Innovation pathways and policy challenges at the regional level: smart specialization

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Innovation pathways and policy challenges at the regional level: smart specialisation*

René Wintjes[1] and Hugo Hollanders[2]

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Abstract

This paper highlights the great diversity in development pathways and trajectories of innovation across European regions. A regional knowledge-based economy has multi-dimensional aspects. It includes a variety of knowledge activities and multiple interactions among a range of actors including universities, research institutes, enterprises, knowledge workers and institutions. The spatial patterns and trends for the different aspects of the knowledge-based economy vary significantly across Europe. Most aspects show convergence and generate catching-up processes, while some show divergence between European regions. Overall, absorption capacity has increased in importance and education is an important challenge for future regional development. Place-based innovation policy is essential to enhance synergies among co-evolving knowledge capabilities and encourage smart specialisation.

Keywords: innovation pathways, regional development, innovation policy
JEL Codes: O18, R11

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INTRODUCTION

The purpose of this paper is to improve our understanding of the relation between the shifts towards a knowledge-based economy and regional disparities in Europe. On the one hand there is a concern that existing regional disparities in income and knowledge potential may widen due to the agglomeration tendency of knowledge intensive activities. While on the other hand there are signs of catching up in recently joined Member States. What could be the situation in 20 years from now, and what are the policy implications for today of the gained insights from a foresight on the regional impact. The main research questions are:

Will the regional impact of innovation in 2020 lead to more polarisation and/or cohesion?

By innovation we refer to all the aspects of knowledge and learning which increase technological change and which fulfil a role in generating socio-economic benefits from technological change. Mapping the innovation performance of European regions shows a polarised view with a core and periphery in terms of innovation potential. Also within Member States there is often a large difference between the best and worst performing regions.

Since innovation is important for sustainable growth it is important to gain insights in the future regional impact in terms of polarisation and cohesion. The spatial patterns and trends for the many different aspects relevant for a knowledge-based economy are not the same; moreover some aspects may generate convergence and catching-up, while others may drive divergence and 'falling behind'. Regional innovation strategies are hence relevant for each region in Europe. When we for instance look at the increased share of cohesion policy spending on R&D, innovation and ICT, we can indeed conclude that innovation policies have become pervasive. Both in the technologically leading, as well as many lagging regions, more than 40% of all structural funds are currently related to research and innovation. All regions in Europe rely on innovation expenditures to increase development: in technologically leading regions to remain ahead; in peripheral regions to catch up.

Will the regional impact of innovation in 2020 lead to more regional specialisation within an integrated European knowledge economy?

In the light of regional diversity and the pervasiveness of innovation policies it is important to address regional specialisation, not only in certain sectors, but in several aspects of regional knowledge economies. Anticipating further integration of the European knowledge economy, specialisation could increase in importance.

Even if we would limit ourselves to R&D activity, there are different regional 'faces' of R&D. We can for instance observe that the distribution of public and private R&D differs. In many countries the region with the highest public R&D intensity is often not the same as the region with the highest business R&D intensity.

Even among the R&D intensive regions there is a diversity of types of regional innovation systems. With future progress in the integration of the European Union as one area of research and innovation (ERA) it is likely that the specialisation of different types of regional knowledge economies will increase. Challenges such as globalisation, demographic change and climate change will have different impacts per type of region. For instance, in many catching up regions in East Europe the specialisation and growth of high- and medium high tech manufacturing has been remarkable, and the high level of education seems promising, but this prospect depends on how the challenge of globalisation and ageing will be addressed.

This paper should be seen in the context of the reflection process on the future directions of cohesion policy after 2013. The main purpose is to improve our understanding of the role of technological development and innovation in promoting sustainable growth and in generating convergence and divergence in Europe. A principal question for the future is how can the innovative capabilities of regions far from the technological frontier be supported and what shall be the role of public policies in the least performing regions.

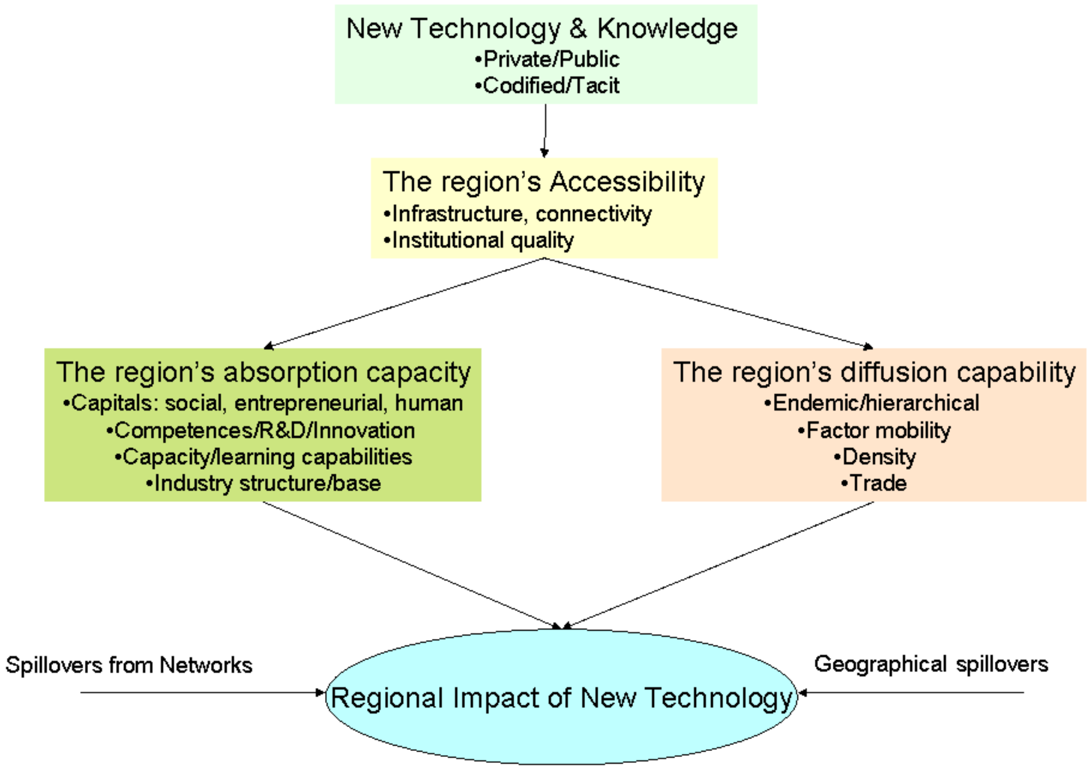
Section 2 will discuss the framework conditions for the regional impact of technological change by focusing on the relevance of three different concepts: the accessibility to knowledge, the capacity to absorb knowledge and the capability to diffuse knowledge. In Section 3 provides a new regional typology of 7 different types of regions by implementing the framework developed in Section 2 using a wide range of statistical data and discusses the policy relevance of this typology. Section 4 discusses different pathways of innovation. Section 5 summarizes the results of the foresight study at the EU level and discusses EU level policy conclusions. Section 6 provides a more detailed discussion of the foresight results for the 7 different types of regions including a SWOT analysis. Section 7 concludes by offering policy conclusions for each type of regions.

2. FRAMEWORK CONDITIONS FOR INNOVATION

Benefiting from technological change and innovation depends on a range of socio-economic and institutional factors and knowledge activities. A region's position and attitude towards technology is determined by three features: the accessibility of the region; how technology can be absorbed by the region and how knowledge diffuses regionally (see Figure 1).

A **region's accessibility** is dependent on a range of factors. Local infrastructure, connectivity, proximity to markets, density, regional governance and the quality of information flows are key determinants of accessibility along with the incidence of knowledge institutes, R&D and innovation activities and networks. Cities and core regions are more accessible than villages or peripheral regions.

Figure 1 Overview of the regional impact of New Technology & Knowledge



A region's **capability to absorb** external knowledge depends on the level of skills, equipment and professional networks operating in the region as well as on the availability of knowledge intensive services and the incidence of outsourcing. Knowledge spillovers from nearby technological opportunities and interdependence among competitors further reinforce the absorption capacity. The adoption of new technology also depends on the level of human capital, while the formation of human capital is driven by the application of new technologies.

The **diffusion of knowledge** and technology is most of all manifested in flows of high-technology products and machinery, both on international export markets as well as in local buyer-supplier networks. Un-traded knowledge flows contribute to productivity as well. Concerning innovation in services, diffusion can often not be strictly separated from absorption. Linkages between industrial activities and private and public R&D feature prominently in knowledge diffusion processes. Foreign investments, international trade, ability of finding new markets and the mobility of professionals over the regions and technological fields, impact on the capability to diffuse knowledge.

Beyond the linear research-based approach to innovation

The above conceptual framework suggests that excellence in technology generating research does not automatically materialise in commercial success. Deriving the economic impact from technology and innovation depends on dynamic interactive processes involving individuals, firms and institutions which absorb, apply and diffuse technology. Therefore a broad set of framework conditions matter for maximising the impact of innovation processes.

In terms of policy, a shift can be observed from technology-push policies towards demand-pull policies. Applications, entrepreneurship, user-driven innovation, innovation in services and in the government sector and the grand societal challenges have become more important on the innovation policy agenda. A region can for instance support innovation and address the challenge of climate change at the same time by serving as a 'launching customer' for producers who apply green technology.

In many regions, most new technologies originate from outside the region. Besides promoting R&D and technology generation there are many other policy options to promote innovation at regional level. Innovation should therefore be considered in a broader sense, beyond the linear, research- or science-based approach. The OECD (2009, pp.65) suggests three ways of thinking about this broader approach to innovation:

- The output-based approach, which looks at the results of innovation, not exclusively technological innovations (product- and process-innovations), but also non-technological innovations (organisational and marketing processes);
- The behaviour-based approach, which looks at new forms of collaborative arrangements and entrepreneurship as ways in which innovating agents interact and organise the process of innovation;
- The challenge-driven approach, where innovation serves to address societal challenges such as climate change or ageing.

Balance and linkages between accessibility, absorption & diffusion

The conceptual framework of accessibility-absorption-diffusion also applies to the level of individual knowledge workers, firms and sectors.

A highly educated knowledge worker may be able to apply new technologies (absorption), however its potential might be underutilized due to limited capabilities to transmit or sell knowledge (diffuse) or limited access to new knowledge. There are therefore limits in benefiting from specialisation in terms of knowledge access, diffusion or absorption. Addressing weak capabilities can enhance economic performance.

However, for certain jobs, firms, sectors and regions the importance of access, absorption, and diffusion may differ, and it can also differ between stages of development. For example, for service firms or SMEs in mature sectors, absorption and interaction with customers and partners may be more important for innovation than research or access to new technology developed elsewhere. A start-up company in a new sector such as biotechnology may first give priority to accessibility to new technology, while at a later stage, when new products are brought to the market, strengthening its diffusion capacity may become more important. A regions absorption capacity based on relatively cheap skilled labour can attract foreign investments in high-tech manufacturing and increase export and diffusion. In a next phase, engineering and access to research could become more relevant, not only for product and process innovations, but also for developing local, innovative buyer-supplier networks which enhance regional diffusion and absorption capacity.

Combination of excellence-based and place-based policies: smart specialisation

The effectiveness and efficiency of cohesion-inspired innovation policy has been questioned from an EU research policy point of view, based on the argument that it could further enhance competition between regions for the same excellence in terms of research, talent and high-tech industries.

Moreover the overlap in the technological or sectoral priorities chosen by the EU, national and regional policy makers could prevent concentration in a few centres of excellence which could compete at a global level. The creation of truly European centres of excellence will be of more benefit in the long-run than each individual country having low-level expertise in a full range of scientific areas.

The 2009 report of the Expert Group on "The Role of Community Research Policy in the Knowledge-Based Economy"[3] therefore calls for more merit-based competition, specialisation and concentration of research. The report also notes the impact that a spatially-blind European Research Area might have on cohesion and innovation policy.

It recommends focusing on *"the design of place-based, smart specialization policies. The search for smart specialization patterns concerns an essentially entrepreneurial process in which the new knowledge produced relates to what appears to be the pertinent specialisations of the region. Public policies have an essential role to play: one of encouraging entrepreneurs both in the private and public sectors (universities, RTOs, more broadly higher technical education) to find their own way and help them to coordinate and be connected to each other in this discovery process."* (Soete 2009, pp.7)

The tension between excellence-based and place-based policies seems more problematic at national level. For basic research the European level seems the most appropriate level of governance, while for innovation policy the regional level seems most relevant.

While scientific excellence (-based policy) may not be very important for every region, place-based specialisation and innovation policy is. However, an excellence-based creation of truly European centres of excellence in specific scientific fields is not necessary harmful from an innovation oriented cohesion-policy point of view. Excellence-based competition can be helpful in discovering area's of smart specialisation as it forces regions in their competition with other regions to search for a niche which relates to regional specific assets. But the extent to which excellence based policy may be helpful in searching for smart specialisations also depends on how 'excellence' in research is defined and measured: does only the opinion of other scientists count or is innovation oriented valorisation included.

Although it will not be easy to create such technology generating concentrations of excellence in Europe, a perhaps even more important challenge remains: how to maximise the economic benefits and how to avoid the danger of creating a new European paradox (good performance in science but poor performance in innovation). In this respect, concentrating technology generation capacity might not be enough to ensure a (linear) agglomeration process by which all relevant agents and knowledge capabilities are attracted quite naturally to the same region as described by Foray and van Ark (2007): *"Star scientists will move to where they can work with other star scientists, or with high-tech firms. Corporate R&D will gravitate to strong universities. Innovation service providers will appear close to large R&D companies. This is called an agglomeration process, and it gives rise to benefits for those participants that are in a position to profit from the pool of talents, ideas, services, and infrastructures that accumulates in that particular region".*

[3] http://ec.europa.eu/research/conferences/2009/era2009/speakers/papers/paper_luc_soete.pdf

Mobility has indeed increased, but scientists, high-tech firms, talented students (of which only a fraction is interested in technology or a research career), and service providers might not favour the same kind of region. Excellence in technology generation does not necessary lead to regional economic benefits. Even those regions which would benefit most from an excellence-based research policy might need place-based innovation policy to enhance knowledge absorption and diffusion capacity in order to maximize regional impact.

The rationale for public intervention

In line with the old 'equity-efficiency' trade-off the traditional rationale for regional and cohesion policy was to compensate lagging regions for location disadvantages with subsidies, often with a sectoral focus. The new paradigm[4] acknowledges that there is more diversity in regional potential and specificity in territorial assets than is suggested by core-periphery models which only separates regions along one dimension: regions with agglomeration advantages from regions without such advantages. The new approach has the objective of "tapping underutilised potential in all regions for enhancing regional competitiveness" (OECD 2009, pp.51). Equity and efficiency policies can be complementary. The OECD (2009) mentions examples of 'increasing returns to adoption' in lagging regions and 'decreasing returns on investments' in core regions to show that equity in public spending can raise efficiency. A third option is called "Dynamic perspective" where they refer to situations and arguments as mentioned above: where concentrating investments (for example in General Purpose Technology generating centres) increases the overall output which can be redistributed to all (or increases the overall access to new technologies which can be diffused to all).

Essential in the shift in the rationale for public intervention is the acknowledgement that a regional knowledge-based economy has multidimensional aspects. It includes a variety of knowledge activities and a variety of actors (for example industries, universities, students, SMEs and policy makers). Across Europe, the spatial patterns and trends for the many different aspects are not the same; moreover some aspects may generate convergence and catching-up, while others may drive divergence and 'falling behind'. Besides the difference in the impact on 'equity' of certain aspects of the knowledge economy, there are also differences in the 'efficiency' of more concentration. For certain fields of science it would be efficient to increase the concentration in a few centres. But other aspects of knowledge economies, such as education, ICT-usage, life-long learning and high- and medium-high tech manufacturing are more important for absorbing and applying technologies developed elsewhere and therefore could play an important role in processes of convergence and catching up at regional level. Regional innovation strategies are therefore relevant for each region in Europe, however the strategies should differ. Adequate capacity for innovation-oriented policy formulation and implementation at regional level is therefore essential.

[4] See also D. Hübner (2009), "Towards third generation of regional innovation policy".

3. REGIONAL TYPOLOGY

Most existing typologies classify regions along a single dimension (for example GDP, R&D intensity or summary of innovation indicators), which allows to identify leading and lagging regions. The present study takes a broader view. Along the multiple dimensions of accessibility-absorption-diffusion and based on a range of underlying indicators, it develops an analytical typology of regions. Seven different types of regions have been identified. Regions belonging to the same type share similar characteristics regarding the relationship between technological change and development.

3.1 Seven types of regional knowledge economies

Based on the dimensions of accessibility-absorption-diffusion a pre-selection have been made of regional indicators. The pre-selection took into account the availability of statistical indicators. The indicators have been grouped around five dimensions: employment, human resources, activity, technology and economy. By grouping the indicators and running a factor analysis separately for each group, the effect of over sampling of factors should be minimized.

Grouping of indicators

The indicators related to *employment* measure the employment share of relevant groups of industries for the economy. The first four indicators capture activities in high-tech and knowledge-intensive sectors, the following three indicators show the relevance of industry, services and government sector for employment:

- Employment share of High-tech manufacturing (including the following NACE classes: Pharmaceuticals (NACE 24.4); Office equipment (NACE 30); Telecommunications and related equipment (NACE 32); Medical and precision instruments (NACE33); and Aerospace (NACE 35.3).
- Employment share of Medium-high and high-tech manufacturing (including the following NACE classes: Chemicals (NACE24); Machinery (NACE29); Office equipment (NACE30); Electrical equipment (NACE31); Telecommunications and related equipment (NACE32); Medical and precision instruments (NACE33); Automobiles (NACE34); and Aerospace and other transport (NACE35).
- Employment share of High-tech services (including the following NACE classes: Post and telecommunications (NACE 64); Computer and related activities (NACE 72); and R&D services (NACE 73).
- Employment share Market services (including the following NACE classes: Water transport (NACE 61); Air transport (NACE 62); Real estate activities (NACE 70); Renting of machinery (NACE 71); and Other business activities (NACE 74).
- Employment share of Industry (including NACE C to E)
- Employment share of Services (including NACE G to K)
- Employment share of Government sector (including NACE L to P).

The indicators related to *human resources* measure the share of people with different educational attainment relevant for the knowledge economy and the share of people with tertiary education working in a science and technology occupation (HRST):

- Share of Human resources employed in science and technology occupations (HRSTO) (% of labour force)
- Share of Employees with completed secondary education (% of labour force)
- Share of Employees with completed tertiary education (% of labour force).

Activity related indicators capture the involvement of females and tertiary educated in the labour force. High rates of activity foster economic growth as does a low share of long-term unemployed as these are more readily available for the labour market:

- Activity rate females (% of employed females out of female labour force)
- Activity rate tertiary educated (% of employed workers with completed tertiary education out of total labour force with completed tertiary education)
- Share of Long term unemployment in Total unemployment

The indicators related to *technology* include both total R&D expenditure as a proxy for the investments in creating and absorbing technology, the share of public sector R&D by universities and research institutes and the number of patents that result from (private) R&D activities:

- Total R&D intensity (Total R&D expenditures (GERD) as a % of GDP)
- Share of university R&D (HERD) in total R&D
- Share of government R&D (GOVERD) in total R&D
- EPO patent applications per million population

The indicators grouped under *economy* measure the effect of technological change on labour productivity in industry, knowledge-intensive services and the investments in new machinery as measured by Gross Fixed Capital Formation (GFCF):

- Gross Fixed Capital Formation as a % of GDP
- Labour productivity in Industry (value added per employed person (NACE C to E))
- Labour productivity in Services (value added per employed person (NACE J to K))

Factor analysis

Using factor analysis the above information has been reduced to eight knowledge-economy factors. For 'employment' two factors emerge: knowledge-intensive services and high-tech manufacturing. The first factor captures the relevance of services employment, in particular knowledge-intensive services. The second factor captures the relevance of medium-high and high-tech manufacturing activities. For 'human resources' two factors emerge: creative workers and skilled workers. The first factor captures the relevance of tertiary educated workers in S&T occupations, or the more creative workers. The second factor captures the relevance of skilled workers, for example those with a completed secondary education. For 'activity' one factor emerges summarizing performance on the 3 selected indicators. For 'technology' two factors emerge: private technology and public knowledge. The first captures applied research and development activities by the business sector. The second captures the research activities of public knowledge institutes. For 'economy' one factor emerges, notably productivity which captures high levels of productivity in both industry and knowledge-intensive services.

Cluster analysis

These factors have then been used to identify seven different types of regions using hierarchical clustering analysis (Figure 2 and 3):

- **Metropolitan knowledge-intensive services (KIS) regions**, including 23 regions in densely populated metropolitan areas in Western Europe. These regions perform above average on absorption capability and average on both diffusion capacity and accessibility to knowledge. These regions show high rates of urbanisation and their level of economic performance is highest of all regions. Many regions serve as their country's capital region,

- **Knowledge absorbing regions** including 76 regions mostly in France, British Isles, Benelux and Northern Spain. These regions perform average on absorption capability, diffusion capacity and accessibility to knowledge. Their level of economic performance is just above average.
- **Public knowledge centres** including 16 regions, mostly in Eastern Germany and metropolitan areas in Eastern Europe. These regions perform average on both absorption capability and diffusion capacity and above average on accessibility to knowledge. Their level of economic performance is close to average and economic growth has been strong.
- **Skilled industrial Eastern EU regions** including 44 regions in Eastern Europe. These regions perform below average on both absorption capability and diffusion capacity and average on accessibility to knowledge. They are rapidly catching-up from low levels of economic performance.
- **High-tech regions** including 17 R&D-intensive regions in Germany, Finland, Sweden and the Netherlands. These regions perform above average on absorption capability, diffusion capacity and accessibility to knowledge. Their level of economic performance is above average.
- **Skilled technology regions** including 38 regions in Germany, Northern Italy and Austria. These regions perform average on absorption capability, diffusion capacity and accessibility to knowledge. Their level of economic performance is above average but their growth record has been below average.
- **Traditional Southern regions** including 39 regions in Southern Europe (Portugal, Italy, Greece and Spain). These regions perform below average on absorption capability, diffusion capacity and accessibility to knowledge. Their level of economic development is below average and many regions rely on agricultural and tourism activities.

Figure 2 shows the average factor performance for the different types of regions and Figure 3 shows the geographical illustration of the regional typology.

Figure 2 Average factor scores per type of region

Note: 0 is the average of all European regions.

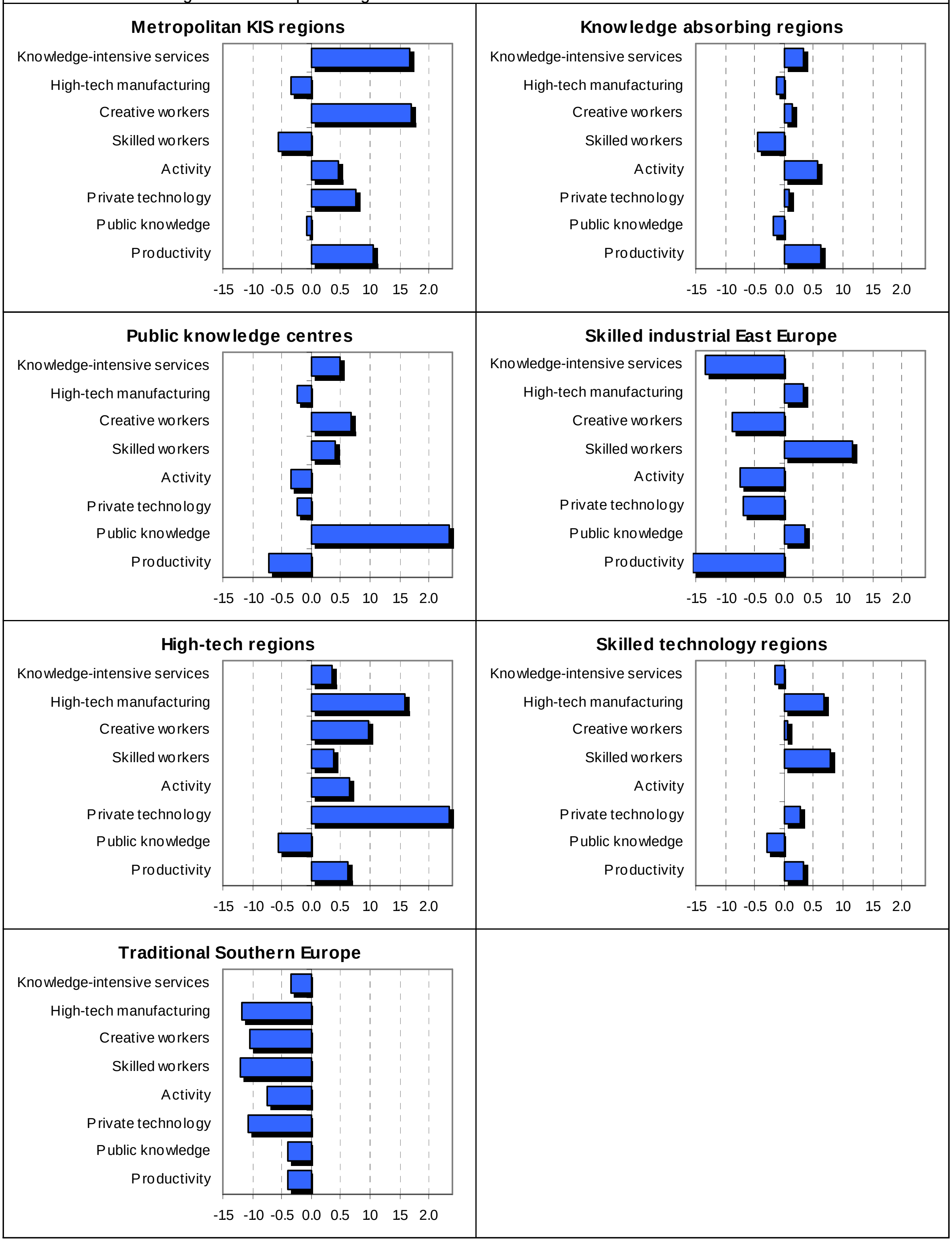
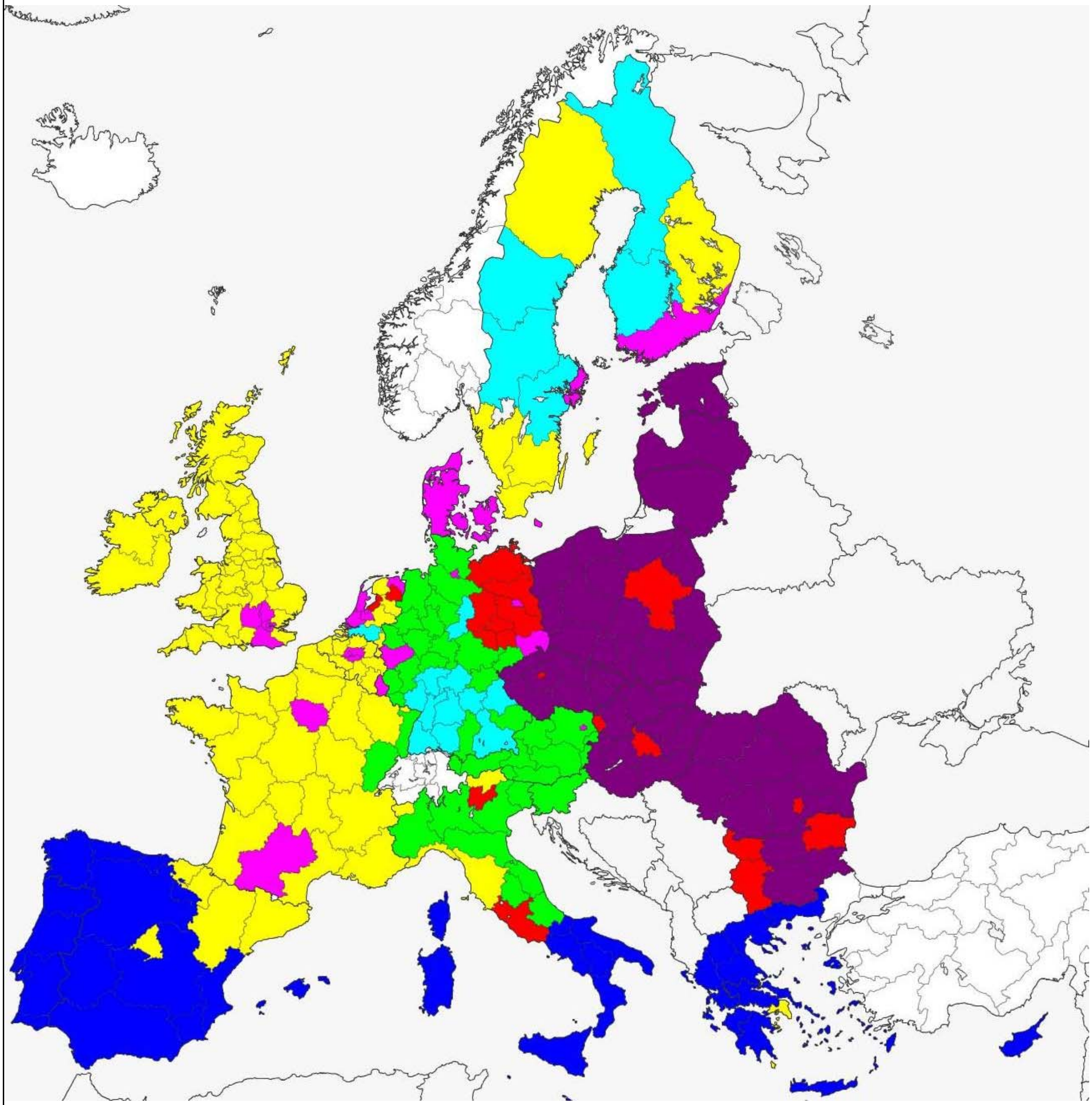


Figure 3 Regional typology



Pink: Metropolitan knowledge-intensive services regions
Yellow: Knowledge absorbing regions
Red: Public knowledge centres
Purple: Skilled industrial Eastern EU regions
Turquoise: High-tech regions
Green: Skilled technology regions
Blue: Traditional Southern EU regions

The 'knowledge-economy factors' can be assigned to the dimensions of accessibility, absorption and diffusion in the following way:

- Accessibility to knowledge is measured by 'private technology' and 'public knowledge' factors (which implies that the interpretation of accessibility has been limited to knowledge generating R&D);
- Absorption capacity is measured by 'knowledge-intensive services', 'creative workers', 'skilled workers' and 'activity' related factors.

- Diffusion capability is measured by 'high-tech manufacturing', 'private technology' and 'productivity' factors.

The types of regions with on average low scores for the above factors (Skilled industrial Eastern EU and Traditional Southern) are the types of regions with on average low GDP per capita. The types of regions with on average high scores (Metropolitan knowledge-intensive services and high-tech regions) show the highest GDP levels per capita (Table 1).

Knowledge absorbing regions and Skilled technology regions score average on all three aspects. Metropolitan knowledge-intensive services regions score average on accessibility however this is due to the limited indication for accessibility by only using two indicators for knowledge generation (private technology and public knowledge). The high score on accessibility for Public knowledge centres is based on the factor 'public knowledge', whereas for High-tech regions on 'private technology'.

Table 1 Classification of types of regions on Accessibility, Absorption and Diffusion

	ACCESSIBILITY		
	LOW	AVERAGE	HIGH
ABSORPTION: LOW DIFFUSION: LOW	7: TRADITIONAL SOUTHERN EU REGIONS	4: SKILLED INDUSTRIAL EASTERN EU REGIONS	
ABSORPTION: AVERAGE DIFFUSION: AVERAGE		2: KNOWLEDGE ABSORBING REGIONS 6: SKILLED TECHNOLOGY REGIONS	3: PUBLIC KNOWLEDGE CENTRES
ABSORPTION: HIGH DIFFUSION: AVERAGE		1: METROPOLITAN KNOWLEDGE-INTENSIVE SERVICES REGIONS	
ABSORPTION: HIGH DIFFUSION: HIGH			5: HIGH-TECH REGIONS

Limits of specialising in either knowledge access, diffusion or absorption

The above matrix confirms that regions cannot afford to have a low score on neither accessibility, nor diffusion or absorption capabilities. A region largely benefits from synergies among the co-evolving knowledge capabilities. Specialisation in only one of the three capabilities may limit the overall economic impact. Section 6 summarizes the policy issues for each type of region, showing in more detail the limits of specialisation in either accessibility, diffusion or absorption.

Increased importance of absorption capacity

The analysis also confirms that absorption capacity has become an increasingly important factor for the development of regional knowledge economies in Europe, both in terms of income and employment.

Accessibility to knowledge and diffusion capability remains vital however the importance of the mere capacity of technological knowledge generation in a region seems to have decreased. For instance, although the R&D intensity of the High-tech regions and the Skilled technology regions has increased, and the R&D intensity has decreased for the Knowledge absorbers and Metropolitan KIS regions, the technology generating and diffusing Skilled technology and High-tech regions have experienced lower growth than regions which have increased their capacity in knowledge absorption (Metropolitan KIS and Knowledge absorbing regions).

Due to globalisation and the spread of information and communication technologies, the access to inventions has increased globally. More patents in a region do not necessarily lead to more innovative production in the region concerned. Value-chains or innovation processes have become geographically fragmented. Measuring the efficiency of R&D activities in terms of patents generated (the knowledge production function) has therefore become less relevant as a methodology to study innovation impact at regional level. In addition, there is an increasing share of R&D activities in service sectors (for example the computer software and services sector has become the largest and fastest growing ICT R&D sector in Europe; IPTS 2009) where patenting does not play a major role.

Moreover, absorption capacity has multidimensional aspects as discussed in section 2. For instance regarding education, the different levels of education have a distinctive role to play. Another aspect is captured by the factor 'activity' which is based on indicators such as the activity rate. The relative increase in the importance of absorption capacity is also related to the increased economic relevance of knowledge intensive services.

3.2 Policy relevance of the typology

The attention from policymakers for R&D and innovation at regional level in the EU has grown over the last decade. Not only from policy makers at regional level, but also at national and EU level. Moreover, at EU and national policy level this interest is manifested at many policy fields and Directorate-Generals: not only within research, innovation and cohesion policy; but also in policy fields like information society, education, employment and 'green' policies.

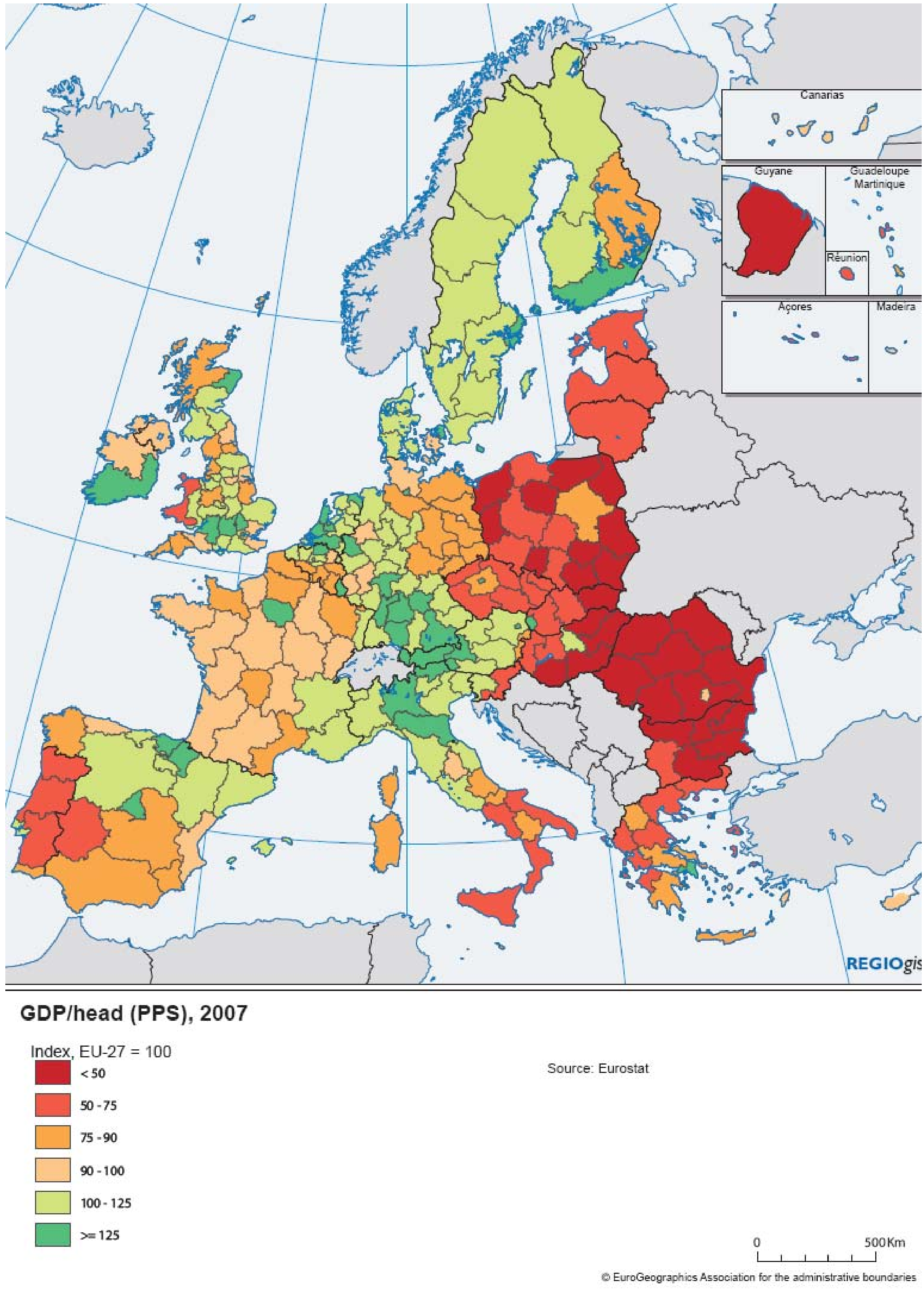
Today most regions have an innovation strategy and most policy fields acknowledge the importance of innovation. The interpretation of concepts and indicators used to measure innovation has also broadened over the years. Innovation encompasses more than R&D and R&D not only leads to technological change. Policy concepts such as 'innovation system', 'triple helix', 'knowledge triangle' and 'multi-level governance' indicate that the dynamics of technological change is not based on one single factor, but on interactions between a range of actors in a variety of socio-economic framework conditions.

Theoretical concepts concerning regional or territorial innovation such as:' Milieux Innovateur' (Aydalot, 1986), 'National Innovation System' (Nelson, 1993); Lundvall, 1992; and Edquist, 1997), 'the learning region' (Morgan, 1997), and the more recent concepts of 'knowledge-based economy' (Cooke and Leydesdorff, 2006), 'Open Innovation' (Chesbrough, 2003) and 'Triple-helix' (Leydesdorff, 2006) are not easily translated into verifiable theories. The approach of this study is not based on a single integrated theoretical framework about the regional knowledge economy. The authors of the study claim that there are several models of regional innovation systems and there is no one best model that should be adopted by all the less performing regions.

Differences in regional innovation performance

The 2009 Regional Innovation Scoreboard (Hollanders et al., 2009) shows a considerable diversity in regional innovation performance across Europe where almost all Member States have regions performing at different levels. Spain, Italy and the Czech Republic appear to be the most heterogeneous countries. The 2009 RIS has classified the EU regions into 5 different types of innovators, ranging from low to high innovating regions. There appears to be a clear link between the best and worst innovative regions and the typology developed in this study. Among the high innovating regions we only find High-tech and Metropolitan KIS regions. Except for one region being a medium-high innovator all High-tech regions are high innovating regions and all Metropolitan KIS regions are either a medium-high or high innovator. Similarly, most Traditional Southern European and Skilled Eastern European regions are either a medium-low or low innovating region.

Figure 4 GDP per capita at regional level in Europe, 2007



Diversity among leading regions as well as among lagging regions

Similar observations emerge from comparing the regional typology with a map showing GDP per capita at regional level (Figure 4). The level of GDP has been the major indicator for taking regional policy decisions. The map does not however indicate the role and impact of technology and knowledge in generating GDP. Regions with similar levels of GDP per capita can have distinct knowledge bases. There is a diversity of 'routes' or pathways towards increased GDP per capita, which can be associated with different roles for and impacts from specific knowledge activities (for example education, business R&D, generating patents and employment in knowledge intensive sectors).

Various core-periphery patterns, spillovers and linkages

The regional typology sheds light on different core-periphery patterns. At European level, peripheries can be observed in the Eastern part and in the Southern part of the EU. At a lower level some national core regions remain separated from surrounding regions which belong to a different type of regions. These core-periphery patterns can be classified as follows:

- Metropolitan Knowledge Intensive Services regions are often surrounded by Knowledge absorbing regions.
- Many High-tech regions serve as (technological) core to surrounding Skilled technology regions.
- Two capitals in the South (Knowledge absorbing regions) are surrounded by Traditional Southern regions.
- Skilled industrial East EU regions often surround core regions of Public knowledge centres.

Core regions have a key role to play in the development of surrounding areas. Promoting technological spillovers and strengthening cross-border linkages constitute a major policy challenge, especially in the 'low-GDP-periphery', including Traditional Southern regions and Skilled industrial East EU regions.

The literature review suggests that innovation remains a largely localised phenomenon. Most knowledge spillovers do not travel a long distance. The spillovers however seem to differ for the various core-periphery patterns:

The relation between the High-tech regions and the surrounding Skilled technology regions suggests technological spillovers in manufacturing industries. The core-periphery relation between Metropolitan KIS regions and Knowledge absorbing regions however seems to be more based on a hierarchy or division of labour in services and government, with most knowledge intensive occupations being concentrated in the core. These metropolitan cores are best placed to absorb spillovers from international networks.

4. PATHWAYS OF INNOVATION

The distinction of several core-periphery patterns poses the question to what extent the seven different types of regions represent seven different pathways or models of innovation, and to what extent some types of regions represent different stages of development. Traditional Southern European regions and Skilled industrial East EU regions could in this respect represent two types of lower stages of development, while Metropolitan KIS and High-tech regions could be seen as two types of higher stages of development. In this respect the four identified core-periphery patterns can also be seen as development routes or pathways.

4.1 Trends and changing disparities: convergence and divergence

Processes of convergence and divergence can be identified across European regions for the underlying indicators of the typology.

Table 2 Convergence 1995-2006

Activity rate females	Convergence
Activity rate tertiary educated	Convergence
Business R&D expenditures (% GDP)	**Divergence**
Employment share government	Convergence
Employment share high-tech manufacturing	Convergence
Employment share industry	Convergence
Employment share knowledge intensive high-tech services	**Divergence**
Employment share knowledge intensive market services	**Divergence**
Employment share medium-high-tech manufacturing	
Employment share services	Convergence
Government R&D expenditures (% GDP)	Convergence
Gross Fixed Capital Formation (% GDP)	
HRSTE	**Divergence**
HRSTO	**Divergence**
Patents per million population	Convergence
Per capita GDP (PPP)	Convergence
Population density	**Divergence**
Share of employment with completed primary education	Convergence
Share of employment with completed secondary education	Convergence
Share of employment with completed tertiary education	Convergence
Unemployment rate	Convergence
University R&D expenditures (% GDP)	

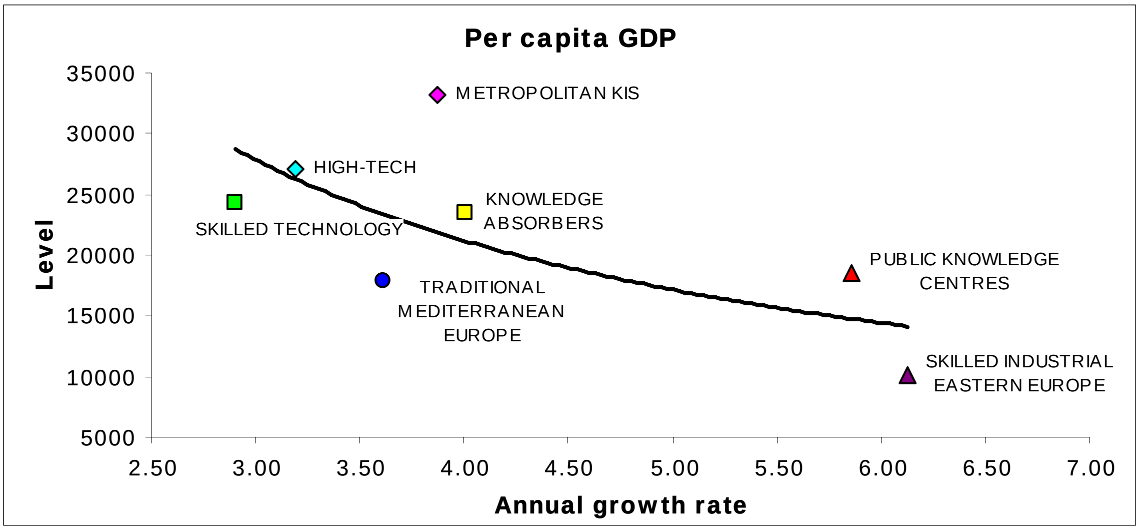
Note: Indicators which show (significant) divergence are in bold

Convergence occurs for most indicators (Table 2)[5], including GDP per capita. The positions of the seven types of regions in this converging trend regarding GDP per capita (PPP) are shown in Figure 5. Divergence can be observed for business R&D expenditures, human resources in S&T and employment in knowledge intensive services.

The trends of divergence can be linked to ‘agglomeration or urbanisation advantages’ and to some extent to the position of the Metropolitan KIS regions and the High-tech regions. However, these two internationally competing types of regions with high levels of GDP contribute differently to the identified diverging trends and their moderate growth did not lead to an overall diverging tendency for GDP.

[5] Here we use so-called sigma-convergence: the differences between regions in the level of an indicator become smaller, i.e. the standard deviation among the regions declines over time. Another type of convergence is beta-convergence which takes place when regions starting from a lower level grow faster than regions starting at a higher level. Beta-convergence however does not necessarily imply sigma-convergence. As sigma-convergence is more strict we have opted to use this concept for measuring convergence.

Figure 5 Economic performance by cluster, convergence of GDP per capita 1995-2006



The leading types of regions show opposite trend in business R&D and tertiary educated

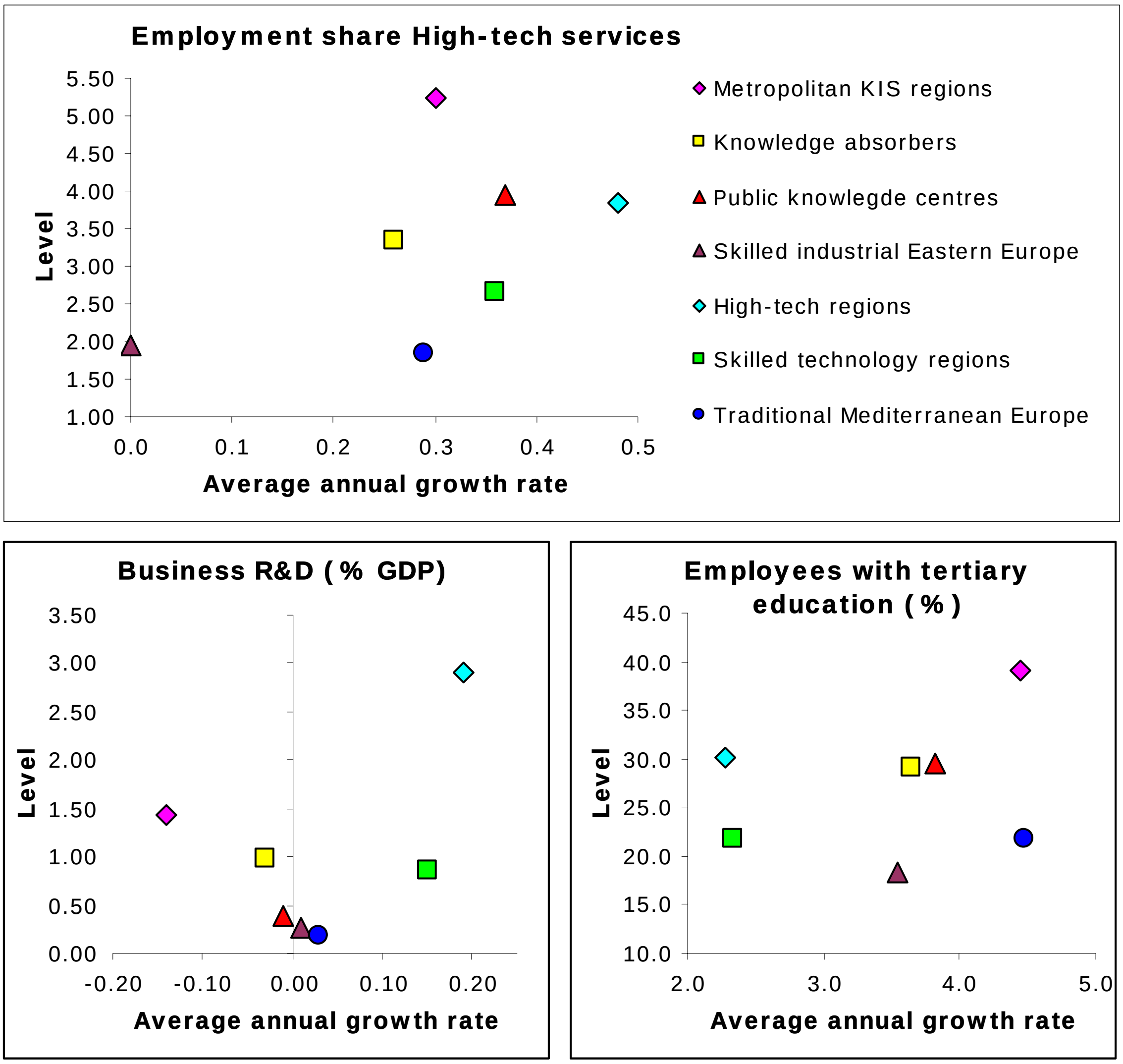
For those knowledge and technology indicators for which divergence is the dominant trend, different types of 'polarisation' can be identified. Regarding the diverging trend for High-tech services, Metropolitan KIS and High-tech type of regions both share a position of 'moving further ahead' (see Figure 6), but, their position and trend on business R&D and tertiary educated are opposite to each other.

Both business R&D and tertiary educated employees serve as input to furthering high-tech services but the High-tech regions seem to specialise in R&D and risk falling behind on the share of tertiary educated. At the same time, the Metropolitan KIS regions are moving ahead in tertiary education while losing ground regarding business R&D.

Similar, but less extreme, diverging trend can be noticed between Knowledge Absorbers and Skilled technology regions. Regarding the level and growth in high-tech services their average situation is similar. However as regards business R&D and the share of tertiary education these two types show different trends. The Knowledge Absorbers show on average a slightly decreasing performance in business R&D expenditures and an increase in the share of tertiary educated (seemingly following the development path of the Metropolitan KIS regions), whereas the Skilled Technology regions show an increase in business R&D and a slow increase in the share of tertiary educated (seemingly following the trajectory of the High-tech regions).

An example of converging trend can be observed for patent applications per million inhabitants. Traditional Southern EU and Skilled Industrial East EU have the lowest score on patents, but show the highest growth, while for High-tech regions the opposite situation can be observed: highest level but slow growth. The 'technology-gap' between the High-tech regions and all the other types however remains significant. One explanation for the convergence could lie in policies promoting patenting and improvement of application procedures in the technological periphery of the EU.

Figure 6 Level and trend per type of region for high-tech services, business R&D and tertiary education



Another explanation for the difference between the spatial trend for patents and for business R&D expenditure could be the shift in the kind of research, for example the increase in R&D expenditure in the high-tech regions could largely occur in software development, which does not lead to a growth in patents. Other 'service oriented R&D' could also explain the opposite spatial trends for patenting and business R&D.

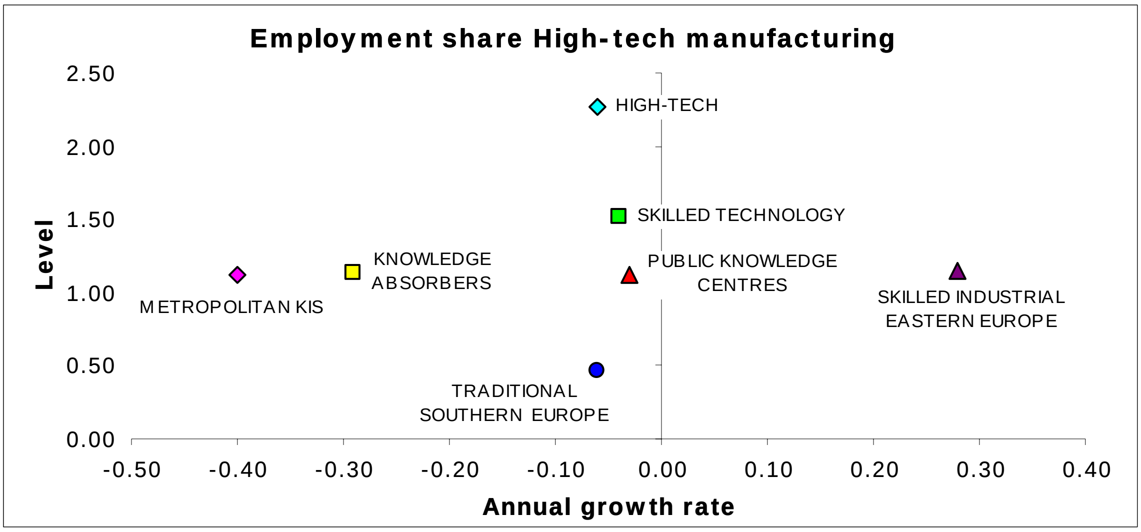
This latter explanation is supported by a second step factor-analysis based on the eight factors used in the regional typology. The scores on the factor 'private technology' (which is based on both patents and business R&D) is co-located with high scores on the factor Knowledge intensive services (and not with High-tech manufacturing).

A similar factor analysis (Dunnewijk et al., 2008) on previous data resulted in a factor which indicated that at regional level high scores on patents and business R&D was associated with a large share of high-tech manufacturing. However the second step factor analysis on the most recent data shows that this is no longer the case. From the second step factor-analysis it can be concluded that regions with a high share of secondary education have a relatively high share of high-tech manufacturing and that business R&D and high-tech manufacturing have become separated geographically to some extent. This could be due to re-location of high-tech manufacturing to Member States in Eastern Europe which have high shares of secondary educated people, while

R&D units are maintained elsewhere. The fact that the share of employees with only primary education in Traditional Southern regions is on average still four times higher than in Skilled industrial East EU regions seems relevant in explaining differences in the share of high- and medium-high-tech manufacturing.

The second step factor-analysis also shows that Knowledge intensive services are associated with high productivity and that both the factors 'creative workers' and 'private technology' are beneficial to growth and increase the benefit of this sector.

Figure 7 Level and trend per type of region for the employment share of high-tech manufacturing



4.2 The impact of knowledge and technology factors on GDP per capita and unemployment

All factors contribute in explaining the level of GDP per capita. Except for the factor 'private technology' these contributions are all significant. The factors 'skilled workers' and 'public knowledge' have a negative impact on the GDP level. The 'knowledge intensive services' factor has the largest positive impact, but also the factors 'high-tech manufacturing', 'creative workers', and 'activity' have a significant positive effect.

It is noteworthy, that three of these four factors contribute to the interpretation of absorption capacity. The 'creative workers' and 'activity' factors have a significant positive effect on the growth in GDP per capita between 1999 and 2005. This confirms the importance of 'Absorption capacity'. For explaining differences in unemployment factors on activity and productivity are excluded. 'Knowledge intensive services' and 'private technology' factors are beneficial to reduce the level of unemployment. For targeting both GDP per capita and employment the sector Knowledge intensive services seems most promising. As knowledge input, 'creative workers' (tertiary educated) seems more important for generating GDP growth than the 'private technology' factor.

Due to regional diversity, GDP for all EU regions cannot be explained in one model. The impact of the knowledge indicators for groups and types of regions needs to be analysed. The sample has been split into two, distinguishing the types of regions according to the level of GDP. For the Skilled technology, Knowledge absorbing, High-tech and Metropolitan KIS regions (which have on average higher GDP per capita levels) only the variables Employees with tertiary education (%), and Lifelong learning show a positive effect. Consequently for the relatively wealthy EU regions, GDP per capita depends on education and training (which are indicators for absorption capacity).

Table 3 The impact of knowledge and technology factors on GDP per capita, for all regions

	Significance and direction of impact on regional GDP per capita (all regions)*
Factor Knowledge-intensive services	++
Factor High-tech manufacturing	++
Factor Creative workers	++
Factor Skilled workers	- -
Factor Activity	++
Factor Private technology	
Factor Public knowledge	- -

* ++/--: Level of significance 5%; +/- Level of significance 10%; else not significant.

For Traditional Southern regions, Skilled industrial Eastern European regions and Public knowledge centres it is interesting to note the positive impact of Business R&D on GDP per capita. Among these low-GDP types of regions, also the regions with high tertiary education and high-tech services show higher levels of GDP.

In order to identify the impact of knowledge variables on unemployment rate, the regions have been split in two groups. Three variables seem to be important for reducing the unemployment rate for higher GDP types of regions: lifelong learning, patents and the Employment share of High-tech services. For the low-level-GDP type of regions the variables which show a significant impact on the reduction of the unemployment rate are: business R&D, employment share of High-tech manufacturing, employment share of High-tech services and patents.

It can be concluded that all factors contribute significantly to the level of GDP with the exception of the factor 'private technology'. Three of the four factors with a positive impact (KIS, creative workers, activity) show the importance of absorption capacity. High-tech manufacturing indicates the positive contribution of diffusion capability. The impact on GDP per capita from generating new technology in the region (especially the factor Public knowledge) seems less evident.

Table 4 The impact of knowledge and technology indicators on GDP per capita among regions of leading types and among regions of lagging types of regions

Impact on GDP per capita 2005	**Significance & direction of impact***	
	Regions of Leading & following types (1,2,5,6)	Regions of Lagging types (3,4,7)
GDP per capita in 1999	++	++
Employees with tertiary education (%)	++	++
Employment share High-tech services		+
Employment share High-tech manufacturing		+
Employment share Med-high-tech manufacturing	- -	
Lifelong learning	+	
Business R&D (% GDP)		+
Patents per million population		- -

* ++/--: Level of significance 5%; +/- Level of significance 10%; else not significant.

The policy opportunities to maximize regional impact differ among the identified types of regions. For the regions of the leading and following type, education and training is most important. Among regions of the lagging types (mostly in the east and south of the EU) interestingly, not only high-tech manufacturing, but also business R&D has a positive impact on the level of GDP per capita, which is however not a patent generating kind of R&D. It seems to be the kind of R&D needed to absorb, apply and diffuse technology.

5. SECTORS OF THE FUTURE AND POLICY CHALLENGES

A foresight study among 329 experts from 26 countries of the EU, representing 123 regions at NUTS II level was developed to identify the most important sectors and technologies for future regional development, the main challenges for economic development, barriers hampering research and innovation, and policy measures strengthening the impact of RTI on regional growth. Half of the survey respondents are involved in regional innovation policy. The other half has expertise in research and innovation, with equal representation of companies, universities and research institutes. The results of the survey have been discussed in eight local focus group workshops (see foresight report). In this paragraph we discuss the results for all types of regions. In paragraph 6 we address some type-specific results.

5.1 Most important sectors for regional economic development

Respondents were asked to identify the most important economic sectors for the further development of their regions. Respondents could identify up to five sectors from a predetermined list in response to the question: "Which sectors of economic activity do you expect to have the strongest effects on society and economic development (growth and employment) in your region until 2020?". The sectors could be selected from a list of NACE-classes, mostly at NACE 2 level. Overall, 38 sectors are mentioned by the respondents. Sectors which are mentioned more than 30 times are listed in Table 5.

Most mentioned sectors are: 'research and development (contract research)', 'education', 'transport, storage and communication services', 'motor vehicles', 'hotels and restaurants', 'health and social work', 'agriculture, forestry and fishing', 'pharmaceuticals', 'food products, beverages and tobacco', 'machine-tools and special-purpose machinery'.

It is striking that many of the most mentioned sectors are quite traditional. The focus group workshops confirmed that most answers reflected the existing regional importance of the sectors. Per type of regions the answers differed, in the sense that in Metropolitan KIS regions more than half of the sectors mentioned are in services. In Skilled industrial East EU regions tourism was mentioned most often. In the High-tech and the Skilled technology regions ‘motor vehicles’ was most often mentioned. For Traditional Southern regions 'agriculture', 'tourism' and 'food' are most often mentioned by respondents as most important sectors for future economic development of ‘their’ region.

The regional respondents were also asked to rate the importance of basic science, applied development and higher education for the development of the above mentioned promising sectors. According to the respondents scientific knowledge is most important in 'pharmaceuticals', 'general research and development', and 'aircraft and spacecraft', while it has little relevance for service sectors such as: 'construction', 'tourism', 'business services' and 'public administration'. Applied development and product/process innovation is generally seen as most important and education is often considered more important than basic science, but overall we note a quite balanced importance of all the three types of knowledge activities. This perception of the future by the respondents corresponds with the argument as put forward in paragraph 2 that mere specialisation in only one type of knowledge activity or capacity is not a smart form of specialisation.

Table 5 Sectors with most future regional economic potential and the importance of certain types of knowledge activities* for those sectors

	Times mentioned as one of 5 most promising sectors	Basic science	Applied development	Higher education
Research and development (contract research)	118	4.33	4.44	4.56
Education	89	3.77	3.95	4.36
Transport, storage and communication services	80	3.17	3.93	3.49
Motor vehicles	76	3.56	4.31	3.77
Hotels and restaurants	74	2.13	2.97	3.49
Health and social work	73	3.66	3.97	4.08
Agriculture, forestry, fishing	70	3.70	3.86	3.73
Pharmaceuticals	64	4.45	4.31	4.38
Food products, beverages and tobacco	59	3.30	4.09	3.70
Machine-tools, special-purpose machinery	58	3.60	4.43	4.15
Computer and data services	57	3.82	4.49	4.16
Business services (consultancy, advertising, cleaning etc.)	55	2.43	3.53	3.83
Electricity, gas and water supply	55	3.86	4.32	3.79
Construction	53	2.89	3.72	3.28
Chemicals, chemical products and man-made fibres	45	3.82	4.26	4.11
Electrical machinery and apparatus	45	3.45	4.23	4.13
Medical, precision and optical instruments, watches and clocks	45	4.16	4.37	4.08
Software	45	3.58	4.49	4.26
Public administration	38	2.55	3.21	3.68
Recycling	38	4.06	4.42	4.12
Fabricated metal products	35	3.18	4.06	3.64
Aircraft and spacecraft	33	4.29	4.45	4.06

Source: ETEPS-survey of research, technology and innovation in European regions, 2009; * according to a ranking on a scale from 1 ('unimportant') to 5 ('very important'). Mean values of importance.

Note: only sectors mentioned more than 30 times are listed.

However, an assessment of promising sectors by using a given classification has a serious drawback, since the NACE classification is based on the economic structures of the past. This became apparent in the discussions in the focus group workshops, where participants struggled to select and define the most important sectors for future development of their regions. The sectors or specialisations they had in mind where often not mentioned in the list. The promising specialisation referred to combinations, cross-sector fields of specialisation or to the application of a certain field of technology in an existing sector. In this respect, a large part of the focus group discussions involved discovering and describing fields of ‘smart specialisation’ as mentioned in Section 2.

5.2 Most important technologies for the development of promising economic sectors

Respondents were also asked: "Which technologies do you expect to be the most crucial ones for the development of the sectors mentioned above?". They could name up to five technologies. The answers result in a list which is totally different from the list of selected NACE-sectors. The respondents were free how to describe the technological fields. Afterwards the answers have been classified (see Table 6).

Table 6 The most frequently mentioned technologies

Technology categories	**Number of indications**
ICT, internet and computer technologies	152
Alternative energy technologies	81
Biotechnology, Pharmaceutical, and Biochemistry	63
Nanotechnology and nanomaterials	56
Process-, control, automation, and robotics	55
New materials	45
Health technologies and Life sciences	37
Computing, mathematics	29
Environmental technologies	23
Alternative automotive technologies	18
Electronics	13
Logistics	13
Software	12
New education technologies	9
Systems analysis and modelling	8
Agricultural technologies	7
Food technologies	7
Chemistry	6
Mechatronics	5
Water technologies	5
Machinery	5

The nine most mentioned technology fields can be seen as General Purpose Technologies as they are important for many industries. Besides ICT, which is applicable in all sectors, we also note the importance of energy technologies, biotechnology, nanotechnology, automation and new materials. New and rapidly developing fields of technology are rarely specific to one sector only, but are very often of a more generic nature. It is especially important to consider that they are also used in traditional industries which can be transformed into completely new industries, or into new hybrid specialisations, linking formerly distinct industries and technologies.

The generic nature of many important future technologies and the blurring of boundaries between industries became also apparent in the focus group workshops, where promising regional specialisations where mentioned, which comprised of specific cross-roads or combinations of certain sectors and technology applications, for example combining:

- Food industry, sustainable agriculture, biotechnology and the health sector;
- Textile and chemical industries with new fibres (new materials);
- Textiles and clothes linked with new materials, nanotechnology, and software;
- Nanotechnology with pharmaceuticals;
- New materials and, textiles and the aircraft industry;
- Water recycling, medicine and health, biochemistry and biotechnology;
- ICT and software linked with office machinery, machine-tools and the automotive sector;
- Mechatronics, robotics and machinery.

5.3 Challenges for society and economic development

Respondents were also asked: "What are the major challenges for your region's society and its economic development (growth and employment)? How important are these challenges?". For a list of 18 pre-defined challenges the respondent could answer: 'very important', 'important', 'not very important', 'not important at all' or 'don't know'.

Almost all challenges are assessed to be at least important by a majority of the respondents. Looking only at the 'very important' challenges, 'Education and training' leads the ranking before 'Employment'. Out of the intensively debated Grand Challenges 'Energy security and renewable energy sources' and 'Sustainable development' are considered more important challenges for economic development than 'Globalisation'. The least important perceived challenges are 'Migration', 'Shrinking population/labour force', 'Safety' and 'Social polarization'.

Table 7 Importance of challenges for society and economic development

	Very important (%)	Important (%)	Not very important (%)	Not important at all (%)	Don't know (%)
Education and training	47.1	44.4	7.9	0.3	0.3
Employment	46.5	42.2	9.4	1.2	0.6
Energy security and renewable energy sources	43.2	46.2	9.7	0.3	0.6
Sustainable development	39.8	49.2	10.0	0.3	0.6
Globalization	38.9	46.5	10.3	1.5	2.7
Regional development	38.6	47.4	12.2	1.2	0.6
Environmental protection	37.7	50.8	10.3	0.6	0.6
Medicine and health, sustainable healthcare systems	35.3	46.2	15.8	2.1	0.6
Ageing	31.6	46.8	18.2	2.1	1.2
Economic welfare	28.9	56.5	12.2	0.6	1.8
Water resources	26.1	37.4	29.8	5.5	1.2
Climate change	22.8	43.8	24.9	6.4	2.1
Information and media	20.4	46.2	28.0	4.0	1.5
Shrinking population/labour force	17.0	35.0	34.3	9.7	4.0
Safety (safety at work, industrial hazards)	16.7	41.9	32.5	7.9	0.9
Social polarization	15.8	35.6	36.5	7.6	4.6
Migration	15.5	39.2	33.4	10.0	1.8
Security (personal security, antiterrorist protection)	13.7	32.8	38.3	13.1	2.1

5.4 Barriers hampering research and innovation

The foresight study also explored the relevance of different barriers to innovation. Respondents were asked the following question: "Do the following barriers seriously hamper research, technology and innovation in your region?". For a list of 13 barriers the respondents could tick: 'agree', 'disagree' or 'don't know'. The results for the whole sample of 329 respondents are presented in Table 8.

The most frequently mentioned barrier is the 'Lack of (risk) capital'. It is the only barrier that receives a rate of agreement close to two thirds of respondents. Lack of capital is always a frequently mentioned barrier in innovation surveys, but the financial crisis must have made it even worse. A majority agreeing can be found on four further barriers: 'Limited production, transfer and use of knowledge', 'Limited cross-sectoral collaboration', 'Lack of entrepreneurship' and, 'Longer-term negative effects of the financial crisis on the funding of R&D'. During the local workshops and validation workshops in Brussels the importance of cross-sectoral collaboration was confirmed and emphasised. Cross-sectoral collaboration is important for developing specific niches of expertise: fields of 'smart specialisation'.

Some potential barriers are hardly seen as being serious, at least as far as the own region is concerned. This applies to barriers where the rate of agreement is 40% or less: 'Lack of qualified human resources', 'Limited use of ICT' and 'Unattractive living and working conditions'.

Table 8 Relevance of certain barriers hampering RTI in the region

	Agree (%)	Disagree (%)	Don't know (%)
Lack of available (risk) capital	64.4	17.3	3.6
Limited production, transfer and use of knowledge	55.3	21.9	8.2
Limited cross-sectoral collaboration	53.8	21.3	10.3
Longer-term negative effects of the present financial crisis on the funding of R&D	50.8	20.4	14.3
Lack of entrepreneurship	50.8	26.7	7.9
Insufficient quality of government services	48.3	28.0	9.1
Lack of R&D infrastructure	44.7	39.2	1.5
Limited foreign investments	44.7	27.4	13.4
Limited inter-regional collaboration	42.2	31.6	11.6
Limited knowledge creation capacities	41.3	37.1	7.0
Lack of qualified human resources	38.6	44.4	2.4
Limited use of ICT	32.5	44.1	8.8
Unattractive living and working conditions	26.1	55.0	4.3

5.5 Policy measures strengthening the impact of RTI on regional growth

Respondents were also asked: "Which policy measures do you think to be particularly necessary to strengthen the impact on growth from research, technology and innovation in your region?". For a list of 16 policy measures they could answer: 'particularly necessary', 'less important', 'not important' or 'don't know'.

The policy measures most often assessed to be particularly necessary are:

- Spend more on co-funding of applied R&D and innovation projects;
- Run a more research- and innovation-friendly economic policy;
- Improve the public education and training system.

In addition to these top three ranking measures eight other types of measures receive rates of agreement of more than 50 percent. The two policy measures which are most frequently perceived to be not important are:

- Establish new or extend the existing public research organizations;
- Improve the soft location factors (for example quality of residence, cultural events).

Co-funding of applied R&D and innovation projects is considered more important than co-funding research projects. This confirms that at regional level it is especially important to promote the application of technology.

It can be concluded that the importance of the challenge regarding education and training does not seem to refer to the barrier of a lack of qualified human resources, but to the perceived need to improve the public education and training system.

Table 9 Importance of policy measures to strengthen the impact of RTI on regional growth

	Particularly necessary (%)	Less important (%)	Not important (%)	Don't know (%)
Spend more on co-funding applied R&D and innovation projects	69.9	11.6	3.0	0.3
Run a more research- and innovation-friendly economic policy	64.4	15.8	3.0	1.5
Improve the public education and training system	60.5	21.3	2.7	0.3
Make the legal environment more research- and innovation-friendly	60.2	18.2	5.2	1.2
Spend more on co-funding research projects	55.3	26.4	2.7	0.3
Offer additional venture capital	53.2	24.3	4.0	3.3
Fight the present financial crisis to avoid that companies curb their spending on R&D	53.2	23.1	4.9	3.6
Organize or support a regional research, technology and innovation strategy process	52.0	24.3	6.4	2.1
Support the mobility of qualified personnel	51.4	27.1	6.1	0.3
Support the networking between relevant agents within and outside the region	50.8	27.1	4.6	2.4
Coordinate the regional research, technology and innovation policy better with national and European RTI-policies	50.2	24.6	7.0	3.0
Attract more foreign investment	47.7	27.1	6.4	3.6
Promote Information and communication technologies	43.2	35.6	5.8	0.3
Establish new or support the existing intermediaries like technology centres	38.9	35.6	9.1	1.2
Establish new or extend the existing public research organizations	36.8	34.3	13.1	0.6
Improve the soft location factors (for example quality of residence, cultural events)	28.3	38.9	15.5	2.1

5.6 Statements on future impact from RTI on regional development in Europe

The statistical analyses which were used to establish a typology of European regions led also to a number of hypotheses concerning the future impact from research, technology and innovation on regional development. These hypotheses have been tested by formulating them as statements and asking the respondents to the survey whether they agree with them or not. The rate of agreement within the whole sample is presented in Table 10.

In general, agreement is quite high. To almost all statements more than half of the respondents agree. The highest rates of agreement is received by statement 10 - stressing the importance of attracting innovative high-tech companies in order to reap the benefits of a well developed knowledge infrastructure and statement 5 – underlining the importance of education for high-tech manufacturing in low-income regions.

Only three quite provocative statements receive a lower agreement than 50%. It is particularly contested that metropolitan regions will not only lose their manufacturing sector but also the associated business-R&D. This is the only statement with which more respondents disagree than agree. Furthermore, there are also many experts who do not think that de-industrialization in the EU will continue and that trading patents and high-tech services will increase as a way of diffusing new knowledge.

Table 10 Agreement or disagreement to statements on the future impact of RTI on regional development

		Agree (%)	Dis-agree (%)	Don't know (%)
10	Even if regions have well developed knowledge systems (for example well performing universities) they still need to attract innovative high-tech companies to reap the full benefits from existing technological knowledge	78.4	4.6	2.7
5	Education is the driving or catching-up factor for high-tech manufacturing in low income regions	74.5	6.4	4.9
7	Accessibility will remain important for regions in developing knowledge intensive services	70.2	7.3	7.9
9	There will be increased competition between high income regions for attracting students and creative knowledge workers	70.2	5.2	10.3
14	Eastern European regions need to improve living and working conditions in order to stop the net outflow of skilled and young people	69.3	4.9	11.6
12	Regions with a strongly developed government research sector need to strengthen local private R&D-activities to improve their economic performance	67.8	5.5	12.5
1	Services will remain the primary drivers of employment growth	67.5	10.6	7.9
4	Business R&D and patents will remain the drivers for high-tech manufacturing in high-income regions	67.5	10.3	7.9
8	Universities will be the main driver for knowledge intensive services	55.3	20.1	10.3
11	Southern European regions need to strengthen their knowledge absorption and diffusion capacities by intensifying their investments in secondary and tertiary education	53.5	5.8	26.4
2	More medium-high-tech manufacturing will move from the central parts of Europe to Eastern Europe	51.4	21.0	13.4
6	The long term and EU-wide trend of de-industrialisation (shrinking share in employment) will continue	43.8	22.2	19.8
13	Knowledge of high tech regions will be increasingly diffused by trading patents and by high-tech services and less by trading new products	38.6	23.1	24.0
3	Not only manufacturing industries but also the associated business R&D will more and more disappear from metropolitan regions, which will become even more service oriented	28.6	45.6	11.6

6. POLICY ISSUES FOR EACH TYPE OF REGION

This section discusses the policy issues for each type of region by confronting the statistical trend analysis with the perception of the future as provided by the respondents to the survey and the participants at local workshops. Due to the diversity among regions of the same type, it is neither the intention nor possible to propose concrete policy recommendations for individual regions.

6.1 Metropolitan knowledge-intensive services regions

Accessibility to knowledge and diffusion capability is average for Metropolitan KIS regions, but absorption capacity is high. These regions perform on average strong in the factors ‘knowledge-intensive services’ and ‘productivity’ and relatively weak in ‘high-tech manufacturing’ and ‘skilled workers’. The R&D intensity is high with on average 2.38% of which more than 40% is spent by universities and public research institutes. Employment in services, both business sector services and government, is almost 80% of total employment. Labour productivity in financial services and business services is high and labour productivity in industry is highest among the different types of regions. Technological performance is strong with a high number of patent applications. Metropolitan KIS regions show high rates of urbanisation with more than half of the population living in large cities. Population density is also extremely high, and increasing. Many regions in this group serve as their country’s capital region, for example Brussels, Berlin, Paris, Vienna, Helsinki, Stockholm, and Inner and Outer London. On average for these regions business R&D intensity has dropped, and also employment in high-tech and medium high-tech manufacturing has decreased. Metropolitan KIS regions have showed the strongest increase in the share of tertiary educated employees.

When differences in the level of GDP per capita explained with a regression, it can noted that among Metropolitan KIS regions employment in High-tech manufacturing has a significant positive impact on the level of GDP per capita (Table 11). This suggests that the decreasing share of high-tech manufacturing appears to be a threat for reaping the full benefits of the knowledge economy. Based on this statistical analysis the recommendation would be to increase policy efforts to keep, grow or attract more high-tech manufacturing.

Table 11 Explaining differences in GDP per capita among Metropolitan KIS regions

Impact on GDP per capita 2005	Significance and direction of impact*
GDP per capita 1999	++
Patents regarding electrical machinery	- -
Patents regarding non polymers	++
Employment share High-tech manufacturing	++
Patents on electrical components	- -

Dependent Variable: Per capita GDP (2005); Stepwise regression; * ++/--: Level of significance 5%; +/- Level of significance 10%; else not significant.

The results from the survey suggests that respondents from Metropolitan KIS regions indicate 'education and training', 'energy security and renewable energy sources' and 'employment' most often as very important challenges, which is similar to the whole sample. Challenges that are clearly more often mentioned by Metropolitan KIS regions are 'climate change', 'education and training', 'environmental protection' and 'information and media'.

Strengths	**Weaknesses**
• High and increasing % of employment in tertiary educated • High and increasing share high-tech services • High R&D expenditures as % of GDP • Highest productivity and GDP per capita • Young population	• Decreasing business R&D expenditures • Decreasing High-tech manufacturing • Decreasing employment share in financial services
Opportunities	**Threats**
• More co-funding applied R&D and innovation projects • Promote private R&D • Promote high-tech manufacturing • Improve the education and training system • Promote entrepreneurship • Promote ICT-usage	• Decreasing regional returns on policies supporting the attraction of talent and KIS • Further decrease in (high-tech) manufacturing and industrial R&D • Pollution, climate change • Fierce global competition for talent

The local workshop with innovation policy experts in Metropolitan KIS regions suggested that the challenge for these regions is to develop and exploit the business opportunities in trying to address the global threat of climate change. Regarding education and training local workshop respondents explained that the imbalance due to low shares of people with secondary education is seen as threat for future development.

The barriers most frequently mentioned by Metropolitan KIS regions are 'lack of entrepreneurship', 'negative effects of the financial crisis' and 'lack of capital'. Metropolitan knowledge-intensive services regions indicate almost all barriers less often than the whole sample. Especially regarding the availability of (risk) capital and the R&D infrastructure the situation in Metropolitan KIS regions is perceived to be much better than in other types of regions.

The most frequently mentioned particularly necessary policy measures for Metropolitan KIS regions are 'more co-funding of applied R&D', 'better education and training' and 'a more research/innovation-friendly economic policy'. Although ‘Limited use of ICT’ and ‘Unattractive living and working conditions do not seem to be important barriers in Metropolitan KIS regions, the only two policy measures which are more often mentioned as particularly necessary than in the whole sample are: 'promotion of ICT' and 'improvement of soft location factors'.

In the case of almost all statements the agreement of Metropolitan KIS regions is clearly lower than in the whole sample. Only in the case of two quite provocative statements the agreement is higher. Regarding the higher agreement with statement 6 (‘The long term and EU-wide trend of de-industrialisation will continue’), we note that the share of employment in industry in these Metropolitan KIS regions is already the lowest of all types, and still decreasing. However, only 20 percent of the experts agree with the idea that: ‘Not only manufacturing industries but also the associated business R&D will more and more disappear from metropolitan regions’. This indicates that the experts in Metropolitan KIS regions are more confident that further de-industrialisation in their regions would not lead to a further decline in business R&D expenditures.

6.2 Knowledge absorbing regions

Accessibility to knowledge is average, absorption capacity and diffusion capability is average for knowledge absorbing regions. The factor scores are also close to average. The strongest factors are ‘activity’ and ‘productivity’ and the weakest factor is ‘skilled workers’. The average R&D intensity is 1.48% of which 65% is spent by the business sector. Employment in services, both business sector services and government, exceeds 70%. Labour productivity in financial services and business services is highest of all groups. Labour productivity in industry is high and unemployment is low. Life-long learning is high. Growth of per capita GDP between 1999 and 2005 has been average and in terms of patents technological performance is below average. The employment share in industry has dropped with 3.16 %-points and the employment shares of services and in particular government services has increased strongly. These regions are ageing with a declining youth share and an increasing share of elderly. There has been a shift from business R&D (0.03 %-point decline) to government and university R&D. Participation in life-long learning has increased strongly at 4.89 %-points.

Strengths	**Weaknesses**
• High productivity, especially in service industries • Large share of employment in government • High and increasing lifelong learning • Increase in university R&D • Low unemployment	• High and hardly reduced share of employees with primary education • Limited government R&D • No growth in business R&D • Reduced employment in medium- high-tech manufacturing
Opportunities	**Threats**
• Support private and public investments in applied R&D and innovation projects • Increase investments in education and training • Promote cross-sector collaboration	• Loss of jobs in manufacturing; • Lack of qualified human resources

The survey shows that experts from Knowledge absorbing regions mention 'Regional development', 'Sustainable development', 'Employment', and 'Education and training' as the most important challenges. Especially 'regional development' is more often mentioned as a challenge by experts of Knowledge absorbing regions compared to experts in other regions.

The top two innovation barriers in knowledge absorbing regions are 'Limited production, transfer and use of knowledge', and 'Limited cross-sectoral collaboration'. The innovation barrier 'Limited knowledge creation capacities' is more often mentioned than for the average region. This expert perception is in line with the relatively low averaged scores on the factors 'Public knowledge' and 'Private technology', and the decreasing business R&D expenditures. Based on these survey results and the focus-group workshop we can conclude that Knowledge absorbing regions could benefit from regional development policy focussing on the generation and cross-sectoral diffusion of knowledge. New technology and cross-sector collaboration seem very valuable to re-vitalise 'traditional sectors'. For example experts from Knowledge absorbing regions mentioned at the workshops that this is why they expect that for instance textiles and food as a sector now have good prospects for the future again.

The top priority policy measures mentioned by experts from Knowledge absorbing regions are: 'Spend more on co-funding applied R&D and innovation projects' and 'Fight the financial crisis to avoid companies spending less on R&D'. These two R&D policies seem indeed relevant to avoid a further decreasing performance compared to other types of regions in both the factors 'Public knowledge and Private technology'.

The statement that Knowledge absorbing regions agreed with the most is 'even if regions have well developed knowledge systems they still need to attract innovative high-tech companies to reap the full benefits from existing technological knowledge'. This indicates that the experts of this type of region are aware that their relative weakness in terms of High-tech manufacturing is hampering their performance. However, more then 70 percent agree that 'services will remain the primary drivers of employment growth'.

6.3 Public knowledge centres

Accessibility to knowledge is high in Public knowledge centres and both absorption capacity and diffusion capability are average. This group scores very high on the factor 'Public knowledge'. The average R&D intensity is 1.15% of which almost 70% is spent by universities and especially government research institutes. Technological performance is low with about 33 patents. Employment in services, both business sector services and government, exceeds 70%. Labour productivity in services and industry are both low. Unemployment is very high. Growth of per capita GDP between 1999 and 2005 has been high at almost 3.6% per year. Employment in business services has increased, but overall unemployment has increased.

Public knowledge centres are characterised by relatively high levels of R&D activities by public research institutes (on average 0.52% of GDP). It seems that the regions of this type are not fully exploiting their catching-up potential, which might be caused by an imbalance in private and public R&D activities, such that private R&D activities are insufficient to fully exploit the knowledge accessible through the research institutes in these regions. Urbanization in Public knowledge centres is above average, but population density is declining, a result of a declining population due to migration to other European regions. It is striking that the youth share is falling rapidly. Public knowledge centres face a challenge to keep their young and skilled people; otherwise they are in danger of losing momentum in their strong economic development.

Strengths	**Weaknesses**
• High government research expenditures as % of GDP • High level of education • High share of high-tech manufacturing and services • Increased employment in services • High growth of GDP per capita	• Low productivity • Low private and university R&D expenditures • No growth in patenting • Quality of government services
Opportunities	**Threats**
• More research and innovation-friendly government • More co-funding of applied R&D and innovation projects in companies • Improve education system and increase university R&D	• Low and decreasing share of youth

Respondents from Public knowledge centres indicate the challenges of 'education and training', 'healthcare system' and 'sustainable development' most often as very important. Challenges that are clearly more often mentioned by Public knowledge centres are 'social polarization', 'safety' and 'security'.

Public knowledge centres have a specific high-ranking barrier in addition to the two more widely quoted barriers 'lack of capital' and 'limited production, transfer and use of knowledge'. This is 'insufficient quality of government services', the third highest rated barrier. This type-specific barrier seems to be related to the high relevance for this type of regions of the policy to ‘make the legal environment more research/innovation-friendly’.

Respondents from Public knowledge centres indicate the barriers 'lack of R&D infrastructure', 'insufficient quality of government services' and 'unattractive living/working conditions' clearly more often than the whole sample. Given the fact that this type of regions is mainly characterised by its strength in the public knowledge factor, it is striking that more than half of the responding experts mentioned ‘lack of R&D infrastructure’ as an important barrier. This barrier might refer to the low share of university R&D, since the policy option to ‘Establish new or extend the existing public research organizations’ is hardly mentioned as being important, while among the policies mentioned most often as being important is to ‘Improve the public education and training system’. Since for this type of region the results of the survey were not discussed in a local workshop this interpretation could not be confirmed.

In Public knowledge centres 'more co-funding of applied R&D', and 'a more research/innovation-friendly legal environment' are mentioned most frequently as particularly necessary policy measures. Policy measures which 'make the legal environment more research/innovation-friendly' are clearly more frequently mentioned in Public knowledge centres. A policy option which is clearly less often perceived to be important in the future for Public knowledge centres is: ‘Fight the present financial crisis to avoid that companies curb their spending on R&D’. This might be due to the fact that most R&D in this type of regions is done in government research institutes.

It is interesting to note that respondents for Public knowledge centres agree much less (than respondents from other types of regions) with statement 12 'Regions with a strongly developed government research sector need to strengthen local private R&D-activities to improve their economic performance'. Given the imbalance of the regional innovation system for this type of region with often a dominant position for government research labs, while clearly lacking business R&D expenditures, it is surprising to see that hardly half of the respondents agree with this statement. One of the possible explanations could be the perceived role or division of labour of the Public knowledge centres in a national context. Capital regions in this group of regions such as Prague, Warsaw, Rome and Budapest have a tendency to concentrate specialised research capacities. This also questions how these government research organisations are linked to business activities in surrounding regions.

6.4 Skilled industrial Eastern Europe

For the group of Skilled industrial Eastern EU regions accessibility to knowledge is average and both absorption capacity and diffusion capability are low. This group performs weak on the factors: 'knowledge-intensive services, creative workers, activity, private technology' and 'productivity'. The group is performing strong in 'skilled workers'. The average R&D intensity is 0.49%. Employment in industry, business sector services and government is less than 80%. These regions rely also on agricultural activities and tourism. Labour productivity is very low and unemployment is very high, but growth of per capita GDP between 1999 and 2005 has been highest at almost 4% per year. Technological performance is below average with less than 100 patents, but increasing.

Skilled industrial Eastern EU is the only group of regions where the employment share of both medium-high-tech and high-tech manufacturing has increased. Based on the large share of secondary educated people Skilled industrial Eastern EU regions benefit from a relocation of medium-high-tech and high-tech activities from Western European regions. This has resulted in an uptake of economic activities and a strong increase in income. However, income levels are still (far) below average.

In order to be able to suggest which of the weaknesses would be most relevant to address by policy makers it is worth looking again at the differences in GDP per capita. The regions among this group that have a higher level of GDP, could serve as a benchmark for their type of region and indicate which (type-specific) aspects of knowledge and technology would be best to support with public policies. The regression results show that among Skilled industrial Eastern EU regions the number of patent applications, especially in computers has a positive impact on the level of GDP. For most other types of regions we did not find such a positive impact on GDP of the capacity to generate technology within the region. Over the past decade the absorption capacity of the skilled workforce has attracted high- and medium-high-tech manufacturing. For the future it seems most relevant to improve the generation of 'private technologies' which are relevant for the attracted industries. Although patenting is at a very low level, enhancing the 'private technology' by supporting the generation of technology seems a logical next step which will be helpful in (keeping and) benefiting from the attracted high- and medium-high-tech manufacturing.

Table 12 Explaining differences in GDP per capita among Skilled industrial Eastern EU regions

Impact on GDP per capita 2005	Significance and direction of impact*
GDP_1999	++
Patents regarding computers	++
Patents per million population	++

Dependent Variable: Per capita GDP (2005); Stepwise regression; * ++/--: Level of significance 5%; +/- Level of significance 10%.

However, according to the responding experts for this type of region the real challenge is not GDP per capita, but employment. Skilled industrial Eastern European regions indicate 'employment', 'regional development' and 'sustainable healthcare system' as well as 'education and training' most often as very important challenges. Challenges that are clearly more often mentioned by Skilled industrial Eastern European regions are 'shrinking population and labour force', 'economic welfare' and 'employment'. Challenges that are clearly less often mentioned by Skilled industrial Eastern European regions are 'globalization', 'climate change', and 'sustainable development'.

The barriers most frequently mentioned by Skilled industrial Eastern European regions are 'lack of R&D infrastructure', 'limited production, transfer and use of knowledge' and 'lack of capital'. Skilled industrial Eastern European regions indicate almost all barriers more often than the whole sample, but a clear exception is 'lack of entrepreneurship' which is mentioned less often as a barrier seriously hampering research, technology and innovation.

Skilled industrial Eastern European regions stress particularly 'a more research/innovation-friendly legal environment', 'a more research/innovation-friendly economic policy' and 'more co-funding of applied R&D'. Some measures are mentioned more frequently by Skilled industrial Eastern European regions: 'new/better technology intermediaries', 'more foreign investment', 'a more research/innovation-friendly legal environment', 'a more research/innovation-friendly economic policy' and 'a regional RTI-strategy process'. With these answers the respondents have stressed the importance of improving the framework conditions for innovation and the governance aspects of innovation policies. The need for extending or improving the system of technology intermediaries like technology centres is strongly indicated only in Skilled industrial East EU regions. In all other types, apparently, the demand for such institutions has more or less been satisfied.

Strengths	**Weaknesses**
• High and increased share of employment in high- and medium-high-tech manufacturing • Highest share of employees with secondary education (and low for primary) • Highest gross fixed capital formation, as % GDP • High growth of GDP per capita	• Lowest and hardly changed share of employment in knowledge intensive services • Lowest R&D intensity • Low share tertiary educated • Low productivity • High (long-term) unemployment
Opportunities	**Threats**
• A more RTDI-friendly government • More co-funding applied R&D and innovation projects; • Support regional innovation strategy process • Strengthen intermediaries, technology centres • Growth in patenting	• Remaining slow growth in knowledge intensive services • Global competition for manufacturing • Decreasing % of youth in population • Limited regional capacity in innovation policy implementation

In many cases the agreement with the statements by respondents concerning Skilled industrial Eastern EU regions is clearly higher than in the whole sample. Two statements (2 and 14) specifically refer to this type of fast growing regions in Eastern Europe. To statement 2 - the moving of medium-high-tech manufacturing to Eastern Europe - the rate of agreement is much higher than in all other types. To statement 14 - the necessity to improve living and working conditions in order to be an attractive working place - the agreement in Skilled industrial Eastern European regions is even higher.

6.5 High-tech regions

Accessibility to knowledge, absorption capacity and diffusion capability are all strongly developed in the High-tech regions. The strongest factors are ‘private technology and high-tech manufacturing’. The weakest factor is ‘public knowledge’. High-tech regions excel in technological performance. The average R&D intensity is 3.76% of which 77%

is spent by the business sector. Employment in medium-high and high-tech manufacturing exceeds 12% and these regions apply on average for more than 410 patents. This type of region is specialised in patents in 'Audio-visual electronics' and 'Transport'. Business R&D expenditures have increased strongly, but employment in medium-high-tech and high-tech manufacturing has seen a relative decrease. High-tech regions are the technological frontier or backbone of the EU27. From here technology diffuses to the other European regions. The imbalance in the innovation systems of these regions are in the strength of 'Private technology' and the deficit in terms of 'Public knowledge'.

According to the concept of the Technological frontier as mentioned in the literature report, one would expect that ever more patents are needed to maintain their leading technological position. Among the High-Tech regions the ones that have more Medium-High-tech manufacturing show relatively low level of GDP, but the High-tech regions which have many patents in transport and machinery show the highest level of GDP among the regions of this type (see Table 13). The positive impact of patent applications in the fields of 'transport' and 'energy machinery' could be related to the location of corporate headquarters, but the opposite impact of patenting and manufacturing supports the idea of fragmentation of the value-chain (and in our case the innovation-process). The business R&D might still remain more 'sticky' and less 'foot loose', but with the decreasing share of employment in high- and especially medium-high-tech manufacturing over the past years in this type of region, and considering the global restructuring of the automotive industry, it may not be a surprise to see that respondents for high-tech regions have indicated 'globalization' as the most important challenge.

The share of employees with tertiary education also has a positive impact, but since high-tech regions have on average the lowest increase in the share of tertiary educated, it could limit growth.

Table 13 Explaining differences in GDP per capita among High-tech regions

Impact on GDP per capita 2005	Significance and direction of impact*
GDP_1999	++
Employment share Med-high-tech manufacturing	- -
Patents regarding transport	++
Patents regarding energy machinery	++
Employees with tertiary education (%)	++

Dependent Variable: Per capita GDP (2005); * ++/--: Level of significance 5%; +/- Level of significance 10%.

Respondents to the survey for high-tech regions often indicate 'sustainable development' and 'education and training' as very important challenges. Their assessment of challenges for the future is quite different to the assessment of the whole sample. Challenges that are clearly more often mentioned by High-tech regions are 'globalization', 'climate change', 'sustainable development', and 'shrinking population/labour force'. Challenges that are clearly less often mentioned by High-tech regions are 'water resources', 'migration', 'employment', 'social polarization', 'safety' and 'security'.

High-tech regions mention 'lack of capital', 'negative effects of the financial crisis on funding R&D' and 'lack of entrepreneurship' most frequently as barriers seriously hampering research, technology and innovation in their region. High-tech regions indicate most barriers less often than the whole sample, except for 'negative effects of the financial crisis on funding R&D'. Since public R&D is clearly under-represented in this type of regions, the strong dependency on business R&D expenditures seems to make them especially vulnerable to the financial crisis.

Strengths	Weaknesses
• High and growing business R&D expenditures (on average 2.9 % of GDP) • High share of high-tech manufacturing • Patents, especially in Audio-visual-electronics and Transport • Growth in knowledge intensive services	• Lowest share University R&D in total R&D • Lowest share of Government R&D in total R&D • Lowest increase in tertiary educated • No growth in patenting
Opportunities	**Threats**
• Strengthen public research at universities and government labs • More co-funding applied R&D and innovation projects • Additional venture capital • Attract high-educated globally	• Negative impact crisis on R&D funding • Decreasing regional returns on patenting; • Limited growth in knowledge intensive services due to shortage in high-educated

The policy options mentioned for high-tech regions point at the importance of financial policy measures: 'more co-funding of applied R&D', 'measures against the financial crisis' and 'additional venture capital'. Some policy measures are more often indicated by High-tech regions than in the whole sample, besides more capital ('additional venture capital' and 'measures against the financial crisis') it is interesting to note that 'establish new/extend existing public research organizations' is clearly more often mentioned by respondents in High-tech regions than those in other regions.

To statements 9, 10, 12 and 14 the agreement of High-tech regions is clearly higher than in the whole sample. In high-tech regions they also more often agree with the statement that: ‘Services will remain the primary drivers of employment growth’. The agreement with statements 2, 3, 8 and 11 it is clearly lower. The statement that “trading patents and high-tech services will increase as a way of diffusing new knowledge” explicitly refers to High-tech regions. Nevertheless, the rate of agreement is slightly less than in the whole sample.

6.6 Skilled technology regions

For Skilled technology regions accessibility to knowledge is average, as well as absorption capacity and diffusion capability. The strongest factors are ‘skilled workers and high-tech manufacturing’. This group has no real weak factors, but ‘public knowledge’ and ‘knowledge intensive services’ are below average. The average R&D intensity is 1.30% of which 65% is spent by the business sector. Employment in services, both business sector services and government, is about 66%; employment in medium-high-tech manufacturing is high at 7.5%. Labour productivity is high, but also unemployment is relatively high and population is ageing rapidly. Life-long learning is below average. Growth of per capita GDP between 1999 and 2005 has been low. Technological performance is strong with more than 150 patents.

The regions in this group rely on industrial activities, but they flourish more by adopting technologies developed elsewhere then by pushing the technological frontier. Skilled industrial technology regions have seen an increase in the employment share of medium-high-tech manufacturing. Business R&D has increased with 0.15 %-points. The backbone of economic activity in these regions is in the medium-high-tech manufacturing sectors, including activities in automotive and machinery. In terms of patents this group of regions is specialised in metal products and machine-tools.

For Skilled technology regions it is interesting to note that the regression (explaining the difference in GDP per capita among the 38 regions of this type; see Table 14), suggests that they could benefit from more Government R&D. Again we can conclude that policy efforts should address the main weaknesses of its knowledge economy. Concerning the moderate performance on the factor ‘Activity’ which includes unemployment, we also note that among Skilled technology regions the ones with more Life-long learning have significantly higher GDP per capita.

Table 14 Explaining differences in GDP per capita among Skilled technology regions

Impact on GDP per capita 2005	Significance and direction of impact*
GDP_1999	++
Lifelong learning	++
Employees with tertiary education (%)	
Employment share Market services	- -
Government R&D (% GDP)	++

Dependent Variable: Per capita GDP (2005); * ++/--: Level of significance 5%; +/- Level of significance 10%.

From the survey results it can be observed that Skilled technology regions indicate 'energy security and renewable energy sources', 'employment' and 'education and training' most often as very important challenges, which corresponds with the assessment of the whole sample. Challenges that are more often mentioned by Skilled technology regions are 'globalization', 'energy security', 'ageing', and 'migration'.

The barriers most frequently mentioned in Skilled technology regions are: 'lack of capital', 'negative effects of the financial crisis', 'limited cross-sectoral collaboration' as well as 'lack of entrepreneurship'. Skilled technology regions indicate most barriers more often than the whole sample with the exception of 'limited knowledge creation capacities'.

Strengths	**Weaknesses**
• Large share of high- and medium-high-tech manufacturing • Strong patenting in metal products and machine tools • Increased Business R&D intensity	• Low increase in tertiary educated • Limited share high-tech services
Opportunities	**Threats**
• More co-funding applied R&D and innovation projects • Improve the education system and invest more in Life-long learning • Strengthen government research organizations	• Ageing, highest and most increasing share of elderly • Limited risk capital and foreign investments

The most frequently mentioned particularly necessary policy measures of Skilled technology regions are 'more co-funding of applied R&D', 'a more research and innovation-friendly economic policy' and 'better education and training'. Concerning the perceived need of the responding experts to improve the education and training system in this type of regions, we also recall the modest performance of this type of regions in terms of the factor ‘creative workers’ (which refers to the share of tertiary educated). Besides tertiary education, the statistical analysis has also shown the importance for this type of regions to invest more in Life-long-learning policies.

Skilled technology regions agree to most statements more often than the whole sample. Only in the case of statement 3 “Not only manufacturing industries but also the associated business R&D will more and more disappear from metropolitan regions, which will become even more service oriented” the rate of agreement is clearly lower.

6.7 Traditional Southern EU regions

For Traditional Southern EU regions accessibility to knowledge, absorption capacity and diffusion capability are all weak. This group performs weak in the factors: ‘high-tech manufacturing, creative workers, skilled workers, private technology’ and also in ‘activity'. The average R&D intensity is only 0.56%. Employment in industry, business sector services and government is less than 80%. These regions rely also on agricultural activities and tourism. Labour productivity in financial services and business services is high. Unemployment is high. Life-long learning is high. Growth of per capita GDP between 1999 and 2005 has been average. Technological performance is far below average with less than eight patents.

As many regions rely on agricultural and tourism activities, knowledge might not be as important for these regions. This seems to be confirmed by their levels of income which, although being below the EU average, are close to those of Public knowledge centres and well above those of Skilled industrial Eastern EU regions. However, one may doubt whether these regions can maintain or even increase their rate of economic growth without shifting towards a knowledge economy. Traditional Southern EU regions seem to be in an unfavourable position to benefit from existing and new technological developments.

The level of education is one of the main weaknesses for Traditional Southern regions. The share of people with primary education is still by far the highest of all types of regions, although this is decreasing twice as fast as for the rest of the EU regions (and both the shares of secondary and tertiary education have increased more than in the other types). The regression results (Table 15) which explain the differences among regions of this type confirm that the level of education is the main issue. Those regions of this group that have a higher share of tertiary educated have a higher level of GDP.

Table 15 Explaining differences in GDP per capita among Traditional Southern regions

Impact on GDP per capita 2005	Significance and direction of impact*
GDP_1999	++
Employees with secondary education (%)	- -
Employees with tertiary education (%)	++

Dependent Variable: Per capita GDP (2005, ln); Stepwise regression; * ++/--: Level of significance 5%; +/- Level of significance 10%.

The results of the survey show that Traditional Southern regions indicate 'water resources', 'employment' and 'education and training' most often as very important challenges. This differs in one respect to the whole sample: 'water resources', a very specific challenge for the South of Europe. Other challenges which are more often mentioned are 'globalization', 'sustainable development', 'employment', and 'regional development'. Challenges that are clearly less often mentioned by Traditional Southern EU regions are 'ageing' and 'shrinking population and labour force'.

Traditional Southern EU regions stress the following barriers most: 'lack of capital', 'limited production, transfer and use of knowledge' and 'limited cross-sectoral collaboration'. Traditional Southern EU regions indicate the barriers 'lack of capital', 'limited foreign investments' 'limited inter-regional collaboration', 'limited production, transfer and use of knowledge' and 'limited use of ICT' clearly more often than the whole sample. Especially the weakness to exploit the potential of ICT (barrier 'limited use of ICT') seems to be a particular problem in the Traditional Southern regions. In all other types there is also room for improvement, but it is rarely seen as a serious deficiency.

The most important policy measures for Traditional Southern EU regions are different from those in other types. 'Better coordination of regional, national and European RTI-policies', 'a more research/innovation-friendly economic policy' and 'organise or support a regional RTI-strategy process' are the most frequently mentioned particularly necessary policy measures in this type of region. Some policy measures are more often indicated by Traditional Southern EU regions than in the whole sample ('new/better technology intermediaries', 'more networking within and outside the region', 'promotion of ICT', 'a regional RTI-strategy process' and 'better coordination of regional, national and European RTI-policies'), some less often ('new/extended public research organizations', 'more co-funding of research', 'more co-funding of applied R&D'.

<table>
<tr><td>Strengths
• Productivity in service industries
• High university research expenditures as % of total R&D
• Increased level of education
• Increased patenting</td><td>Weaknesses
• High share of employees with primary education
• Lowest share of employment in high-tech manufacturing and services
• Low productivity in manufacturing industries
• Lowest business R&D as % of GDP</td></tr>
<tr><td>Opportunities
• Invest in education and training
• Support regional strategy processes
• Improve multi-level governance
• Support networking, also across sectors and across regions
• Support applied R&D and innovation projects</td><td>Threats
• Scarce water resources
• Unemployment</td></tr>
</table>

It can be concluded that for Traditional Southern regions public funding of R&D seems less relevant. According to the experts in these regions most important policy needs revolve around improving the governance of innovation support (strategy processes, coordination, networking and intermediates).

Traditional Southern EU regions show an extraordinary pattern of agreement with the statements in the survey. This is especially true for the relatively high agreement with statement 1 - services as primary drivers of employment growth - and the relatively low agreement to statement 5 - stressing the importance of education for establishing high-tech manufacturing in low-income regions. Most often the agreement of Traditional Southern EU regions is lower than in the whole sample. Only to the statements 3 and 11 the agreement is clearly higher. The type-specific statement 11 - stressing the necessity to strengthen the knowledge absorption and diffusion capacities of the respective regions in Southern Europe by improving their education institutions - receives higher rates of agreement than average. The statement that education is the driving or catching-up factor for high-tech in low income regions receives a very strong agreement in almost all types. A quite remarkable result in this respect is that the rate of agreement is lowest in the lagging economies in Southern Europe.

7. CONCLUSIONS

This section is structured along three levels of conclusions: per type of region, at regional level (across all types) and at EU policy level. The corresponding key messages emerging from this study are:

I. Regional diversity in path-dependent trajectories of innovation in Europe calls for differentiated policies per type of region;

II. At regional level a broad range of knowledge activities and (socio-economic and institutional) framework conditions are important for future benefit from innovation and technology. Moving beyond a linear research-based approach the conclusion is that towards 2020, absorbing knowledge and applying technologies will be more important at regional level than hosting basic research;

III. At EU level there is a need for complementary policy approaches: promoting research excellence, place-based 'smart specialisation' and improving basic framework conditions.

Regional diversity calls for differentiated policies per type of region

Regional diversity in pathways and models of innovation calls for differentiated policies, in order to maximize the potential of regional knowledge economies in Europe. Most existing typologies rank regions in terms of high and low performance, suggesting that the differences are merely stages in following the same route, and that progress along this single pathway can be achieved by adopting good practice policies of the best performing regions. However, the typology of this study shows that regions with similar levels of GDP per capita or R&D intensity can have distinct knowledge bases or innovation models. One may conclude that there is no single best model that should be adopted by all the less performing regions.

The typology reveals various core-periphery patterns. At European level, the traditional core-periphery pattern is manifested by the centre archipelago and by the peripheries mainly in Eastern and Southern Europe. At a lower level, some national core regions emerge from surrounding regions. Promoting knowledge spillovers and linkages between leading and lagging regions constitute a key policy challenge. The nature of the inter-regional spillovers seems to differ between the different types of regions. The relation between High-tech regions and the surrounding Skilled technology regions suggests technological spillovers in manufacturing industries. The core-periphery relation between Metropolitan KIS regions and Knowledge absorbing regions seems to be more based on a division of labour in services and government, with most knowledge intensive occupations being concentrated in the core regions. The patterns of spillovers however need to be explored and tested in further research.

For the types of regions with relatively lower levels of GDP per capita the impact of business R&D is promising, both in terms of GDP per capita and employment. For the more wealthy type of regions, specific attention is drawn on the positive impact of education and training (share of high educated, and life-long learning respectively) on GDP per capita and employment.

The literature review shows that absorption capacity is often emphasised as being especially important for less developed regions as a pre-condition for catching-up. This analysis supports this view, in the sense that the high share of secondary educated has been important for the Skilled industrial Eastern EU type of regions in attracting high-tech manufacturing. A 'higher-level' of absorption capacity (in the form of the share of tertiary educated and knowledge intensive services) is associated with higher levels of regional productivity, and typically the Metropolitan Knowledge Intensive Services (KIS) regions are moving further ahead in this type of absorption capacity. The concept 'technological frontier' is well associated with the High-tech regions, where access to technology (in terms of Business R&D and patents) is high and increasing.

Overall convergence occurred in terms of GDP per capita and for most of the other indicators. Divergence has been observed for knowledge intensive services, tertiary educated and business R&D (BERD). Regarding knowledge intensive services the Skilled industrial Eastern EU regions are falling further behind, whereas the High-tech and Metropolitan KIS regions both move ahead in knowledge intensive services. However, the latter regions show opposite trends in terms of business R&D and the share of tertiary educated. High-tech regions are getting stronger in private R&D and Metropolitan KIS regions are moving further ahead in their share of tertiary educated.

Conclusions per type of region

For *High-tech* regions the lagging trend in the share of tertiary educated seems a threat to their potential in knowledge intensive services. While the share of employment in knowledge intensive services has grown, it did not for high- or medium-high-tech manufacturing. New forms of diffusion and absorption capacity could be needed to keep benefiting from a further increasing technology generation capacity. Within the technology generation capacity, the share of university and government R&D is relatively low in High-tech regions. More public R&D investments in high-tech regions seem efficient from a regional perspective. The need to establish new or extend existing public research organizations was ranked high by respondents to the foresight survey.

For *Skilled technology regions* it is shown statistically that they would benefit from investing in absorption capacity, especially in the form of life-long-learning. 'Public knowledge' is identified as a relative weak factor for Skilled technology regions. While the impact on GDP from government research in most types of regions is disappointing, among Skilled technology regions the ones that have more government R&D have a significant higher level of GDP per capita. The increased R&D intensity is due to increased business R&D. The lack of foreign investments and available (risk) capital however was underlined by survey respondents as key barriers to innovation.

For *Skilled industrial East EU* regions, addressing their relative weakness in knowledge generation (and/or access) seems beneficial to higher GDP levels. The lack of R&D infrastructure and limited knowledge creation capabilities constitute the most important barriers to innovation according to the foresight survey. Specifically relevant policies for this group of regions are:

- A more research and innovation-friendly legal and economic policy environment;
- More co-funding of applied R&D and innovation projects;
- Organise or support a regional RTI-strategy process;
- New or improved technology intermediaries like technology centres.

We conclude that the governance aspects of innovation policies are important framework conditions for Skilled industrial east EU regions and it seems that the economic impact of the increased high-tech manufacturing activity could be enhanced with more innovative input from engineering and applied R&D.

For *Metropolitan KIS regions* the decreasing trend in knowledge generation capacity from a decreasing business R&D intensity, and a reduction in the diffusion capacity from further decrease in high-tech manufacturing, seems to frustrate future prospects to maximize the level of GDP. The economic benefits of ever more absorption capacity based on attracting talent and knowledge intensive services seem limited, when poorly linked to a decreasing technology generation and diffusion capacity.

For *Public knowledge centres* the technology generation capacity of the national research institutes (dominant in R&D infrastructure with more than half of total R&D) seems poorly linked to industry needs. Strengthening the weak position of business R&D and university R&D could bring more economic benefits to technology users and diffusers in its knowledge intensive industries. The survey underlines the need to ensure a more research and innovation-friendly legal environment and address the insufficient quality of government services. Limited production and transfer of technology, low cross-sectoral collaboration and the lack of R&D infrastructure was also underlined together with the need to provide more co-funding of applied R&D and innovation projects.

For the *Traditional Southern regions* investing in its weakness regarding absorption capacity by reducing the still high levels of people with only primary education seems the best option to maximize the benefits of technological change and innovation potential. This option is supported by the fact that among this type of regions those regions with a higher educated labour force have a significant higher level of GDP per capita. Education and employment are the most important challenges for Traditional Southern regions. Lack of risk capital, limited production, transfer and use of knowledge and low cross-sectoral and cross-regional collaboration were listed among the main barriers. The need to support a regional RTI-strategy process and networking was also stressed.

On average for *Knowledge absorbing regions* the strength in access, absorption and diffusion capacity is relatively balanced, but addressing the weakness in 'skills' which relates to the relatively high share of employees with only primary education will be important for maximizing its benefits as a knowledge economy. The trend of reduction of employment in high- and medium-high tech industries is a threat, but new forms of diffusion capacity and improved linkages between the capacities (for example based on user- and demand driven innovation and innovation in the relatively large public sector in this type of regions) seem important policy options. Limited knowledge creation capacities together with low cross-sectoral collaboration were listed among the main barriers to innovation. The importance of supporting firm investments in applied R&D and innovation projects was also stressed.

Policy challenges at regional level: towards 2020

From the above analysis we conclude that for all types of regions, extensive specialisation at regional level in any of the three dimensions of accessibility, diffusion or absorption capabilities may limit the overall economic impact. A region largely benefits from synergies among the co-evolving knowledge capabilities.

This paper underlines the overall importance of absorption capacity, as indicated by the share of tertiary educated population, and the share of knowledge intensive services. For targeting a higher level of GDP per capita, the impact from tertiary education is particularly important. For targeting a lower level of unemployment the impact of knowledge intensive services is essential.

The foresight exercise has shown that many of the long list of sectors considered promising for the future are quite traditional, for instance transport and agriculture. This might be partially explained by the use of NACE classification which represents the economic structure of the past. Focus group workshops confirmed that most answers reflected the existing regional importance of sectors. Promising activities referred to cross-sector fields of specialisation, to application of new technologies in existing sectors and specialisation in specific niches in the innovation landscape (smart specialisation).

The technologies considered most crucial for the future development of the selected sectors in a region are so-called General Purpose Technologies, as they are important for many industries. ICT, energy technologies, biotechnology, nanotechnology, automation and new materials were most frequently cited. These technologies are also used in traditional industries which can be transformed into new industries, or into new hybrid specialisations linking formerly distinct industries and technologies.

Lack of risk capital was most frequently cited among the major barriers to innovation followed by limited production, transfer and use of knowledge, limited cross-sectoral collaboration, the lack of entrepreneurship and the long-term negative effects of the financial crisis on R&D funding.

Applied R&D and innovation is seen as the most important factor for the development of future sectors followed by higher education and basic science. Linkages between these knowledge activities are crucial in maximizing the potential of the regional specific specialisations. Running a more research and innovation-friendly economic policy was also considered essential along with the need to improve the governance of innovation policies. Co-funding of applied research and innovation projects is considered more important than co-funding research projects. This confirms the particular importance of promoting the application of technology at regional level.

The foresight exercise also revealed that the perceptions of the experts on the future are often linear extensions of the current regional strengths. This could lead to a (policy) 'locked-in' situation, whereas investments would concentrate on the same strong factors, without taking due account of structural threats. Merely focussing on strong ties within regional networks and more support for existing 'triple-helix' co-operations might increase the existing imbalances and limit synergies which could have been generated in a more balanced policy mix.

Complementarities between EU policies promoting research excellence, place-based innovation and improving framework conditions

Promoting further growth of technologically leading areas and at the same time ensuring that other parts of Europe are not lagging further behind, requires complementary policy approaches promoting the absorption and diffusion of new technologies. Excellence-based competition can focus on leading edge centres of excellence competing at the world's technological frontier.

This paper confirms that 'cohesion-inspired' regional innovation policies should effectively become complements for European Research Area policies: *"focusing less on research excellence in abstracto, but more on local innovation application, while at the same time attracting highly skilled activities and human capital in particular local specialisation areas ..."* (Soete 2008, p.5) in line with the ideas of 'smart specialisation', as formulated by Foray and van Ark (2007).

Developing place-based innovation policy in the form of 'Smart specialisation' is a promising way for each region to maximize the benefits of technological change and regional innovation potential. It is about regional specific niches on cross-roads between sectors, challenges and technologies, which can be developed by linking it to applied R&D and education and training. How broad or narrow the fields of specialisation should be, depends on the economic importance, and scientific and technological development of region concerned.

Excellence based research policy is not only beneficial for creating General Purpose Technologies (ICT, new materials, biotech), and creating European centres of excellence in research, but, more in general it also makes public R&D more mobile. At present the lack of mobility seems one of the reasons for the imbalance in the spatial distribution of business and public R&D. But also the regions which would benefit most from excellence-based science and research policy would need a place-based innovation policy to benefit economically from their technology generating capacity.

The new paradigm acknowledges that there is more diversity in regional potential and specificity in territorial assets than is suggested by core-periphery models which separate regions along one dimension: regions with agglomeration advantages from regions without such advantages. This study shows there are different types of agglomeration advantages. Therefore there is 'no winning region which takes all'. Each type of region can benefit from enhancing its knowledge capacities. The new approach on cohesion policy has the objective of: "tapping under-utilised potential in all regions for enhancing regional competitiveness" (OECD 2009). Equity and efficiency policies can indeed be complementary: concentrating investments in General Purpose Technology generating centres increases the overall access to new technologies for all regions. Benefiting economically depends on their innovative capacities to absorb, apply, re-produce and diffuse knowledge.

For research policy the European level is the most efficient level of governance. It should promote concentration of research excellence, especially for basic, fundamental, and long term research that could develop new General Purpose Technologies. For innovation policy the regional level is most appropriate.

Regional innovation strategies are in essence too specific to be transferred to other regions, including regions of the same type. In this respect a typology of regions or a technology foresight study can never replace the individual analysis of regions. Trans-regional exchanges could however certainly be a source of fresh, external inspiration, and it is also important to actively search for commonalities and complementarities with other regions, since there could be options for networking, co-operation and in some cases even integration, for example in the case of border-regions. For Traditional Southern regions for instance there is a common challenge regarding 'water resources'.

Regional innovation policy making has become more complex. In terms of policy intelligence and implementation capacity it has become more demanding. According to the experts in Traditional Southern regions most important policy needs revolve around improving the governance of innovation support (strategy processes, coordination, networking and intermediates). The respondents from Skilled industrial Eastern EU regions and Public knowledge centres have particularly stressed the importance of improving the framework conditions for innovation and the governance aspects of innovation policies (and the quality of government services in general). At national level, a continuing challenge is the need to improve higher education systems. With regards to science and research policy, Member States should actively contribute to the development of the European Research Area, such as for example transforming 'national research institutions' into nationally supported centre of excellence attracting talent and public and private research partners globally. In parallel however, and in particular with regard to innovation policy, it is important that national policy makers improve coordination with regional policymakers through different strategic platforms in order to maximize the benefits of cohesion policy investment in innovation.

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