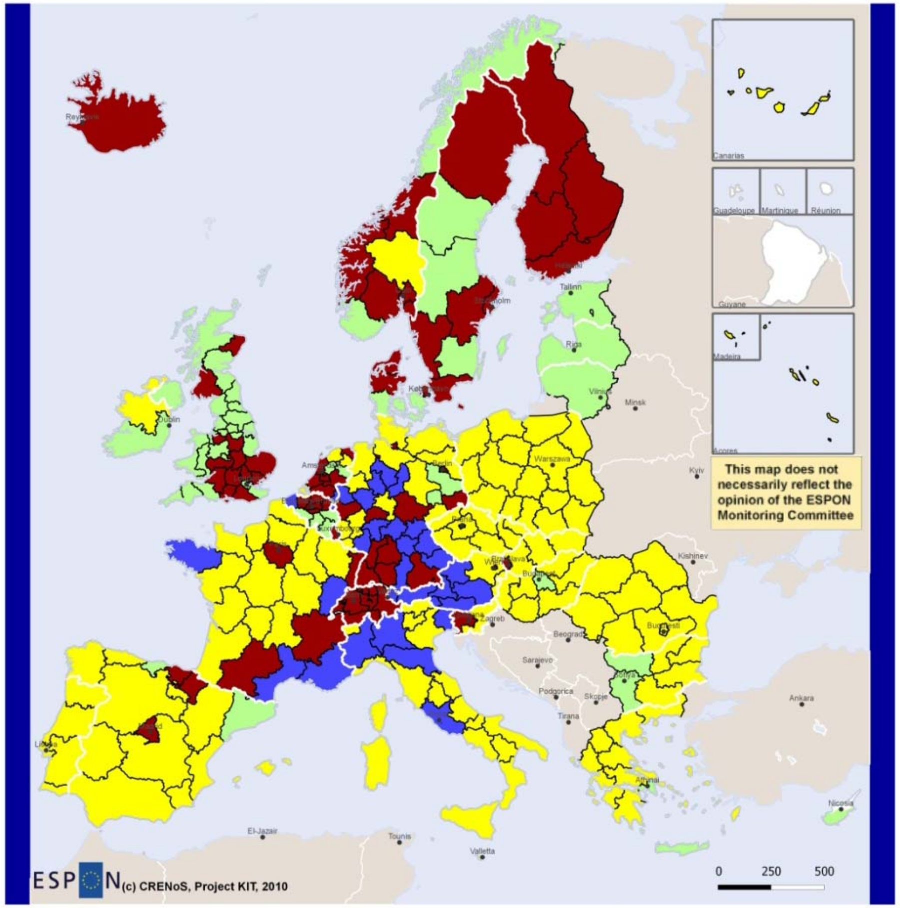
Technologically-advanced regions

2007

- NA
- Low tech regions
- Advanced manufacturing regions
- Advanced services regions
- Technologically-advanced regions

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



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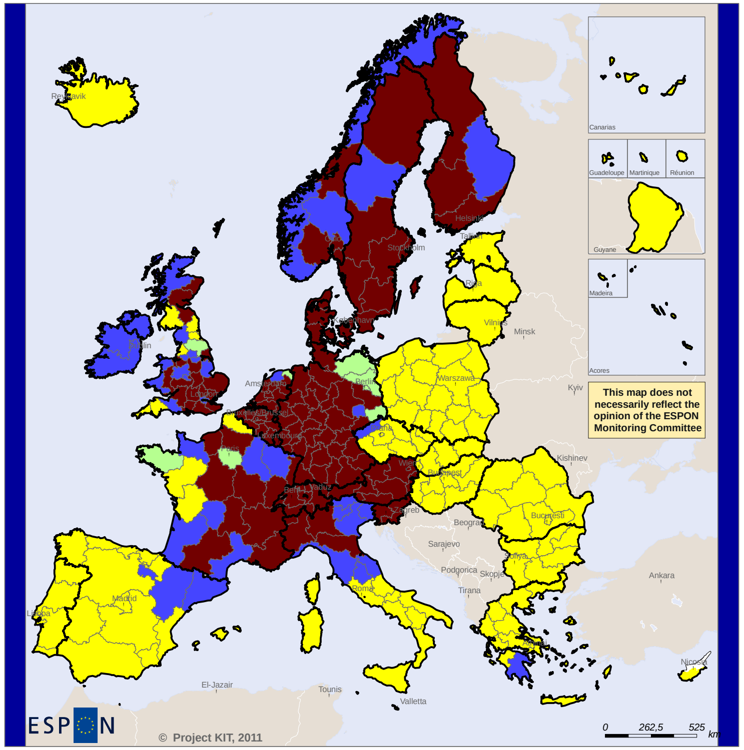
(c) EuroGeographics Association for administrative boundaries
Source: CRENoS elaboration, 2010
Origin of data:Eurostat, OECD REGPAT database, ISTAT and Institut National de la Statistique et des Études Économiques data, CORDIS data
Regional level: NUTS 2

Legend

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

Map 1.1.2. Scientific regions in Europe



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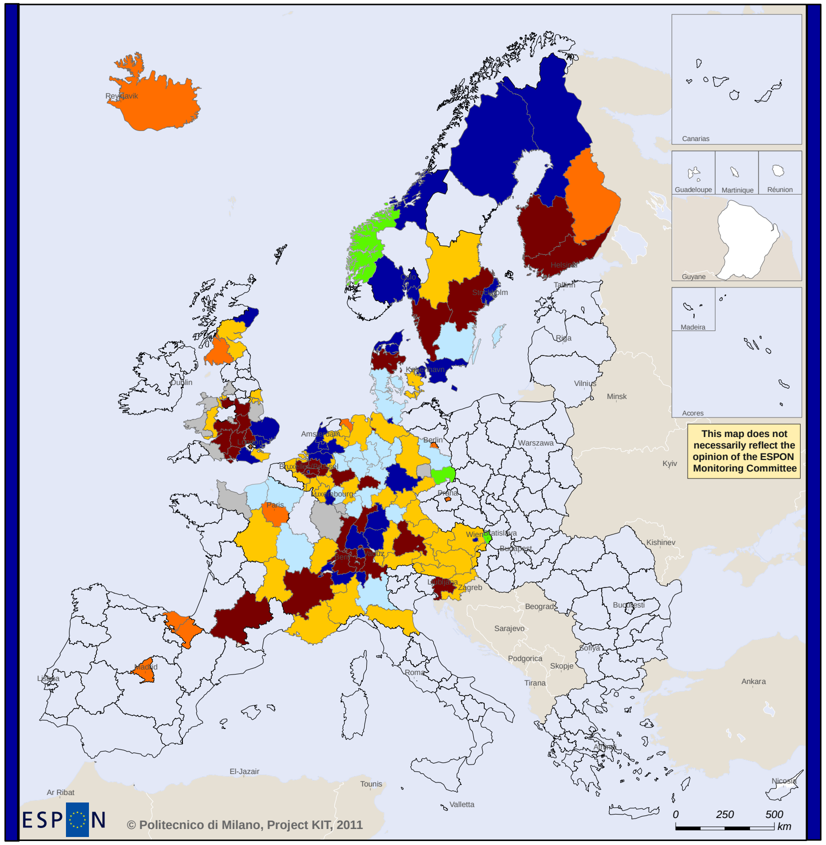
Category	Meaning	Specialization in spatial linkages	Specialization in a-spatial linkages
1	Non-interactive regions	No	No
2	Clustering regions	Yes	No
3	Globalizing regions	No	Yes
4	Networking regions	Yes	Yes

Knowledge networking regions

- Non-interactive regions
- Clustering regions
- Globalizing regions
- Networking regions

Map 1.1.3. Knowledge networking regions in Europe



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Regional level: NUTS2
Source: Politecnico di Milano, 2011
Origin of data: EUROSTATand RegPat
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Technologically-advanced regions

Knowledge economy regions

- NA
- None
- TAR only
- Scientific regions only
- Networking regions only
- TAR and scientific regions
- TAR and networking regions
- Scientific and networking regions
- Integrated knowledge economy regions

Typology	Numerosity
TAR only	9
Scientific only	11
Networking only	43
TAR and scientific	3
TAR and networking	19
Scientific and networking	29
TAR, scientific and networking	31
None	135

Map 1.1.4. The Knowledge Economy in Europe

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,[2] 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 scientific activity and a higher than average high-quality human capital. They are 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 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 either through a diffusive pattern in which spatial proximity is essential or according to intentional relations based on intentional cooperation networks, for which spatial proximity is not the main explanation for cooperation to occur. 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. This knowledge diffusion can take place through diffusive patterns based on spatial proximity (henceforth "un-intentional linkages") and/or through intentional relations based on un-intentional networks or non-spatially mediated mechanisms ("intentional linkages").

Map 1.1.3 shows *Networking regions*. They 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 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.

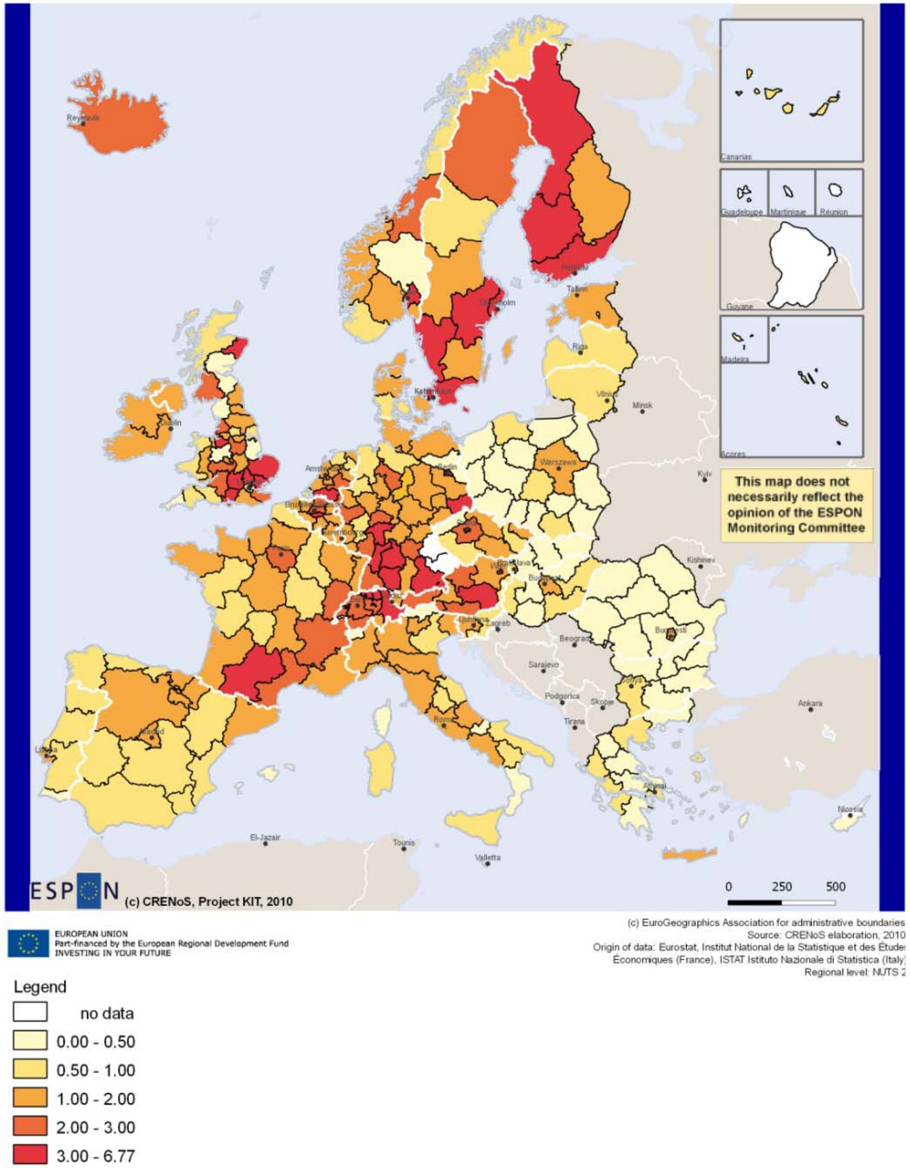
Map 1.1.4 presents an integrated picture of the different typologies of knowledge economy regions. The picture looks very fragmented, with quite a reasonable number of regions being only networking, and mainly in the central part of Europe. Only three technologically-advanced regions host scientific 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

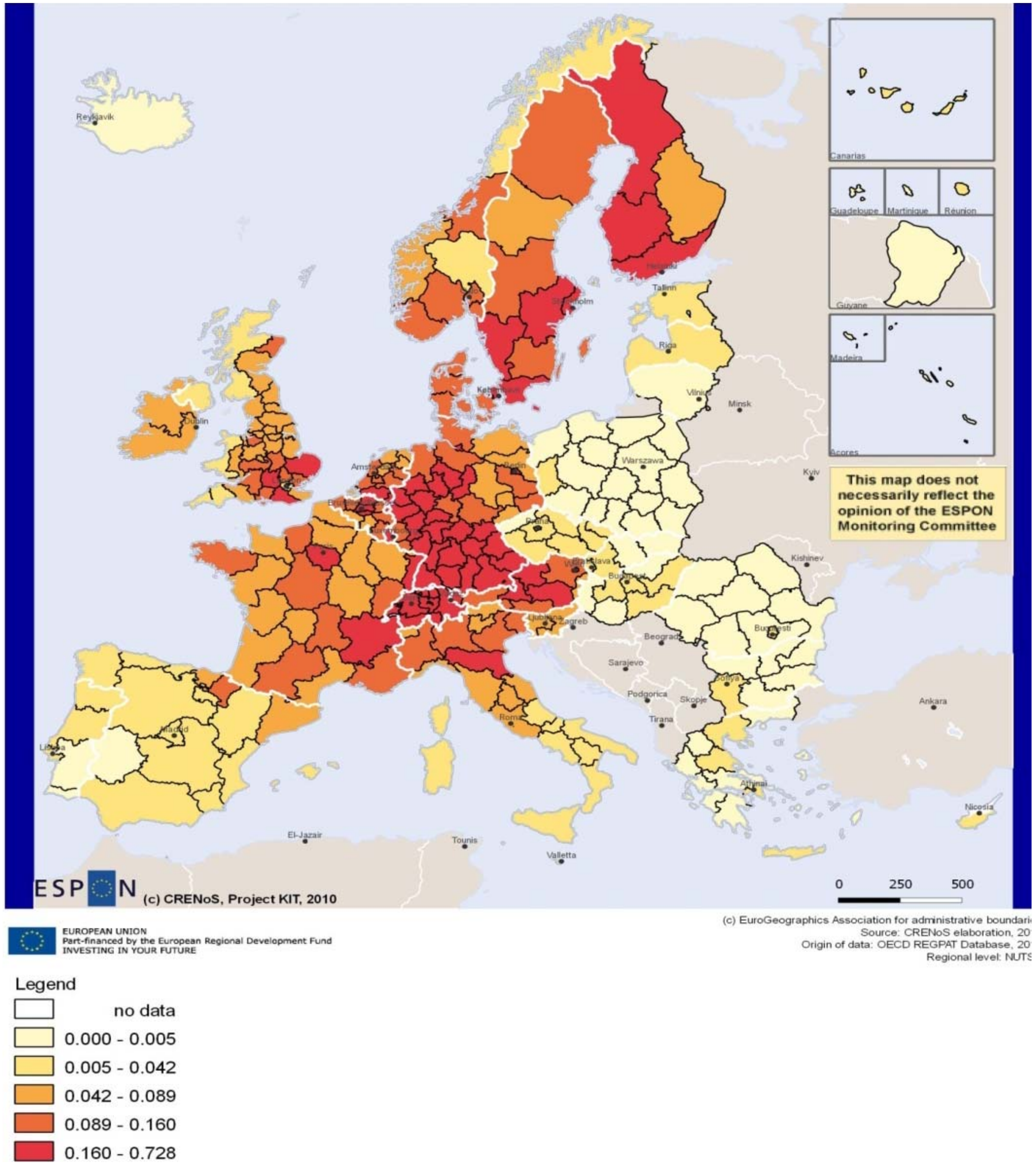
In Map 1.3.1 the spatial distribution of R&D expenditures on GDP is presented. This indicator is rather important since it has been used as a benchmark for the knowledge-economy development policies in official Ministerial documents like the Lisbon Agenda and Europe2020.

---

[2] 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.



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



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

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).

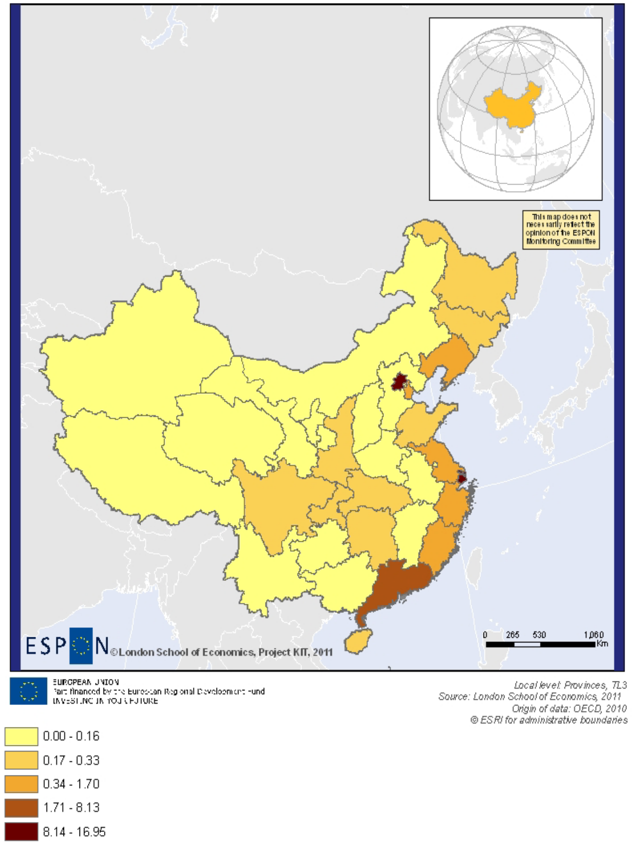
1.4. Spatial patterns of innovation

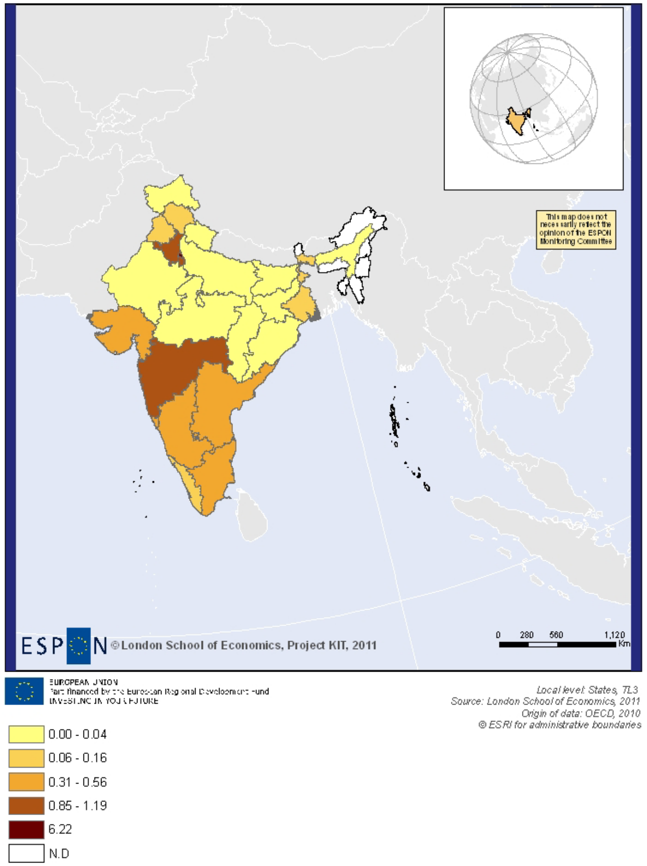
A value added of the KIT project is its estimation of regional innovation data, starting from CIS national data.[3] Data at regional level are made available by the KIT project about the share of firms having developed product innovation only; process innovation only; both product and process innovation; product and/or process innovation; marketing and organizational innovation.[4]

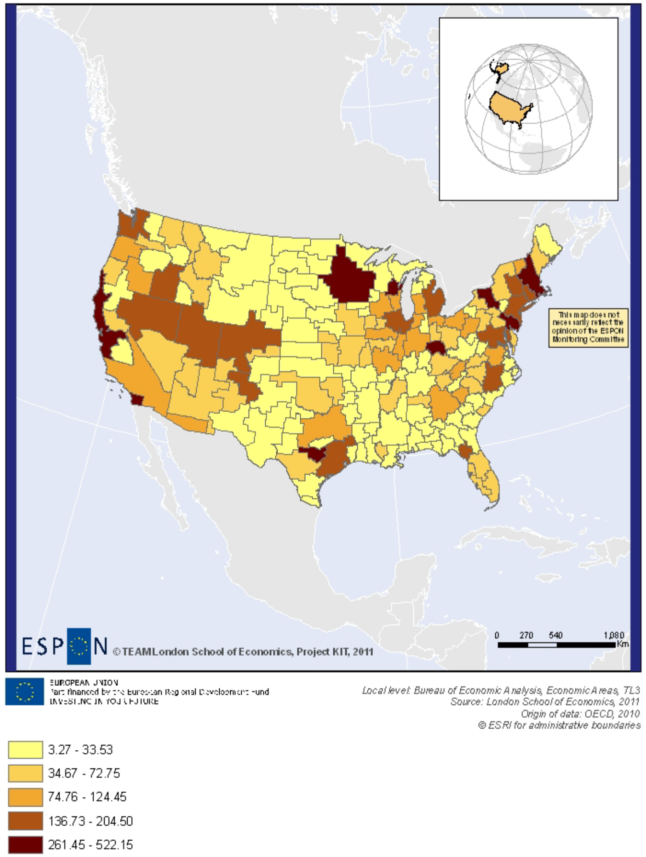
Spatial concentration characterizes product innovation, as is depicted in Map 1.4.1. This variable displays consistent concentration in strong countries, the core of product innovative activity in Europe being carried out in German, Scandinavian, Swiss and British regions, with a few notable exceptions 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.

[3] For the methodology applied, see Chapter 1 in Volume 1 of the Scientific report.
[4] 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.







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)

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.

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.

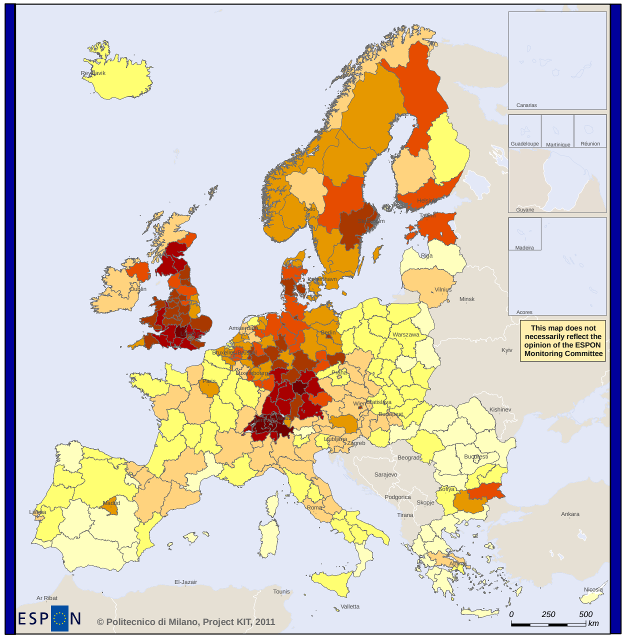
Typologies	Share of product innovation	Share of process innovation	Share of product and/or process innovation	Share of marketing and organizational innovation
TAR	17.42	13.76	43.66	32.75
Scientific	18.16	13.48	43.71	29.51
Networking	16.19	13.20	44.24	31.95
Other	6.34	9.88	27.40	20.58

What is striking in the results presented in Table 1.5.1 is that one would have expected the regions with high 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.



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Regional level: NUTS2
Source: Politecnico di Milano, 2011
Origin of data: Community Innovation Survey 2004
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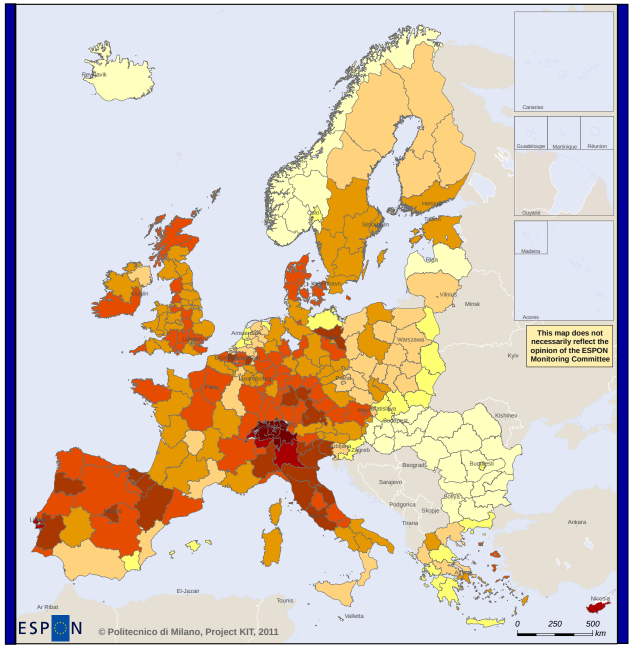
KIT estimates

Share of product innovation only

- NA
- 0 - 3.26
- 3.27 - 5.92
- 5.93 - 9.12
- 9.13 - 12.80
- 12.81 - 17.30
- 17.31 - 23.43
- 23.44 - 33.45
- 33.46 - 44.42

Switzerland: share of product innovation.
Iceland: CIS3 data.
Latvia and Slovenija: CIS 2006 data.

Map 1.4.1. Product innovation only



EUROPEAN UNION
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Regional level: NUTS2
Source: Politecnico di Milano, 2011
Origin of data: Community Innovation Survey 2004
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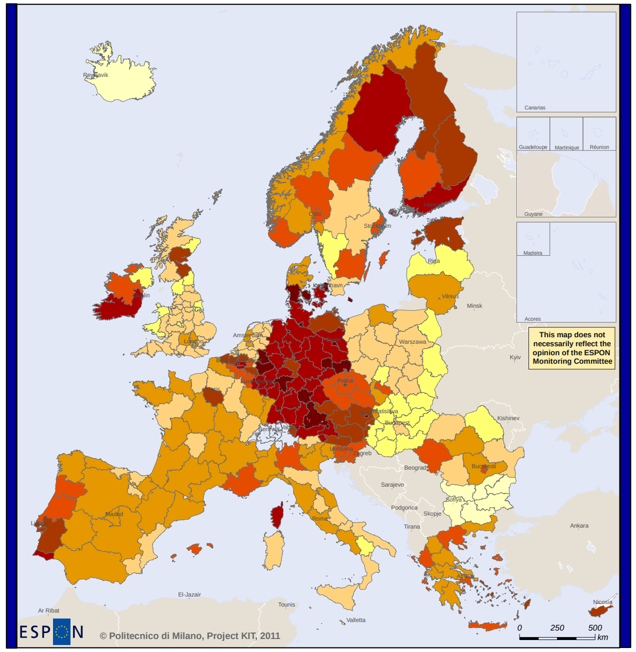
KIT estimates

Share of process innovation only

- NA
- 0 - 5.40
- 5.41 - 8.09
- 8.10 - 10.09
- 10.10 - 12.32
- 12.33 - 14.71
- 14.72 - 18.01
- 18.02 - 25.92
- 25.93 - 55.08

Switzerland: share of process innovation.
Iceland: CIS3 data.
Latvia and Slovenija: CIS 2006 data.

Map 1.4.2. Process innovation only



EUROPEAN UNION
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Regional level: NUTS2
Source: Politecnico di Milano, 2011
Origin of data: Community Innovation Survey 2004
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KIT estimates

Share of marketing and organizational innovation

- NA
- 0 - 9.05
- 9.06 - 15.24
- 15.25 - 19.81
- 19.82 - 23.53
- 23.54 - 29.56
- 29.57 - 37.50
- 37.51 - 48.05
- 48.06 - 78.36

Switzerland: share of product and process innovation.
Iceland: CIS3 data.
Latvia and Slovenija: CIS 2006 data.
Sweden: CIS 2008 data.

Map 1.4.3. Marketing and / or organizational innovation

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);

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.

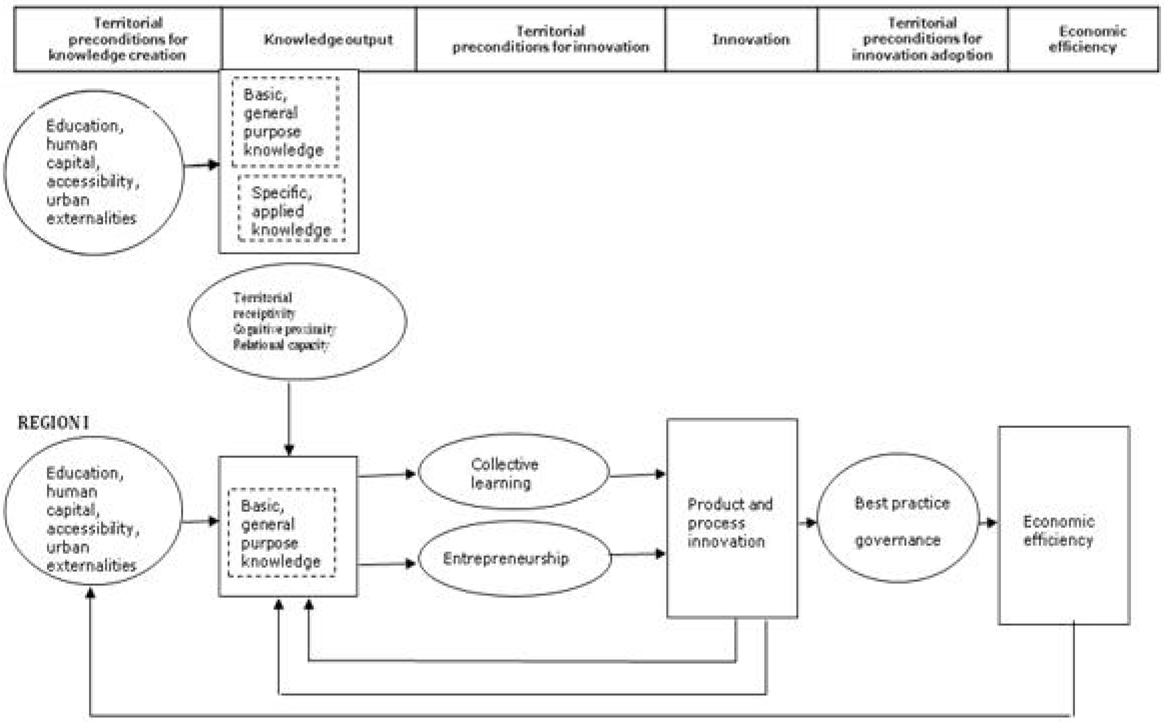


Figure 2.1.1. Endogenous innovative pattern in a scientific network

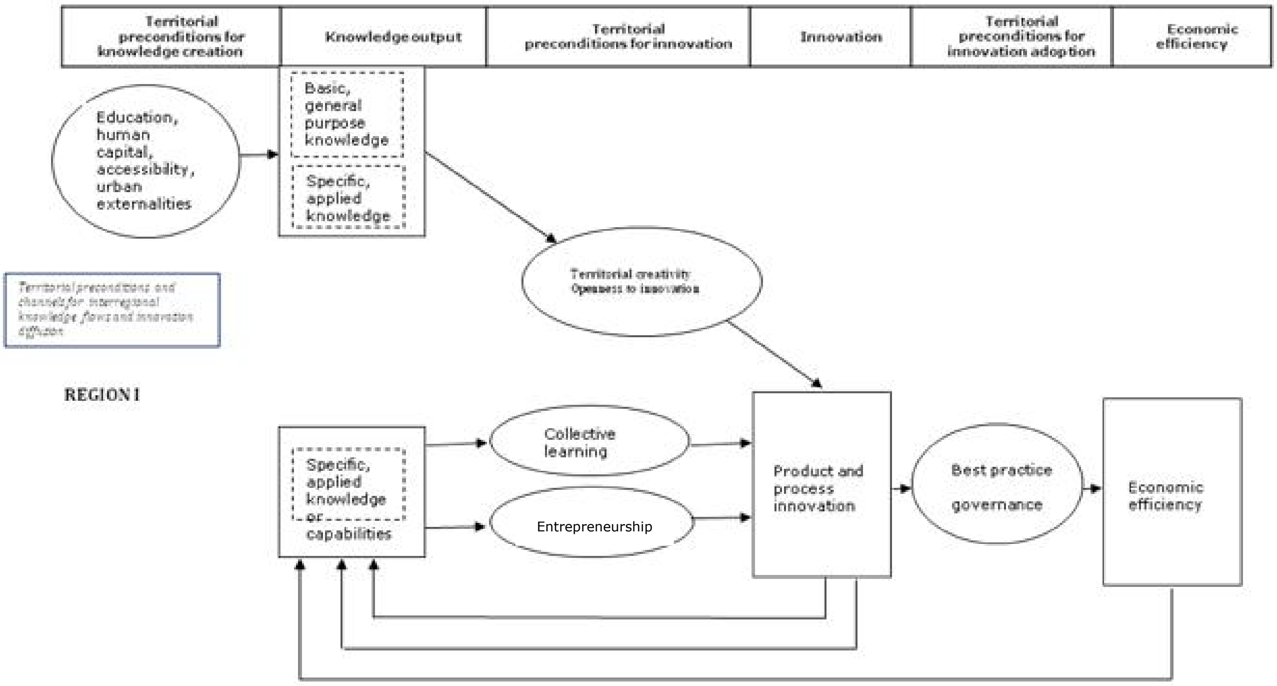


Figure 2.1.2. A creative application pattern

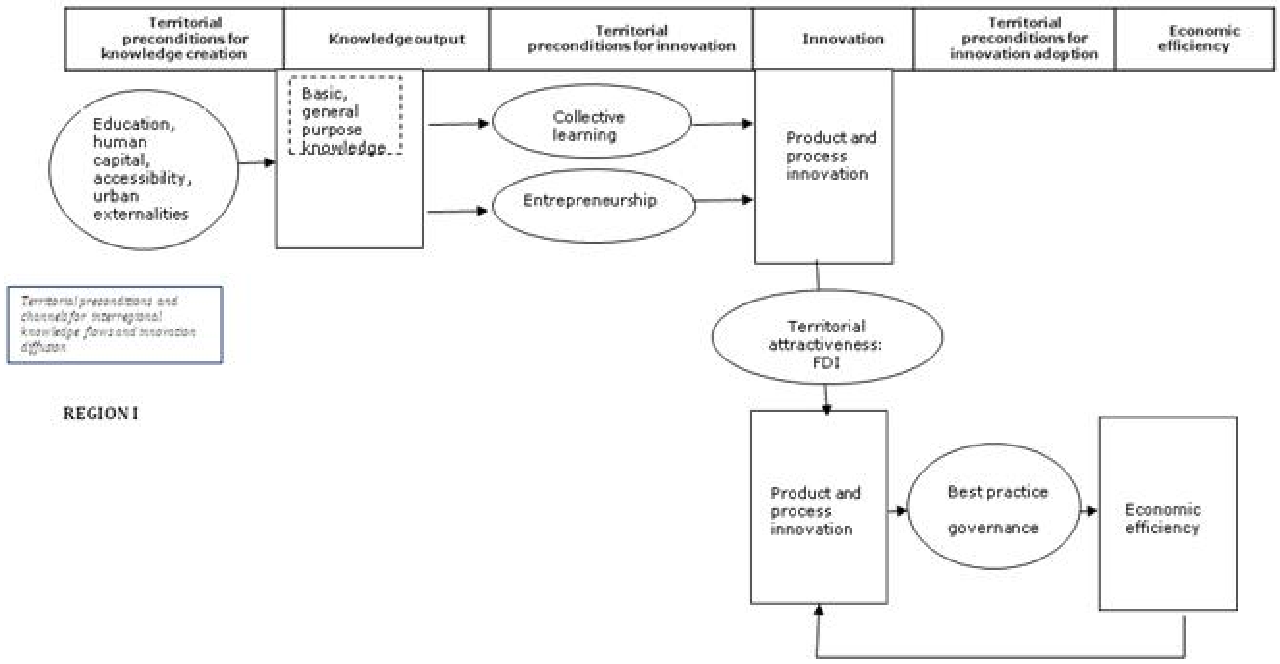


Figure 2.1.3. An imitative innovation pattern

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.[5]

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 degree of knowledge coming from regions with a similar knowledge base. R&D endowment is high in these regions. These regions are mostly located in Germany, with the addition of Wien, Brussels, and Syddanmark in Denmark.

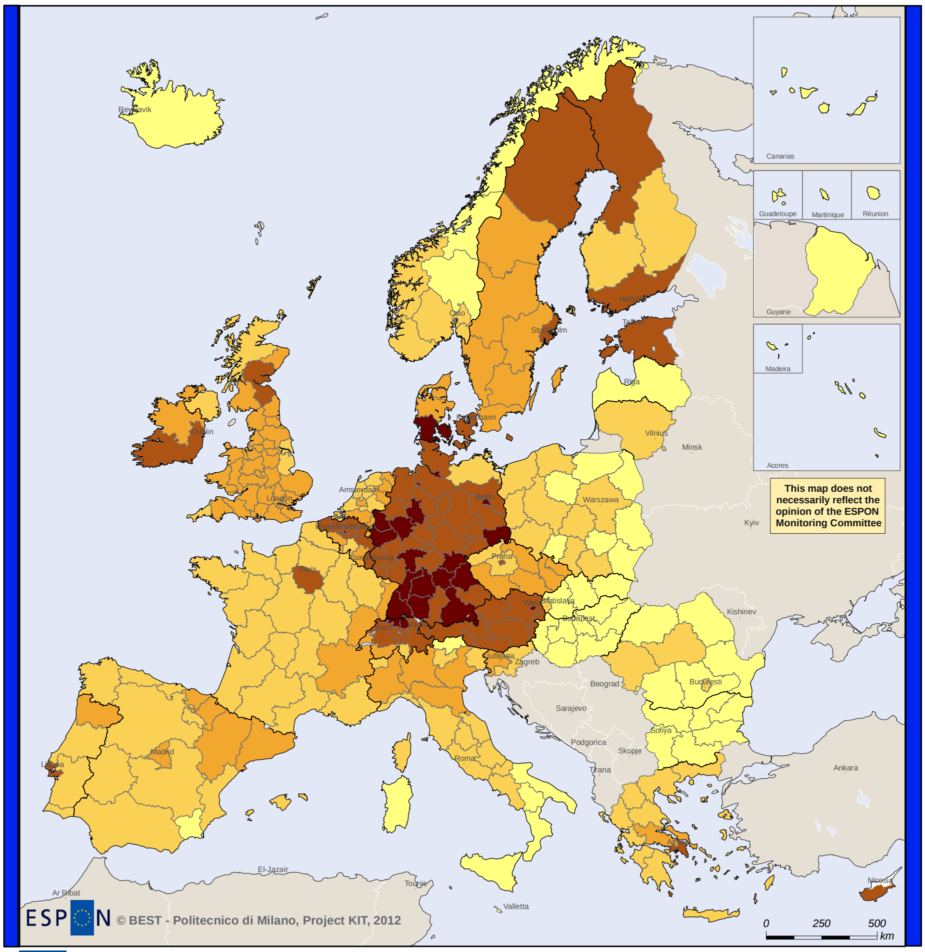
An applied science area (pattern 1b), made of strong knowledge producing regions characterized by applied science, with a high degree of knowledge coming from regions with a similar knowledge base. R&D activity is high also in this cluster of regions. This type of regions is mostly agglomerated and located 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. The target of this group of regions is to achieve specialized diversification across related technologies in diversified technological

[5] 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.

fields of competence. 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.

Territorial patterns of innovation in Europe



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Source: EUROSTAT, own calculation, 2011
Origin of data: BEST - Politecnico di Milano
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Legend

- Creative imitation area
- Smart and creative diversification area
- Smart technological application area
- Applied science area
- European science-based area

Map 2.2.1. Territorial patterns of innovation in Europe

A smart and creative diversification area (pattern 2b), characterised by a low degree of local diversified applied knowledge, internal innovation capacity, high degree of local competences, high degree of creativity and entrepreneurship, external knowledge embedded in technical and organizational capabilities. These regions are mainly located in Mediterranean countries (i.e. most of Spanish regions, Central Italy, Greece, Portugal), in EU12 agglomerated regions in Slovakia and Slovenia, Poland and Czech Republic, few regions in northern Europe, namely in Finland and the UK.

A creative imitation area (pattern 3), in which one measures a low knowledge and innovation intensity, entrepreneurship, creativity, a high attractiveness and a high innovation potentials. 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.

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.

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);

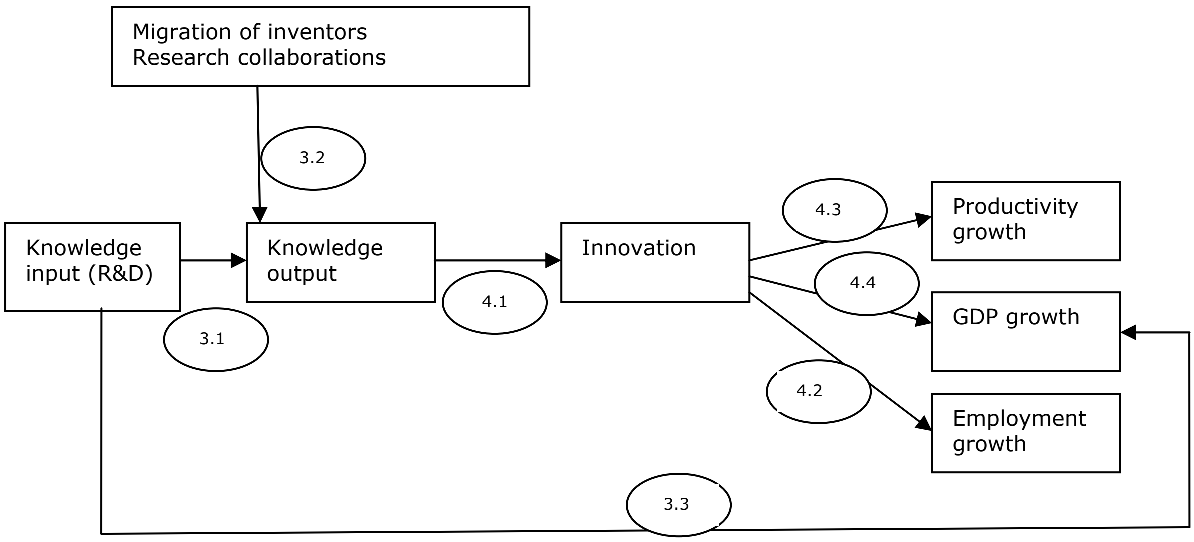
b) generating economic growth from knowledge input (R&D and human capital), capturing which regions benefit the most from an increase in R&D, as suggested by the Lisbon and Europe2020 Agenda (sec. 3);

c) exploiting knowledge for producing innovation (sec. 4);

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 2.1.4, with the main questions addressed and the sections in which questions are answered.



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 2.1.4. Logic of the impact analysis and questions addressed

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).[6]

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).[7] 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 elasticities 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 France, North of Italy, Germany, Spain, Denmark, Austria and 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

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

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 "Creative imitation" 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 "Creative imitation" 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).

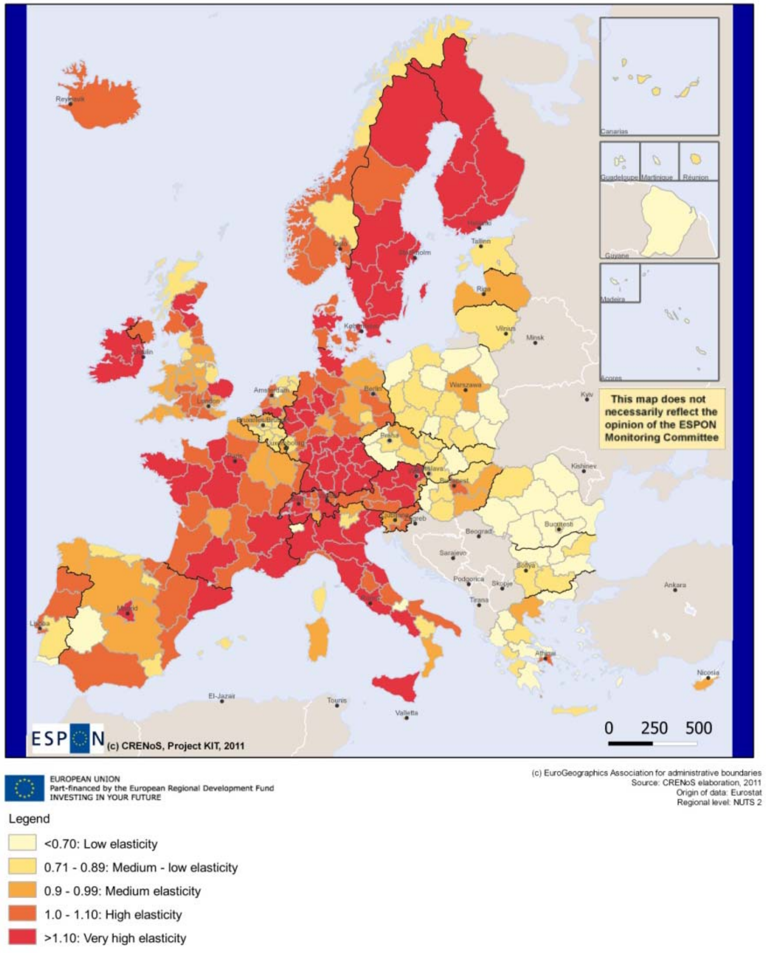
Therefore, **both R&D and human capital are less effective in the regions with the lowest knowledge endowment, witnessing that a certain degree of knowledge is required to generate new knowledge. This is true up to a certain threshold, when increasing returns turn into decreasing returns.**

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).[8] 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.

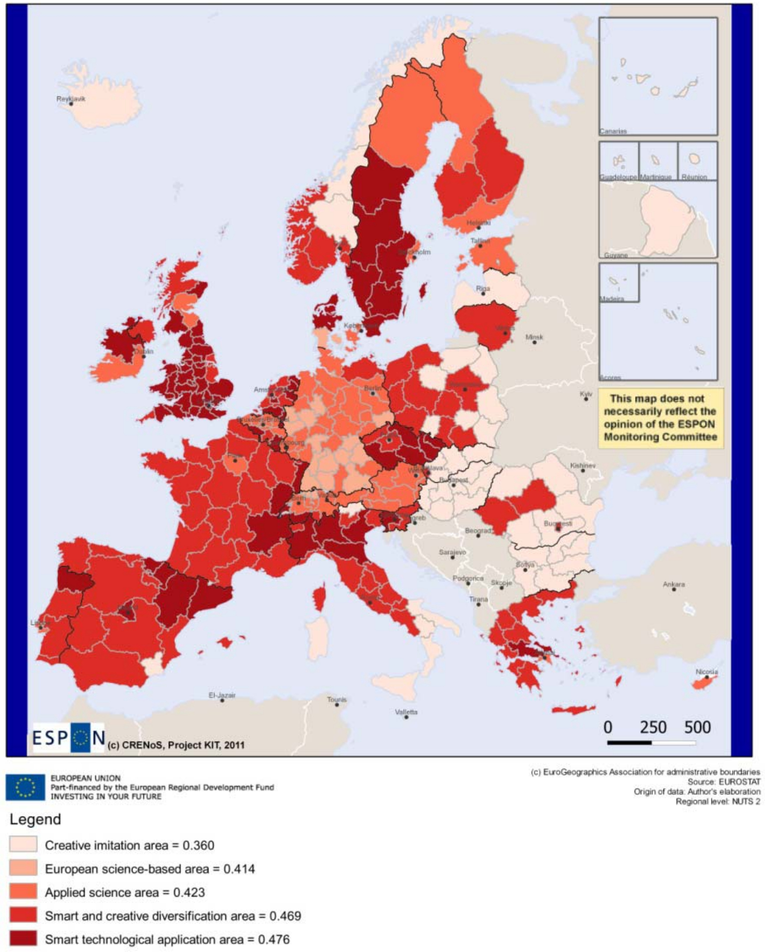
Map 3.1.4 shows that the most efficient territories exhibit a great deal of heterogeneity. The majority of the efficient regions are located in the most central or economically strategic areas of the continent, as it is the case for Île de France, Stuttgart or the Belgian Noord-Brabant. However, due 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 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.

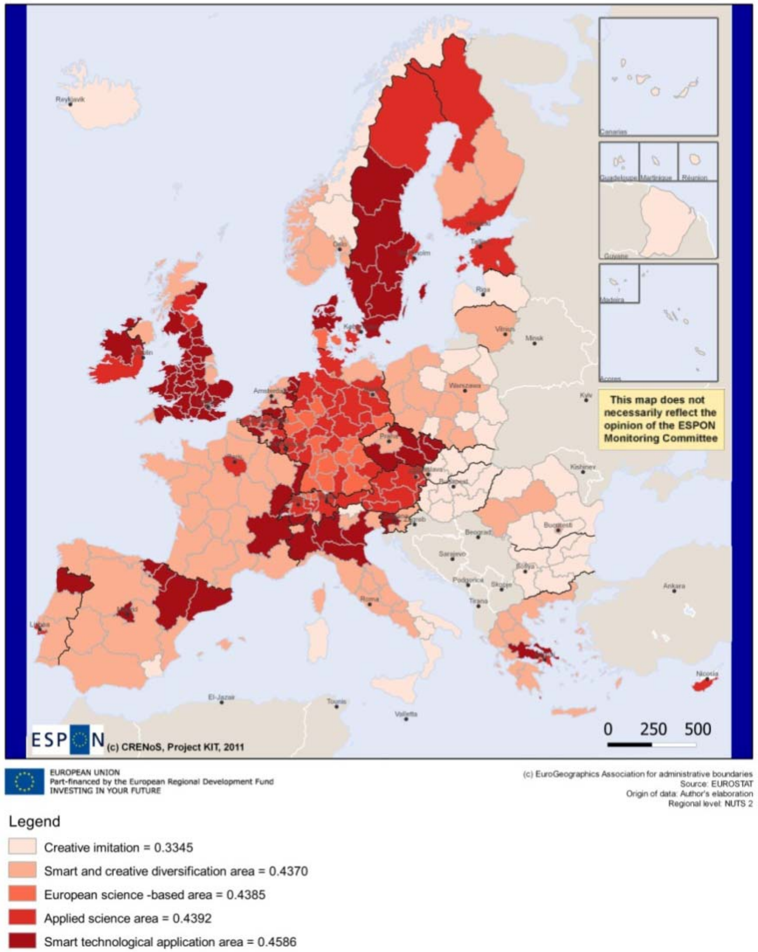
[8] In Chapter 3, Volume 1 of the Scientific report the DEA results are also presented for the initial year 2000.



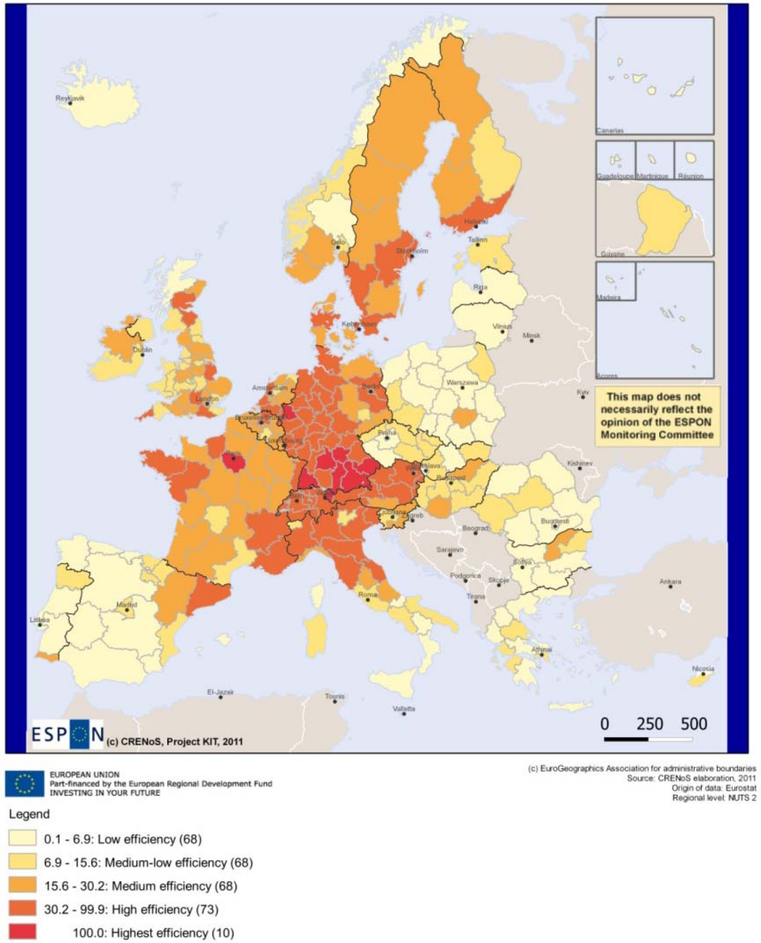
Map 3.1.1. Elasticity of knowledge production to human capital for the individual regions (average 2000-2007)



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



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



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

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.

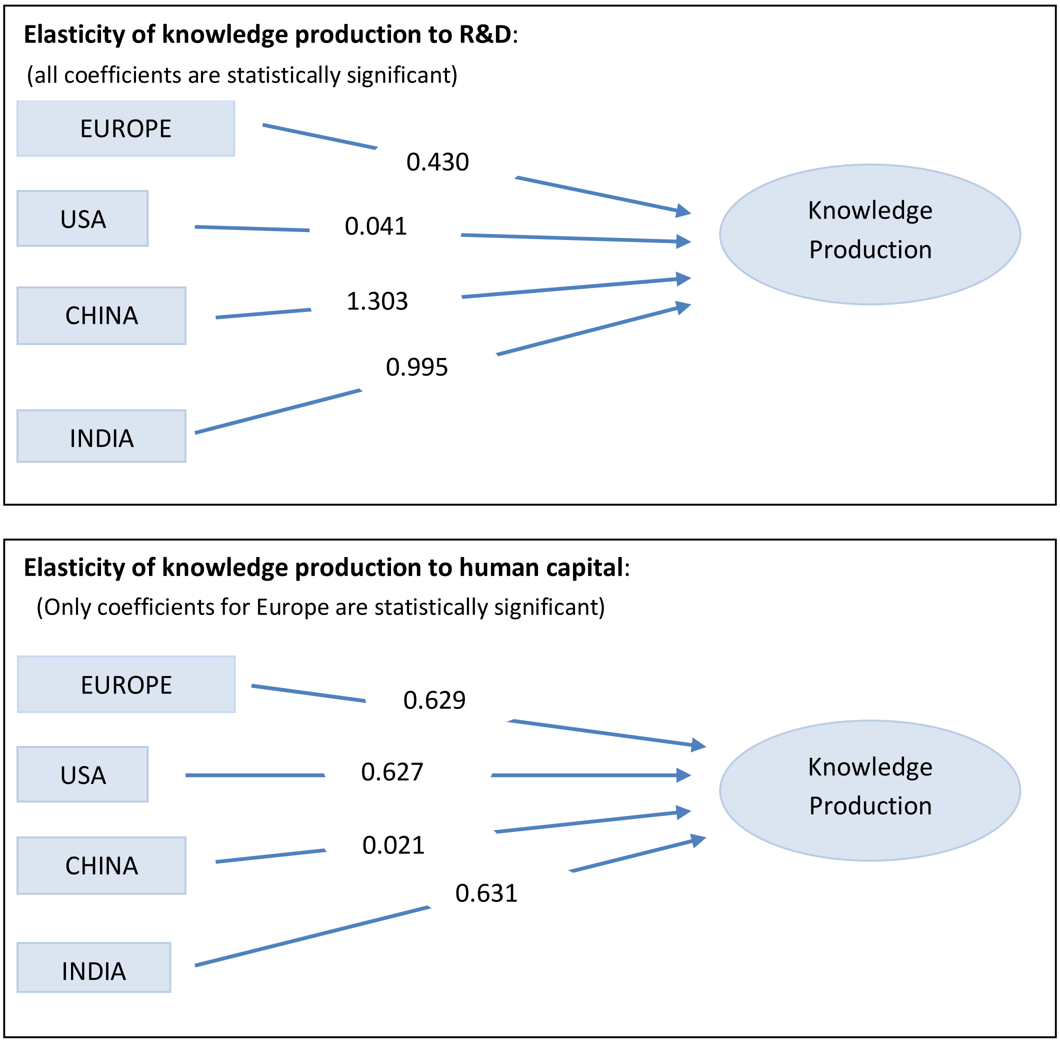


Figure 3.1.1. International comparisons among knowledge production elasticities

The regional knowledge production function links patenting activity to R&D expenditures, human capital and, to control for the region's size, resident population.[9] 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

[9] Details on data and model specifications can be found in the Scientific Report, Volume 1, Chapter 4.

expenditures is shown by USA which is the area where R&D investments are higher.[10] 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 elasticity of knowledge creation to internal inventors' mobility and to internal co-patenting (connectivity) is measured.[11] Among the results, we highlight that both labour mobility and the scale of the networks (no matter whether it is proxied through the average degree centrality index or the connectivity measure) 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 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.

Bearing in mind that 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

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[10] 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.

[11] 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.

networking. In order to analyse this variability, we have introduced cross-effects of the corresponding focal variable with a dummy for the different typologies of territorial innovation pattern.

Figure 3.2.1 displays the elasticity of knowledge to intra-regional inventors' mobility 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 elasticity) 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 "Creative imitation area") do not benefit from the local mobility of skilled workers, being their elasticity of knowledge to labour mobility non-significant in this case.

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 elasticity) in regions that outperform the other 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 elasticity in the case of the regions of the "Smart and creative diversification area" and the "Creative imitation area" also show positive and significant elasticities, 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 elasticities in the case 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.

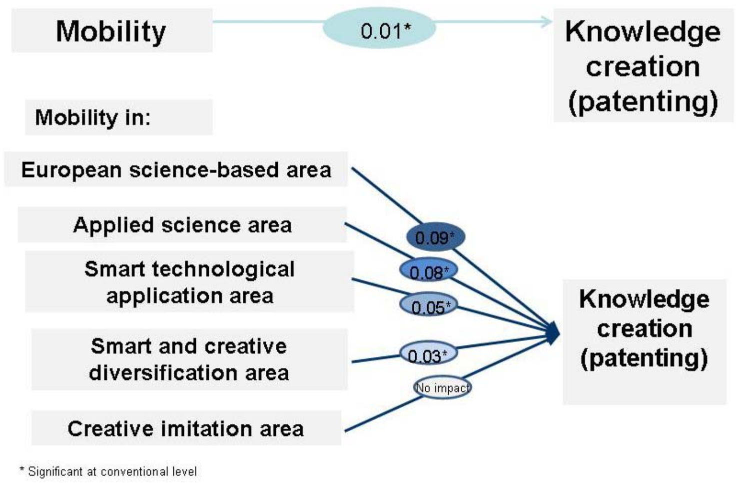


Figure 3.2.1. Elasticity of knowledge creation to intra-regional inventors' mobility by patterns of innovation

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 returns since they are able to translate internal and external knowledge into new specific commercial applications more efficiently than the less innovative regions.

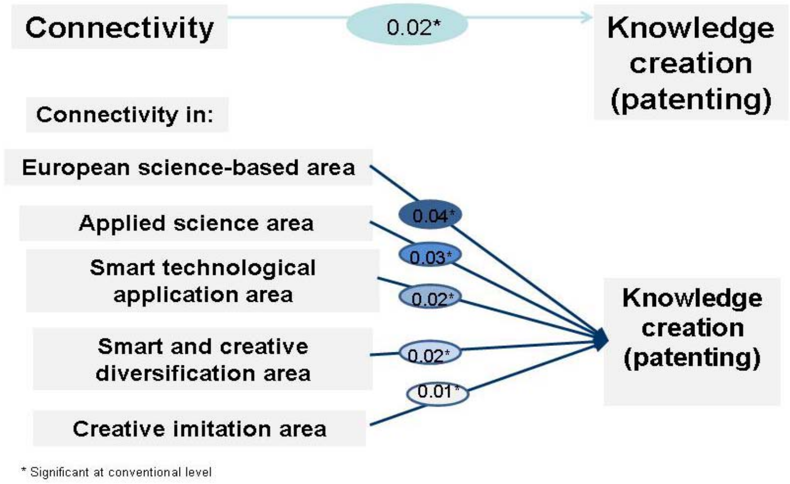


Figure 3.2.2. Elasticity of knowledge creation to internal co-patenting (internal research networks) by patterns of innovation

3.2.2. External knowledge flows and regional knowledge creation

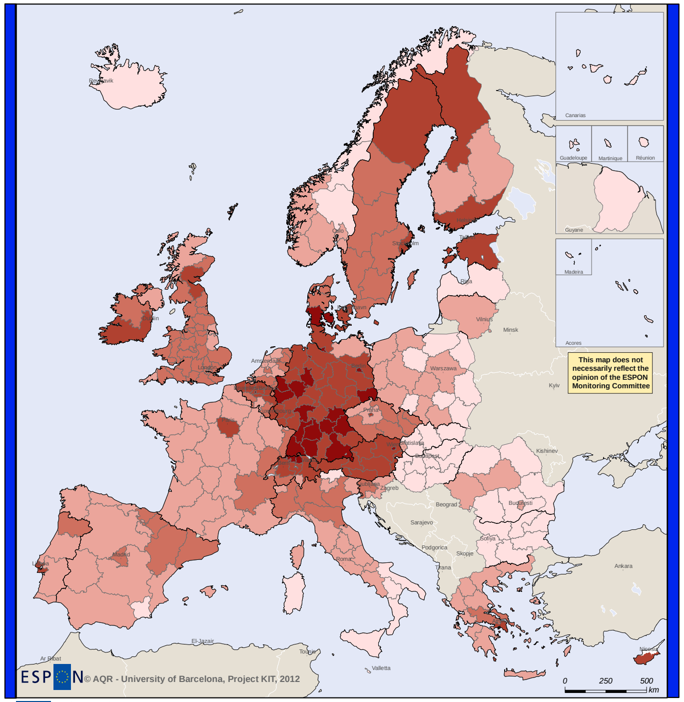
A second important contribution stems from taking into account the external linkages with other regions for the internal knowledge production. As it has been argued in the literature, we claim that cross-regional co-patenting and movements of skilled workers across regions act as main channels through 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 proxies used to capture the knowledge and scientific linkages among regions.[12] 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 elasticity. 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 elasticities of knowledge creation (patenting activity) to cross-regional inventors' mobility, a strong spatial variance occurs. Map 3.2.1 shows the geographical distribution of the regional elasticity of knowledge creation to cross-regional mobility by patterns of innovation. The highest elasticity is registered for the European-science based area, where a 1% increase in net migration of inventors from outside the region increases internal knowledge creation by more than 7%. A high elasticity is also registered by the "Applied science area" (more than 5%) and by the "Smart technological application area" (more than 2%). 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 "Creative imitation area".

[12] 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.

Elasticity of knowledge production to cross-regional mobility by patterns of innovation



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Regional level: NUTS2
Source: EUROSTAT, own calculation, 2011
Origin of data: AQR - University of Barcelona
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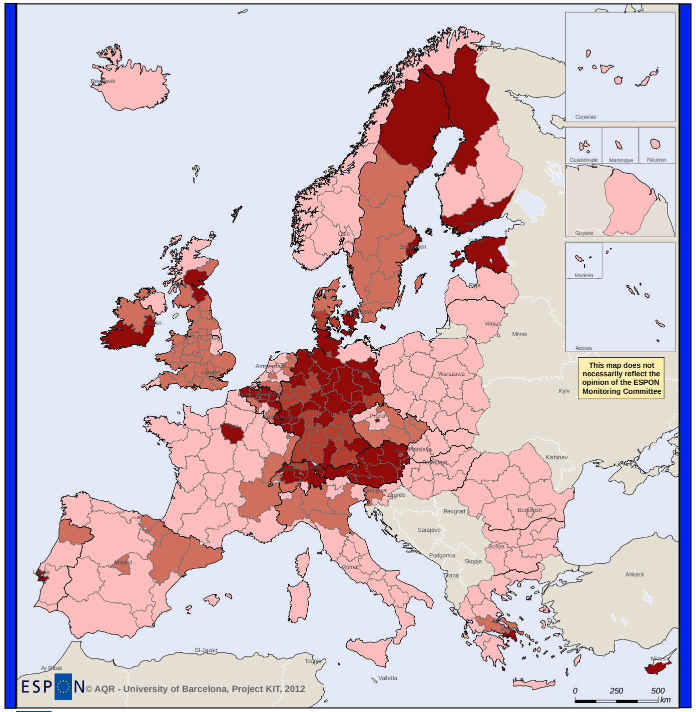
Legend

- Creative imitation area = -1,78
- Smart and creative diversification area = No impact
- Smart technological application area = 2,33
- Applied science area = 5,82
- European science-based area = 7,27

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

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



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Regional level: NUTS2
Source: EUROSTAT, own calculation, 2011
Origin of data: AQR - University of Barcelona
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Legend

- Creative imitation 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

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

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 to take 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, creativity strongly alive.

Similar results are achieved when we analyze spatial heterogeneity of co-patenting activities. Map 3.2.2 shows the elasticity of knowledge creation to cross-regional co-patenting. Similarly, 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 elasticity of knowledge creation to cross-regional patenting. This is not the case for the other two types of regions, where no critical mass of knowledge exists.

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.

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[13]. In particular, the impact of R&D (0.131) and human capital (0.297) turns out to be higher than the traditional physical capital

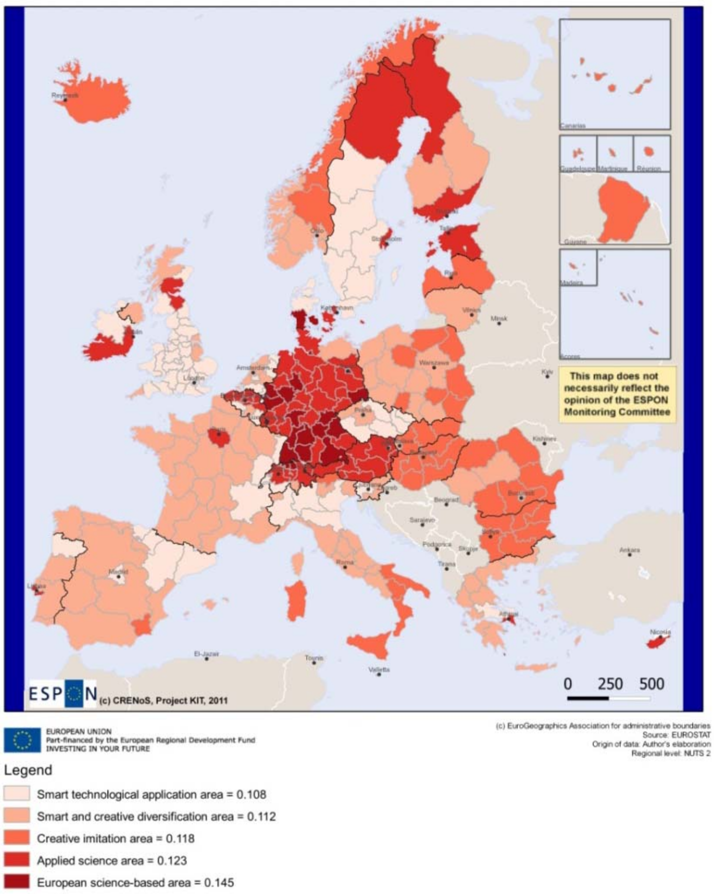
[13] For technical details, see Chapter 3, Volume 1 of the Scientific report.

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.



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

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 "Creative imitation 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 "Creative imitation 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.**

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.[14] 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.

4. Innovation and regional performance

One of the main issue of the KIT project is the identification of the role played by knowledge and innovation on regional performance, 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.

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

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.[15] 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 R&D 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**.

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 "Creative imitation area", respectively).

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).

[15] 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.

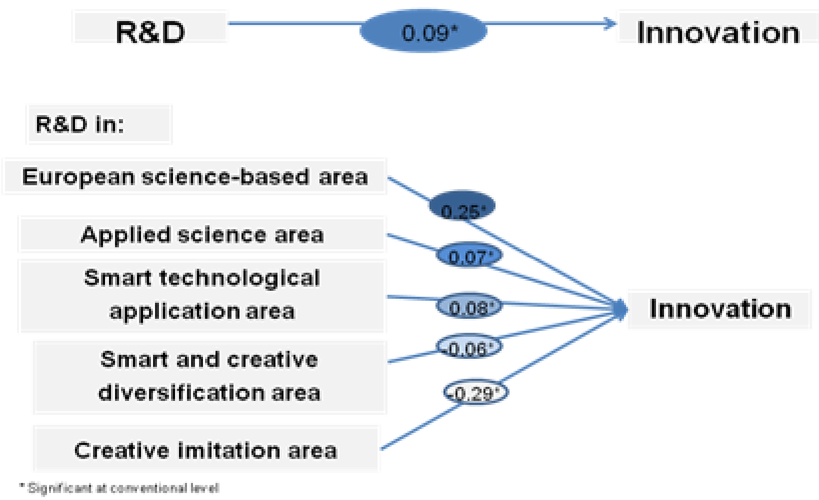
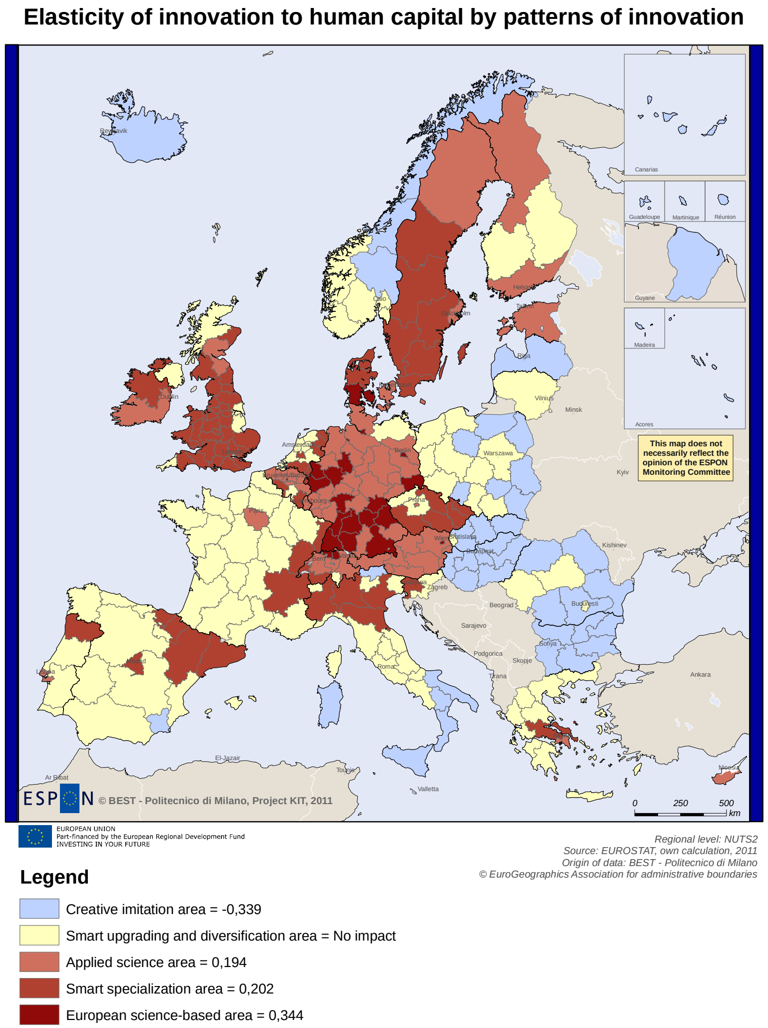


Figure 4.1.1. Elasticity of innovation to R&D by patterns of innovation



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

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.[16] 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.

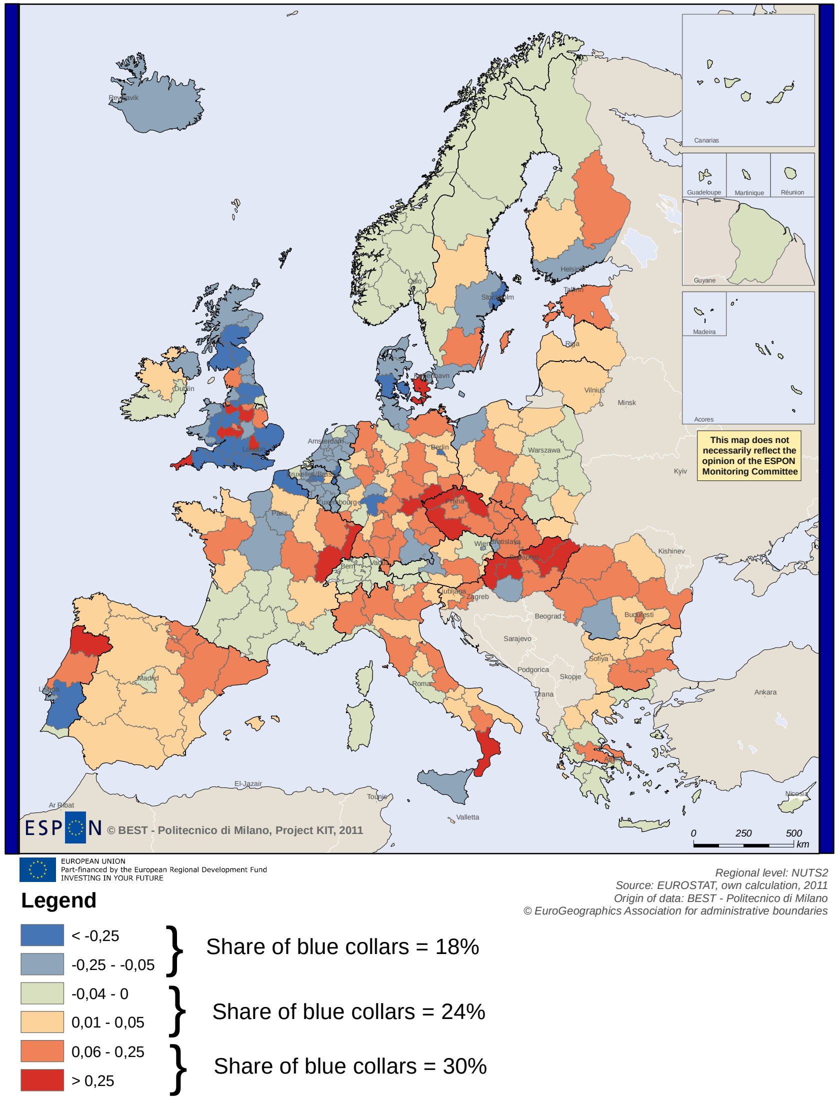
As to process innovation, the labour displacement effects look especially concentrated in specific types of regions, namely in the "Smart technological application area", in the "Smart and creative diversification area" and in the "Creative imitation area". In detail, Figure 4.2.1 shows the elasticity 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, 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)[17], even after controlling for interregional interdependencies (Figure 4.2.2).

[16] 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.

[17] 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.

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



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

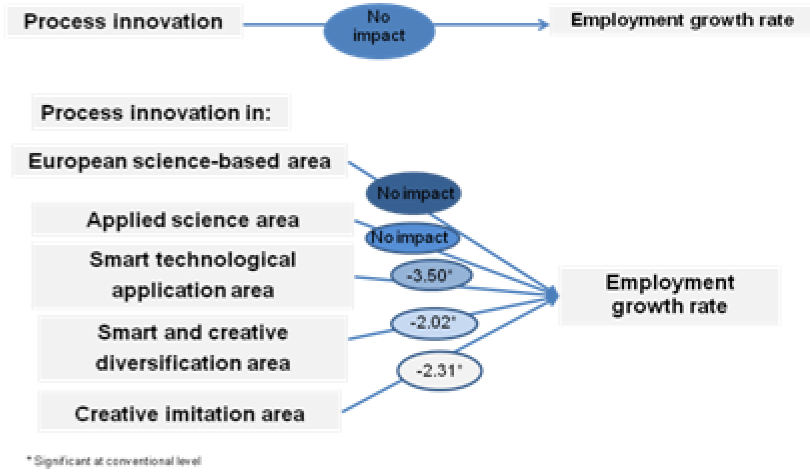


Figure 4.2.1. Elasticity of employment growth rate to process innovation by territorial patterns of innovation

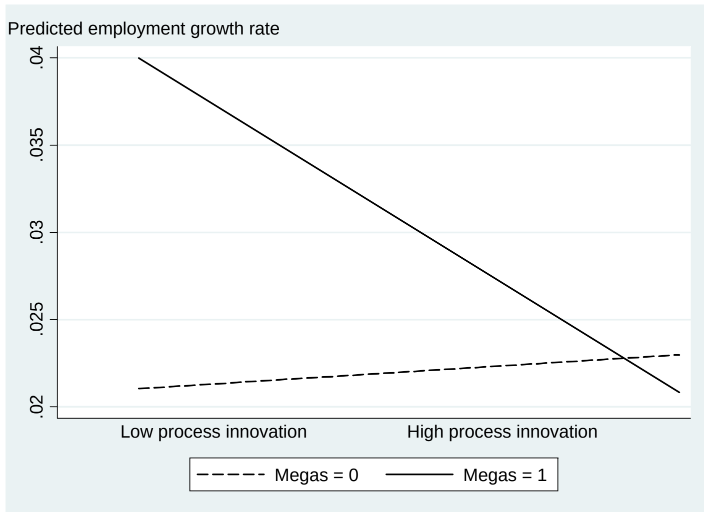


Figure 4.2.2. Elasticity of employment growth rate to process innovation for megas and non megas regions

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[18]) 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 "Creative imitation 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.

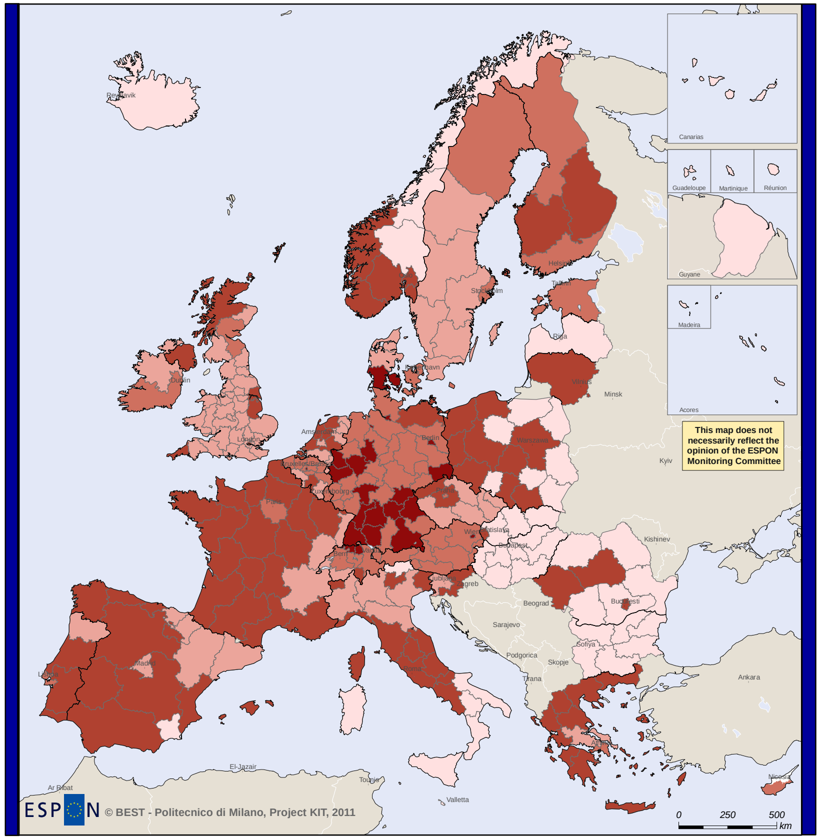
This result suggests that formal knowledge is not the only and chief driver leading to higher efficiency performances. Rather, a tight relationship between knowledge and efficiency level seems to be at place only in those groups of regions in which the local knowledge base is already quite developed 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 seem to react to increases in formal knowledge.

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 science-based area" seems to experience efficiency gains from increases in the local capabilities level.

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.

[18] 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.

TFP level by patterns of innovation



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Regional level: NUTS2
Source: EUROSTAT, own calculation, 2011
Origin of data: BEST - Politecnico di Milano
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Legend

- Creative imitation area = 0,325
- Smart specialization area = 0,393
- Applied science area = 0,394
- Smart upgrading and diversification area = 0,405
- European science-based area = 0,478

Map 4.3.1. TFP level by territorial patterns of innovation

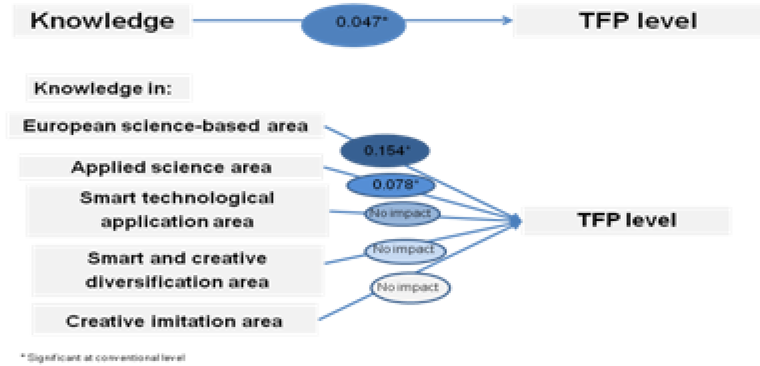


Figure 4.3.1. Elasticity of TFP level to knowledge by patterns of innovation

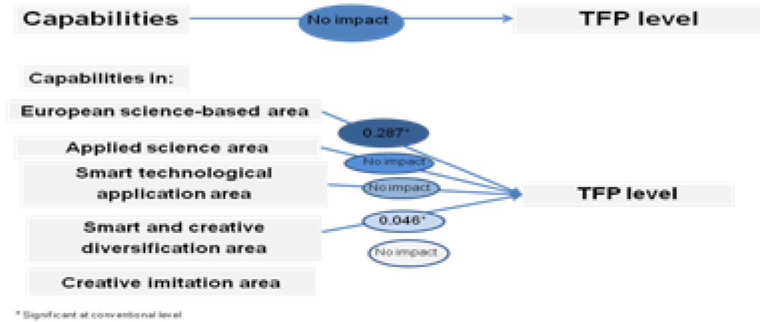


Figure 4.3.2. Elasticity of TFP level to capabilities by patterns of innovation

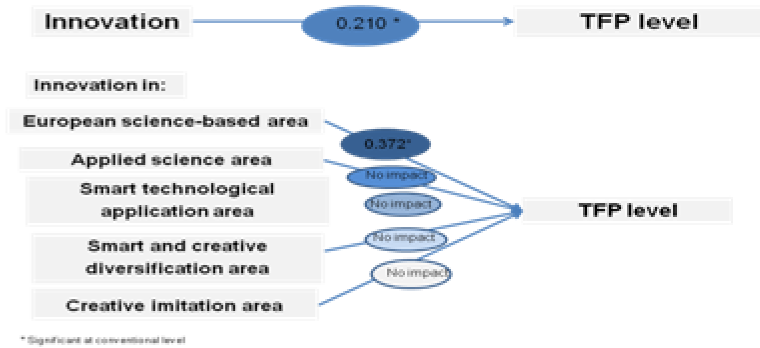


Figure 4.3.3. Elasticity of TFP level to innovation by patterns of innovation

4.4. Innovation and GDP growth

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. However, our findings also suggest some caution in the interpretation of this result.

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**.[19]

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%), "Creative imitation 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 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 "Creative imitation 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.

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.

[19] 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.

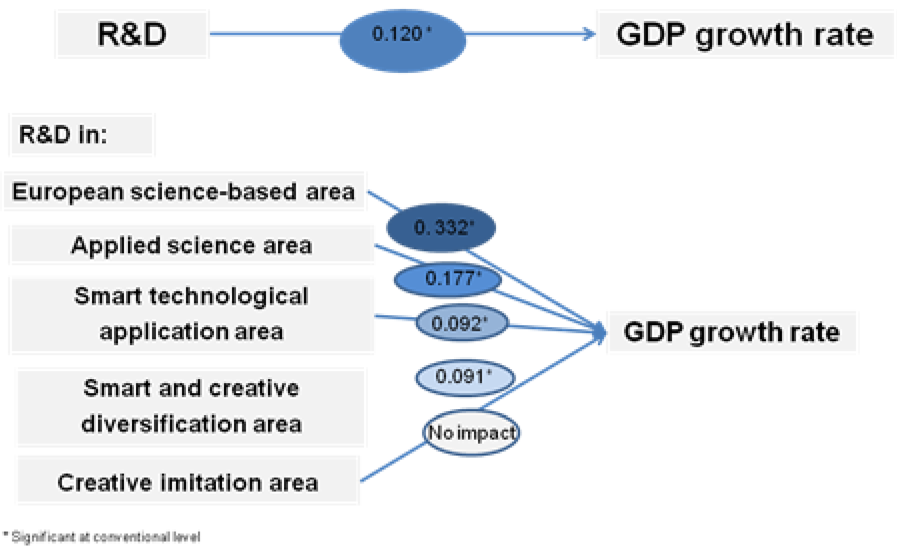
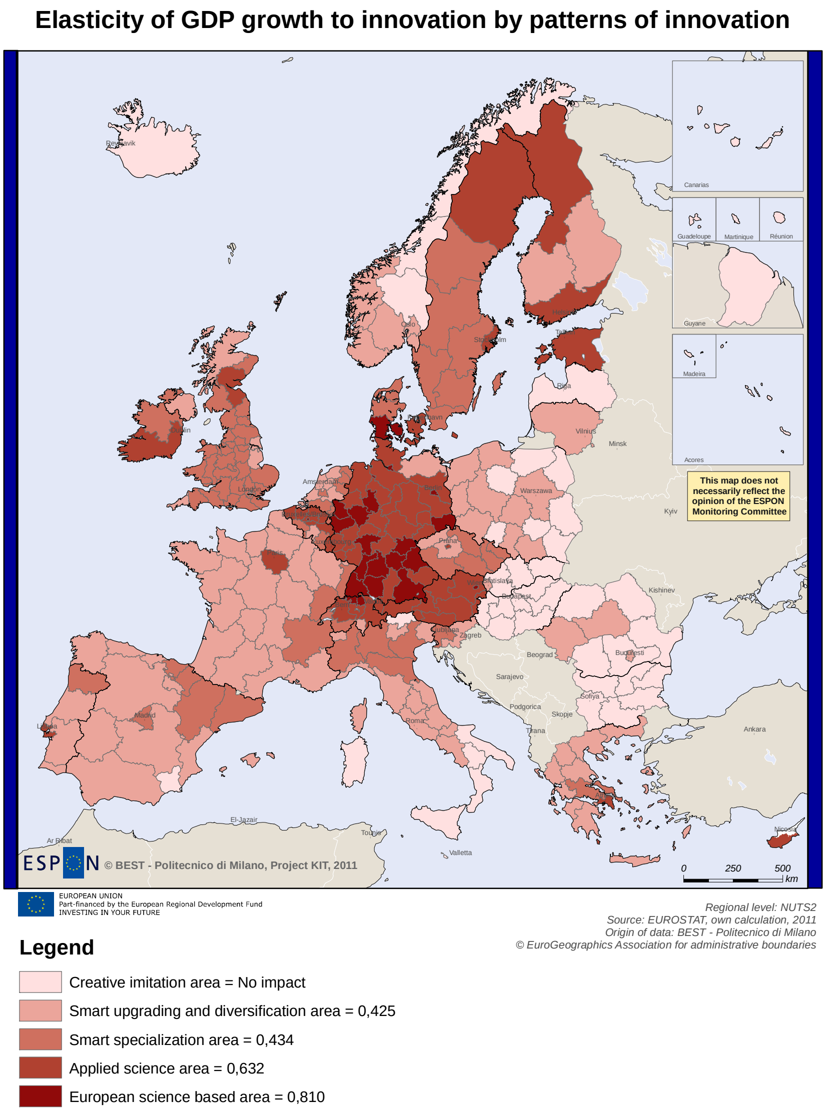


Figure 4.4.1. Elasticity of GDP growth rate to R&D by patterns of innovation



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

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.[20] 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.

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

[20] 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.

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.

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

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.

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.

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 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 built.

Smart innovation policies are defined as those policies able to increase the innovation capability of an area and to make local expertise in knowledge and innovation more efficient, acting on the local specificities and on the characteristics of already established innovation patterns in each region. The two key concepts of "embeddedness" and "connectivity" - put forward in the recent debate on smart specialization (McCann, Ortega-Argilés, 2011) – are a starting point: policies have to be embedded in the local reality, in local assets ("embeddedness"), and have to guarantee the achievement of external knowledge through strong and virtuous linkages with the external world ("connectivity"). Smart innovation policies go a step forward, since they adapt the two concepts of "embeddedness" and "connectivity" to the specificities of each pattern of innovation, without incurring in the unrealistic situation of having one policy action for each European region, or in the paradox of rejecting innovation policies, like R&D funding and specialization, just because they are traditional tools. Smart innovation policies look for ad-hoc interventions - appropriate for each single territorial innovation pattern - with the aim to reinforce regional innovation process, to enhance the virtuous aspects that characterize each pattern, and to reinforce 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.

B - R&D support 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. The return to R&D of such kind of policy are modest in these areas. The innovation policy aim in these patterns can be found in the maximum return to co-inventing application (the typical Schumpeterian profits), which deeply depends on the ability of regions to change rapidly in response to external stimuli (such as the emergence of a new technology).

Table 6.1. Smart innovation policies by territorial patterns of innovation

	Territorial patterns of innovation				
Policy aspects	**European science-based area**	**Applied science area**	**Smart technological application area**	**Smart and creative diversification area**	**Creative imitation area**
Policy goals	Maximum return to R&D investments		Maximum return to co-inventing application		Maximum return to imitation
Policy actions for local knowledge (Embeddedness)	R&D support to:		Support to creative application, shifting capacity from old to new uses, deepening or improving productivity in existing uses, through:		Support to local firms for creative projects with MNCs
	General Purpose Technologies	Specialized technological fields	Incentives to technological projects	Support to the identification of international best practices Support to entrepreneurial creativity	
Policy actions for knowledge spillover exploitation (Connectivity)	Incentives to inventors attraction. 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), especially in related sectors Encourage labour mobility in related sectors	cooperative research activities among related sectors	participation of local actors to specialized international fairs attraction of "stars" even for short periods a work experience in best practice knowledge creation firms of the same sectors	
Policy style	Provide a critical mass of funds Stimulate knowledge transfer mechanisms in related sectors Thematically/ regionally orientation of R&D funding:		Stimulate a bottom up identification of industrial vocations, by raising awareness of local capabilities, in order to:		Stimulate cooperation projects between MNCs and local firms
	given to a critical mass of researchers and of laboratories in general purpose technologies	in specific fields of technological specialization of the area targeted choice of joint research activities with partners external to the area	Stimulate cooperation with strong knowledge creation external partners in the specialized sectors of the area	Support local actors' participation to international fairs in their specialized sectors Support targeted work experiences in best practice knowledge creation firms	
Beneficiaries	University, research centers, large local firms		Local firms	Local entrepreneurs	Local firms

To achieve such a goal, supports to creative application, shifting capacity from old to new uses, deepening or improving productivity in existing uses, are the right policy tools for maximising the return to co-inventing application.

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 for the "Smart technological application area". On the other hand, support devoted to the identification of international best practice, and to entrepreneurial creativity are more in favour of an innovation pattern like the one of the "Smart and creative diversification area".

C - Finally, in the "Creative imitation" pattern the aim has to be devoted to the achievement of the maximum return to imitation, through a creative adaptation of already existing innovation, via adoption processes driven by creative ideas on the way already existing innovation can be adopted to reply to local needs. The maximum return to imitation is supported by incentives to local firms for the development of creative projects with MNCs.

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 **connectivity**. As has been the case for embeddedness, also in the case of connectivity 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 some attention in their design phase in order to be efficient. A **policy style** is necessary for R&D spending. R&D funding has to be provided with a critical mass, and should also be accompanied by stimuli to knowledge transfer mechanisms in related sectors, in order to guarantee permeability of new knowledge. Moreover, the efficiency of R&D funding is dependent on the identification of thematic and regional scientific specializations. For what concerns the support to creative application, its efficiency is guaranteed through a bottom-up identification of local industrial vocations, raising awareness of local capabilities. When imitation is the stake, the efficiency of the policies is dependent on the stimulation of cooperation projects between MNCs and 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 "Creative imitation 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, and that potentially could move to a different pattern. For these regions, evolutionary policies can be foreseen, devoted to the achievement of more efficient innovation patterns.

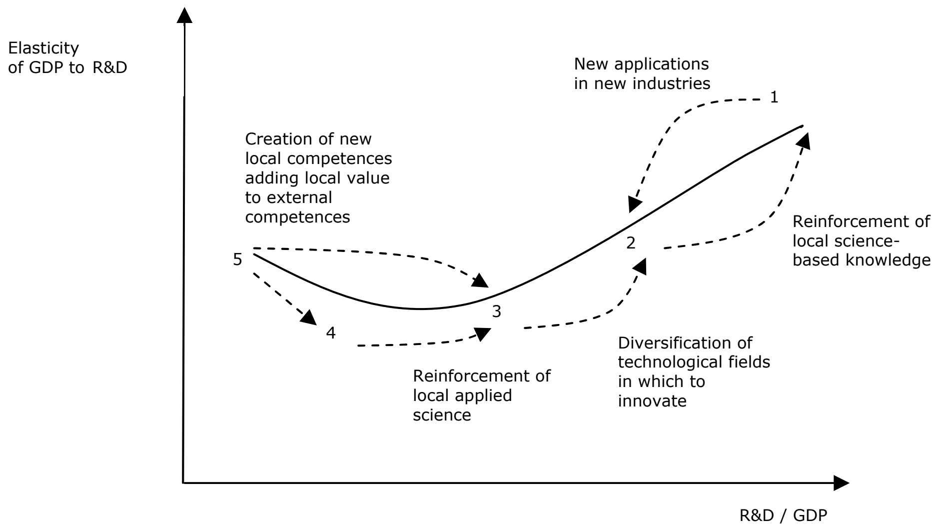
Figure 6.2.1. shows the relative position of each pattern in terms of the elasticity of GDP to R&D. As shown by our empirical analysis, R&D levels require a certain critical mass to become effective; when this is reached, increasing returns start. Figure 6.2.1 represents the dynamic trajectories (and 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 "Creative imitation 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".

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 decreasing returns that are linked to R&D activities, by diversifying its R&D activities through the identification of new applications in new industries, and moving in this way towards an "Applied science area".

Some regions belonging to an "Applied science area", on their turns, could be specialized enough in GPT fields to move to the "European science-based area" by **strengthening the local science base, if already present in a certain critical mass**.



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

Figure 6.2.1. Evolutionary trajectories and policies by patterns of innovation

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".

The application of the evolutionary policies requires the identification of the most efficient regions within each pattern. These regions have to show a strong efficiency with respect to other regions in the same pattern, and especially should demonstrate an already clear policy oriented towards the increase of returns to knowledge and innovation. In this way, evolutionary policies would find a fertile ground on which to produce their virtuous effects.

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 Europe" in the years to come.

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